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HARTFORD,
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The Locomotive.

PUBLISHED BY THE

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

HARTFORD, CONN.

NEW SERIES.
Vol. IX.

HARTFORD, CONN.
1888.

INDEX TO VOL. IX, NEW SERIES.

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NEW SERIES—VOL. IX. HARTFORD, CONN., JANUARY, 1888. No. 1.

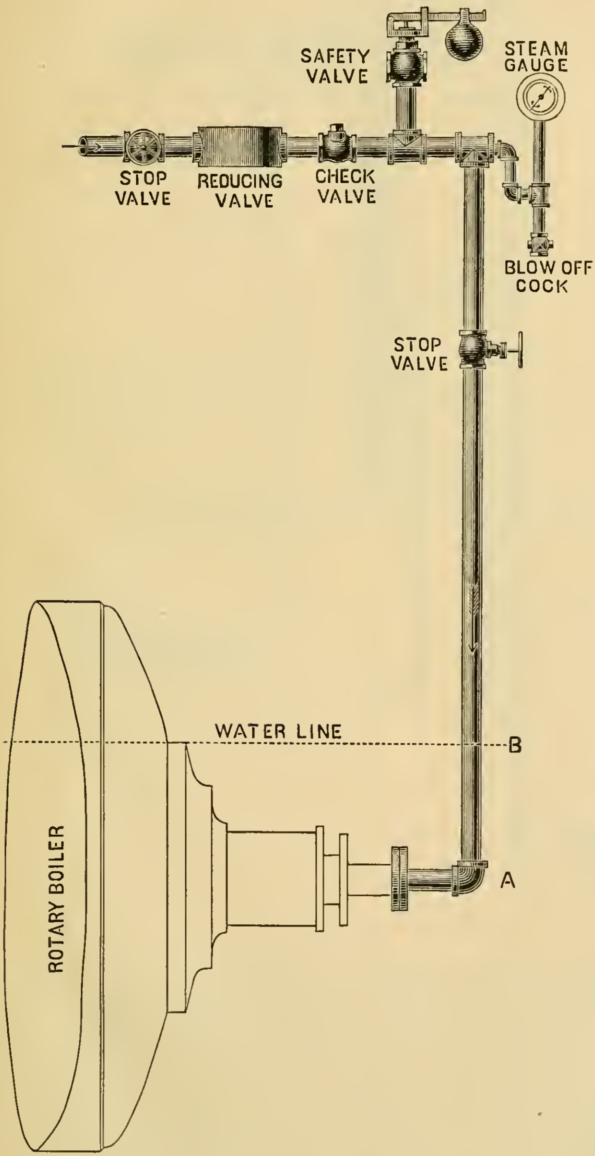


FIG. 1.

Connections for Rotary Boilers.

When rotary boilers, as used in paper mills, are supplied with steam direct from the steam generating boilers, a great deal of trouble is sometimes caused by the digesting liquor flowing back through the steam supply pipes into the boilers, and into the pipes supplying steam for other purposes, whereby much damage is done to stock in process of manufacture. This flowing or working back is caused by fluctuations in the steam pressure at the boilers. For instance: Steam is at 60 pounds per square inch on boilers and rotary; there comes a sudden demand elsewhere for steam, or the fires have to be cleaned, and the pressure falls with comparative suddenness to 40 pounds per square inch in the boilers; the great body of stock and liquor in the rotary is at a pressure of 60 pounds, and temperature due to this pressure; the radiation of heat from the shell of the rotary is not sufficient to reduce the pressure as fast as it falls in the boilers, and as a consequence the stored-up heat generates steam which flows out of the rotary toward the boilers, and takes along a share of the liquor. Also, when the level of the liquor is above the center of the main journal or steam inlet, as it is always supposed to be when working, the greater pressure of steam in the rotary will force the liquor back through the pipes, to an extent depending on the difference of pressure, the length of time it is maintained, and the condition of the check-valves in the steam pipe. It is the experience of manufacturers that a check-valve will not wholly stop the flowing back of the liquor, and even two or three have been put in without curing the trouble.

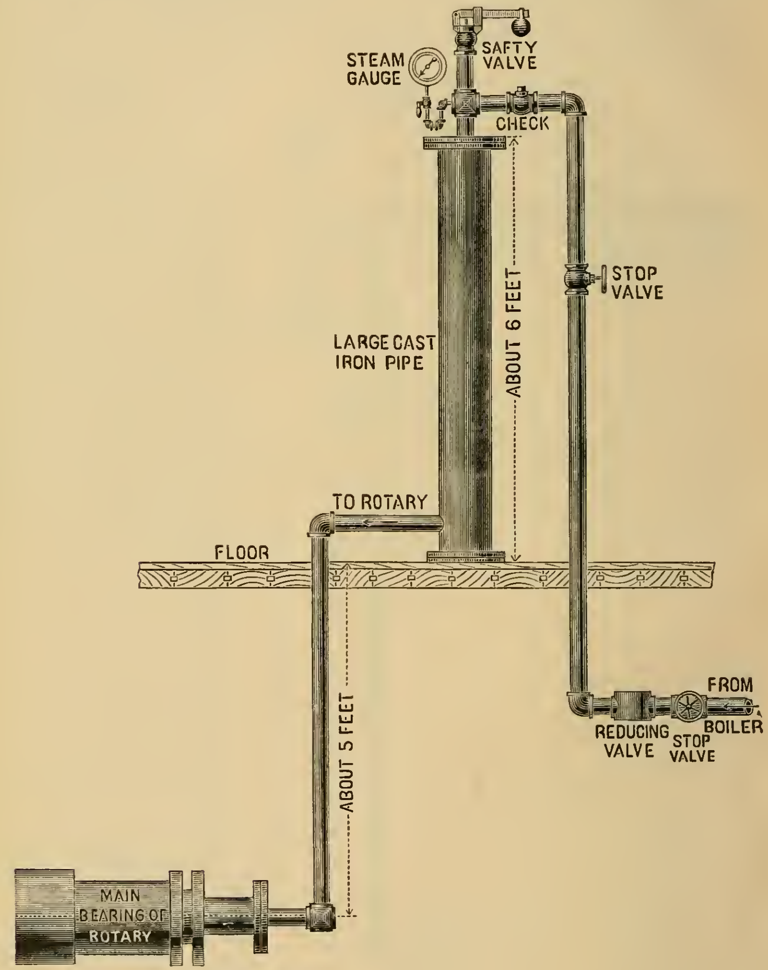


FIG. 2.

Of course, if a separate boiler could be used to boil the rotaries, and no other connections were made to it, the flowing back of the liquor would do no especial harm in many cases. We have known of cases, however, where the amount of grease contained in the rags and stock under treatment, and which found its way back into the boilers, has caused burning of the plates of the shell. But it is rarely desirable, or even practicable, to devote a special boiler to the duty of boiling the rotaries, hence some other means must be adopted to prevent damage to stock from the above described cause.

Our cuts this month show several connections which have been applied in as many different places, and found to very effectually put a stop to the trouble. The essential principle upon which the apparatus is based, is the use of a reduced pressure in the rotary, so that whatever the pressure in the boilers that in the rotary shall always be considerably less, and thus guard against the possibility of a backward flow of steam and liquor from it toward the steam-boilers.

Figure 1 shows the simplest form of the arrangement. The steam coming from the boiler passes through a reducing-valve — of any approved form or make — by which its pressure is reduced to whatever may be considered necessary to properly perform its duty in the rotary. Between the reducing-valve and the vertical pipe connecting with rotary is placed a check-valve. It is essential that this check-valve should be kept clean and in good working order. On top of this vertical pipe is placed a safety-valve, weighted say five pounds above the reduced pressure in the rotary. The object of this is to prevent the possibility of the full boiler pressure, which is often greater than could be safely carried by the rotary boiler, being thrown upon it should the reducing-valve become inoperative. Two stop-valves are placed in the steam supply pipe, one between the reducing-valve and the boilers, and one in the vertical pipe connecting with rotary. This latter valve should always be shut first when the rotary is to be blown off, for the following reasons: — If the valve between steam generators and reducing-valve were shut first, the supply of steam would of course be cut off from all points beyond it, and the rotary and all pipe between it and the valve which was shut would begin to cool off by radiation. But owing to the fact that the pipes have a vastly greater amount of radiating surface in proportion to the volume of steam which they will hold than the rotary, the result will be they will cool off much quicker, but being in free communication with the large body of steam and hot water in the rotary, the pressure will be kept up by the latter, thus causing a flow from the rotary into the pipes. Or we might express the action thus: The steam being shut off, the pipes cool quickly, the steam condenses and

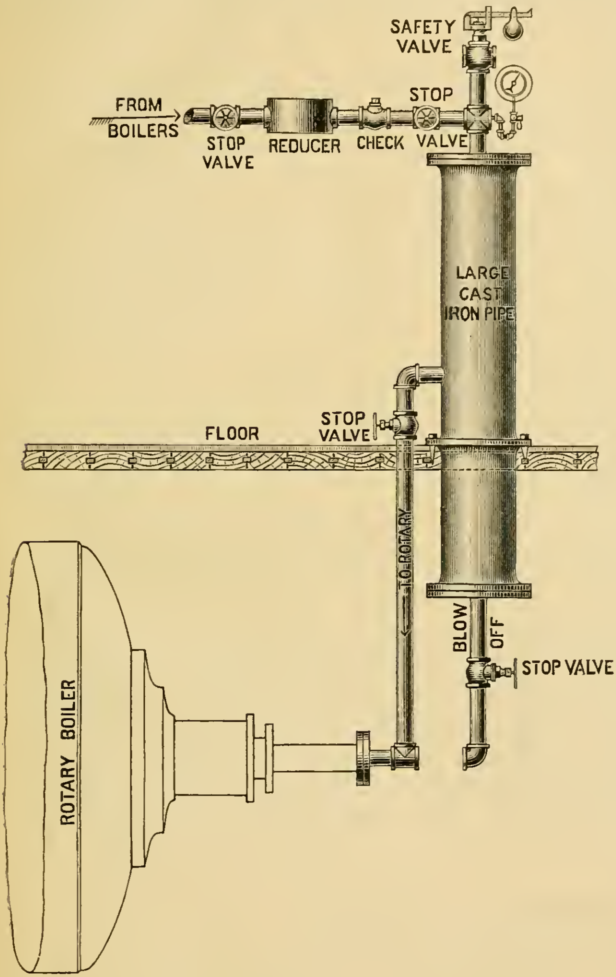


Fig. 3.

forms a vacuum; the large body of steam in the rotary has not time to condense, hence the higher pressure in the rotary causes the liquor, and more or less stock, to "back up" into the pipes. The consequence is that the check-valve, and safety-valve, become clogged with the stock and dirty liquor, and if, as would most likely be the case after the operation had been repeated a few times, the check-valve failed to close tightly, the reducing-valve and steam-gauge would be found in the same condition. Where no stop-valve has been used between reducer and rotary, rags have been found tightly forced into the nipple of the steam-gauge, to get there being obliged to pass back through both check and reducing-valves.

The use of the stop-valve between the rotary and the reducing apparatus and its connections, prevents all this trouble. If care is taken to *shut this valve first* when the rotary is to be blown off, no steam, liquor, or stock can get back beyond it to clog the safety-valve, check-valve, reducing-valve, or steam-gauge.

Figure 2 shows a modification of the foregoing arrangement, designed and used at the mills of the Crocker Manufacturing Company, Holyoke, Mass., and which answers the purpose admirably. This consists of a section of large pipe placed between the reducing arrangement and the rotary, thus forming a sort of trap, which effectually stops the passage of stock or liquor back through the pipes. This arrangement has been in use at the above-named company's mills for several years, and the superintendent states that they have had no trouble whatever since it was put in.

Figure 3 represents a modification of the last-described arrangement which we could recommend where extra precautions must be taken to keep the pipes clean. It consists in simply making the trap deeper below the point where steam is taken out for the rotary, and connecting a blow-off to its lower end, for the purpose of draining out anything that may collect in the lower end. This blow-off had best be run out of doors, or to any convenient point, so that it may be opened while the rotary is in operation.

In making these connections the reducing, check, and safety-valves, and steam-gauge should always be placed some feet above the level of the top of the charge in the rotary, in fact a good rule to observe is to place them in the room above the rotary. For by reference to Fig. 1 it will be seen that if placed below the water line B, which may lie anywhere between the position shown and the top of the rotary, the steam supply-pipe would always be flooded back as far as the check-valve, at least, and if that failed to hold tightly, there would be nothing to prevent the liquor working back through all the pipes in the mill, which happened to be on this same level or below. Where the steam-pipe is of necessity brought to the rotary at this low level, a riser should always be carried at least as high as the top of it, and the reducing arrangement put as high up as it can be.

Inspector's Reports.

NOVEMBER, 1887.

In the month of November, 1887, our inspectors made 3,689 inspection trips, visited 7,249 boilers, inspected 3,003 both internally and externally, subjected 542 to hydrostatic pressure. The whole number of defects reported reached 7,011, of which 978 were considered dangerous; 55 boilers were regarded unsafe for further use. The defects in detail were as follows:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment, - - - -	454 -	- 38
Cases of incrustation and scale, - - - -	675 -	- 37
Cases of internal grooving, - - - - -	23 -	- 8
Cases of internal corrosion, - - - - -	213 -	- 18

Nature of Defects.	Whole Number.	Dangerous.
Cases of external corrosion,	377	29
Broken and loose braces and stays,	232	71
Settings defective,	171	24
Furnaces out of shape,	172	10
Fractured plates,	193	75
Burned plates,	142	46
Blistered plates,	250	18
Cases of defective riveting,	1,970	141
Defective heads,	52	24
Serious leakage around tube ends,	1,066	307
Serious leakage at seams,	486	30
Defective water-gauges,	105	23
Defective blow-offs,	47	11
Cases of deficiency of water,	13	9
Safety-valves overloaded,	27	12
Safety-valves defective in construction,	23	9
Pressure-gauges defective,	221	35
Defective tubes,	61	0
Defective hangers,	26	1
Defective man-hole frames,	4	0
Defective fusible plugs,	4	0
Defective re-enforcing rings,	4	2
Total,	7,011	978

Defective safety-valves are the cause of frequent and often serious accidents to steam boilers, for unless they are kept in good working order at *all* times, and are not allowed to become inoperative for any reason whatever, they are an element of the greatest danger.

Safety-valves may become defective from a variety of causes. An overloaded safety-valve is of course always more or less an element of danger, depending upon how much it is overloaded. Overloading to a small amount while it may not be dangerous in itself, is apt to create a feeling that the boiler is safe at that pressure, and this will probably lead to a still further increase of weight if it is found convenient, so that a point may soon be reached when the boiler will be seriously strained or even ruptured before danger is thought of. But an overloaded safety-valve, if it is in good order, cannot properly be called a defective one. The defect in this case is in the one who has charge of it. A defective valve is one which is inoperative through other causes than overloading, and these causes are many and of various natures.

They often become stuck fast when they are neglected, and the pressure does not often rise high enough to open them. If the pressure carried is so far below what they are set at that they do not often blow off, they should be raised daily to see that they are in working order. This is done in many places, in many other places it is not. It is absolutely essential that it should be done however. Some engineers object to doing it on the ground that it has a tendency to make them leak, but the reverse is the case. If a valve is blown daily the tendency is to keep it clean; if it is opened but once in two or three weeks, or at longer intervals, as is frequently the case, it will become covered with a coating of scale or other foreign substance, which may be so firmly attached that simple blowing for a few minutes may not be sufficient to dislodge it, and the consequence is it gets between the valve and seat and the valve cannot close, leakage results, and under these circumstances the valve and seat are soon cut by the action of the steam, and grinding in is absolutely necessary.

Boiler Explosions.

NOVEMBER, 1887.

——— (155). — A boiler explosion occurred in Anderson County, S. C., Sept. 10th, wounding Patrick Stegall and Frank Anderson, colored, both fatally, and two others painfully.

THRESHING MACHINE (156). — A terrible accident occurred at the farm of Geo. W. Erwin, ten miles southeast of Jamestown, Dak., Nov. 2d, in which three men lost their lives and three others were seriously wounded, two probably fatally, by the explosion of a threshing engine boiler. Ira Gardner the engineer, had the top of his head blown off. Fred Boemaster, one of the feeders, was blown to atoms, parts of his body being found 300 feet distant. The owner of the machine, John Glass, had his entire back, from shoulders to hips, torn out, leaving the lungs and heart exposed. A young Englishman, who went by the name of "Cardiff" received a fracture of the skull. One of the others will live. John Glass, the owner of the threshing outfit, was running the engine himself and it is fully believed that the explosion was caused by his inexperience and carelessness. One piece of the engine was thrown one-half a mile and passed through a house. The shock and noise of the explosion was felt and heard six or seven miles. Hardly a piece of the engine could be found near the place where the explosion occurred.

LOCOMOTIVE (157). — A boiler of one of the engines of the Third Avenue Elevated railroad, New York, burst Nov. 3d, on the track near the People's Theatre, on the Bowery. It is reported that two persons were killed. The concussion was tremendous. Glass in the windows of neighboring houses for a distance of a block each way, was shattered, and there was a panic on the street and in the train to which the engine was attached.

SAW-MILL (158). — On November 4th, the boiler in Wade & Mills' mill, near Owensboro, Ky., exploded. Mills, one of the owners, was fatally scalded, and Tom Whitworth was struck by a piece of timber and killed, while piling lumber fifty yards away. The following were badly scalded: Frank Royalty, Walter Hamilton, Jefferson Wilkins, and B. F. Boyle. Huge sections of boiler were thrown hundreds of yards.

CITY BLOCK (159). — Shortly after 8 o'clock A. M., Nov. 5th, persons who happened to be in the vicinity of the *Herald* building Boston, Mass., were startled by a terrible explosion that shook the buildings thereabouts, and caused pedestrians to momentarily halt in wonderment. Instantly smoke, followed by a sheet of flame, was seen issuing from the basement window of the building occupied on the first floor by the Central Vermont and other offices, directly opposite the *Herald* establishment. An alarm was sounded from box 36, and a few moments' work by the fire department resulted in the extinguishment of the flames. It was then ascertained that a boiler, located in the basement of the building, had exploded. The boiler was of the kind known as the Clay sectional boiler, and was comparatively a new one, having been placed in position less than a year ago. Soon after it was in operation a crack was discovered in it and it was repaired. The cause of the explosion is enshrouded in mystery. The engineer was upstairs sweeping and dusting, and, when last in the basement, everything was apparently all right. Only a minute before the explosion an employee in one of the offices ascended from the boiler-room, and he reports seeing nothing out of the way. The boiler was incased in brick-work, and hardly a brick was left in its original position, while the pipes and other parts of the boiler were wrenched from their places. The damage to the building was slight, nearly all the loss occurring from the demolition of the boiler and its brick inclosure.

Saw-Mill (160). — By an explosion of a stationary boiler in a saw-mill near Knoxville, Ga., Nov. 7th, Forest J. Matthews, the owner, and two negro helpers were killed instantly, and another negro fatally scalded. The boiler had been used twenty years.

Shirt Factory (161).— The explosion of the boiler in Eighmie's shirt factory, Poughkeepsie, N. Y., Nov. 8th, resulted in the instant killing of Thomas Lawrence and Ralph Street. Another of the victims, Emerson Roselle, has since died. The boiler was an old one, and the victims had been repairing it. Roselle was putting a weight on the safety-valve, and noticed that the steam was at twenty pounds when the explosion occurred. The bodies of Lawrence and Street were found in the ruins next morning.

Portable (162).— One of the small boilers used by the Andrews Brothers in sinking driven wells on the Van Rensselaer flats, Albany, N. Y., exploded Nov. 12th. The cone shell was thrown about 100 feet in the air. It was a fifteen-horse power boiler and exploded under sixty pounds pressure. No one was in the vicinity when the explosion occurred.

File Works (163).— One of the boilers in the steel department of Heller Brothers' File Works, Newark, N. J., exploded Nov. 15th, as the engineer was blowing the whistle to call the men to work. Engineer Otto Millie was thrown twenty feet and buried under the falling roof, but crawled out unhurt. Night watchman Thomas Prout, who had charge of the boilers until the engineer arrived, was instantly killed and buried under the walls. Three others, who were in the yard, were knocked down and slightly hurt. The demolished buildings which were all frame structures, took fire and were destroyed. Part of the works were occupied by Dodge & Lyon, steel-tool makers, who lose $20,000 and are insured for $6,000. Heller Brothers lose $40,000 and are insured for $10,000. The boiler was bought second-hand two years ago. The explosion tore it apart in the middle and threw the ends 500 feet in opposite directions.

Blacksmith Shop (164). — A boiler in a blacksmith shop at Ottumwa, Iowa, exploded Nov. 15th. No one was injured but considerable damage was done to property.

Chemical Works (165).— The packing-house of the Hancock Chemical Works, Hancock, Mich., was blown up Nov. 16th, and six men killed.

Saw-Mill (166).— By the explosion of the boiler in J. & W. Atkinson's steam mill, Moncton, N. B., six men were injured, the engineer probably fatally.

Saw-Mill (167).— B. B. Gray's saw-mill, Pinebloom, Ga., was damaged by a boiler explosion to the amount of $3,000.

Saw-Mill (168).— Henry Mahon's saw-mill, Clanton, Ala., was damaged by a boiler explosion.

Saw-Mill (169).— The saw-mill of Forest & Turner, near Dover, Ark., was damaged by a boiler explosion.

Locomotive (170).— A locomotive boiler exploded on the New York Central railroad at Palatine Bridge, N. Y., Nov. 15th, with terrific effect, killing one man and injuring another seriously. As locomotive No. 496, attached to a freight train, had just backed from the stand-pipe to the train, Engineer William Mitchell of Albany, opened the throttle to start up. As he did so the boiler exploded. The engineer was blown through a side window of the cab a distance of fully forty feet, landing in the bushes near the edge of the Mohawk River. The fireman, Charles Gingeras of Albany, was shot out of the rear of the cab like a cannon-ball and landed near the river's edge, between the embankment and a bowlder, fully one hundred feet distant. Both of his arms and legs were broken and his skull was crushed. Brakeman R. E. Tomlinson of Schenectady, who was on the rear of the tender, was thrown about forty feet, and struck on his feet, escaping with a few scratches. The fireman was a married man, and leaves a wife and several children. Mitchell was removed to Albany, when his wounds were dressed. He was badly scalded, but may live.

SAW-MILL (171).— There was a boiler explosion at Mr. O. J. Garner's lumber mill two miles south of Nacadoches, Texas, Nov. 18th, in which there was a wreck of considerable machinery.

SAW-MILL (172).— A boiler in W. Z. Wilson & Co.'s saw-mill, nine miles from Prescott, Ariz., exploded Nov. 19th. The following persons were killed: W. Z. Wilson, one of the proprietors; Timothy Cowley, engineer; J. B. Ackers, foreman; D. A. Collins; Taylor, an unknown. A number of other employees were severely injured. Ackers, the foreman, was killed where he was standing. The entire top of his head was blown away. The intestines of Wilson were discovered near where Acker's body lay, cut in two. His head could not be found. Part of his backbone was found 200 feet away on the top of a hill. Cowley's body was found seventy-five feet from where he was supposed to have been standing. It could be recognized only by the clothing. The bodies of Collins and Taylor could not be found for hours. Collins' remains were found upon a hill 300 feet from the place where he stood. The body and face were so mangled that he could be recognized only by the boots that he wore. Taylor was found 150 feet from the engine-room, wedged head foremost between two logs.

SAW-MILL (173). — The boiler of a saw-mill near Hannibal, Mo., exploded Nov. 21st. Two men were killed, and two others badly injured. Cause, a worn-out boiler.

AGRICULTURAL BOILER (174).— About 7 o'clock A. M. Nov. 22d, one of the boilers on the Australia plantation, situated a few miles above Plaquemine, La., exploded, killing one negro and scalding the overseer so severely that it is thought he will die. Large pieces of the boiler were hurled through the air with great force, lodging some distance off in a canal.

DISTILLERY (175). — The boiler of a distillery near Clarksville, Tenn., exploded Nov. 23d. One man was killed and four injured.

——— (176).— George Carley was killed by the explosion of a boiler in Dunbar's works at Stonebridge, Ont., Nov. 28th.

HOTEL (177). — The boiler in the Kirby House, Milwaukee, Wis., exploded Nov. 28th, knocking part of the rear of the hotel building out. Nine kitchen girls were buried in the débris, but were all taken out more or less injured. Mrs. E. M. Gage, the second cook, was killed; her body was found. Harry Taylor, night cook, was knocked down, but not hurt. Mr. Beckwith was badly hurt by falling bricks. Several girls in *The Sentinel* office, across the alley, were struck by bricks, Nellie Thompson receiving serious injuries.

SAW-MILL (178).— The boiler in J. N. Curtice's box factory at La Grange, O., exploded Nov. 28th. Bird Johnson, the foreman, was instantly killed; George Holmes badly cut and bruised. William Nichols was blown 150 feet across a street, but escaped without serious injuries. The building was wrecked and the machinery destroyed.

SAW-MILL (179).— A boiler of a steam saw-mill near Dennison, Ill., exploded Nov 28th. Ed. Gilky was instantly killed. Joe Clark and Sylvester Norman, mill-hands, were fatally injured. Two other workmen were dangerously injured.

PACKING-HOUSE (180). — The boiler in a packing-house in Lake, Ill., blew up Nov. 28th. The building was demolished, but as no one was about there was no loss of life.

SAW-MILL (181). — A saw-mill boiler blew up Nov. 29th, near Mexico, Mo. Two men were killed, and two others injured.

SAW-MILL (182).— There was a terrific explosion of the boiler of Duncan's mill, thirteen miles from Pine Bluff, Ark., Nov. 29th, which dangerously scalded ten persons and killed one outright. It made a wreck of the mill.

The Locomotive.

HARTFORD, JANUARY, 1888.

J. M. ALLEN, *Editor.* H. F. SMITH, *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.

The Locomotive Engineer, Vol. 1, No. 1, January, 1888, just received, is a new monthly designed to "represent the interests of the engine men of America." The first number is an excellent one and we predict for it a successful career. It is published by the American Machinist Publishing Company, at 96 Fulton Street New York. Subscription price, one dollar per year, ten cents per copy.

THE past year would seem to have been an exceptionally prosperous one for the steel rail makers if the number of miles of railroad built is a safe criterion to judge by. We give in another part of this issue an account of railroad construction the past year from the *Railway Age*, which will be found of great interest.

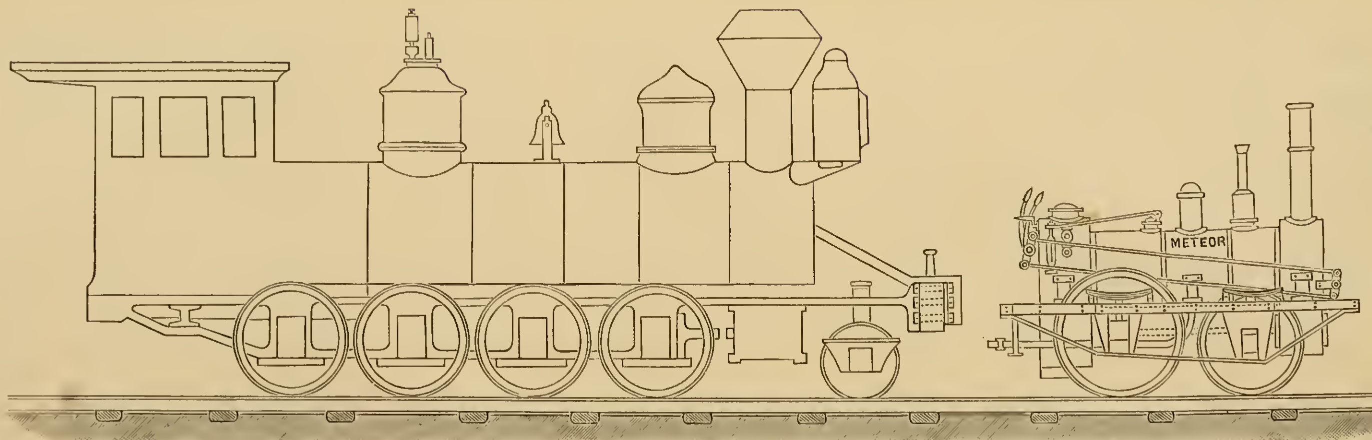
A PRESS dispatch of recent date says that the engineer at an iron works in Pennsylvania, went into one of his boilers to clean it and took along with him a can of crude petroleum to aid in the work. The result is just what might have been expected. The vapor given off by the volatile oil took fire from his lamp, although the press dispatch says it "exploded by some mysterious cause," and the unfortunate man was nearly burned to death. In the absence of any one to assist him it seems a miracle that he got out of the boiler alive, but he did so, although he was very severely burned.

OF a recent boiler explosion, one of the "Great Dailies" says: "It was not the fault of inspection this time." This, while it is very little, is something. It is so very convenient generally to put the blame for an explosion on an inspector, no matter if he has not seen the boiler for months, and has no means of knowing what sort of treatment it has been subjected to meanwhile, that a word like the above is very encouraging.

A CORRESPONDENT writes: We have just put in two new boilers, and there was a discussion between myself and the man who put them up as to the proper way to put in the globe feed valves. I asked him on which side he was going to have the pressure from the steam drum come, and he replied, the under side. I told him I was willing to admit that this was the right way to put in a valve with very few exceptions, but as these were loose disc valves I was going to turn them the other way for this reason: If the disc should come off it would close like a check with the pump pressure on top of it, and prevent water entering the boiler, but if they were turned the other way the pump pressure would come underneath and open it and let water into the boiler. I would like your opinion, through the columns of THE LOCOMOTIVE, as to which was right.

HENRY J. MARSHMAN,
Rockville, Conn.

In such a case as our correspondent describes the position taken by him is perfectly right.—ED. LOCOMOTIVE.



No. 19, Cumberland & Pennsylvania Railroad.

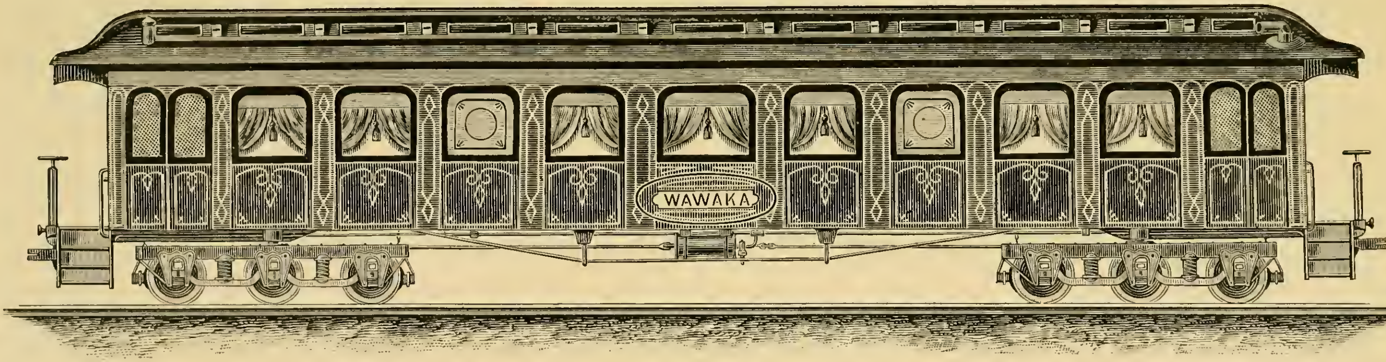
Consolidation Freight Locomotive of the present day, as built by Mt. Savage Locomotive Works in 1884.

Diameter of Cylinders, - - - - - - - - - - -	20 inches.
Stroke of Piston, - - - - - - - - - - - - -	24 "
Weight, - - - - - - - - - - - - - -	105,782 pounds.

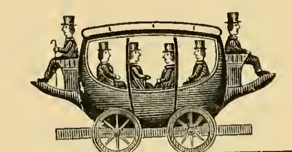
The Meteor.

The first Locomotive used on the Boston & Worcester Railroad, built by Stephenson, at Newcastle-on-Tyne, England, in 1833.

Diameter of Cylinders, - -	9 inches.
Stroke of Piston, - - - -	17 "
Weight, - - - - -	18,000 pounds.



Drawing-Room Car of 1888.



Passenger Car of 1834.

Railroading Fifty Years Ago.

THE cuts on preceding pages show the relative dimensions of the first engines and cars that were used on the Boston & Worcester Railroad, now a portion of the Boston & Albany, and the consolidation freight locomotives and drawing-room cars of the present day. For drawings, from which the cuts are made, and also for the following interesting notes, we are indebted to Mr. Samuel Nott, of this city:

THE METEOR. — The first locomotive of the Boston & Worcester Railroad, built by Stephenson at Newcastle-on-Tyne, England, reached Boston, Mass., about January 1, 1834, was set up in the Boston & Worcester Railroad engine-house, near and west of Washington street, Boston, and on the north side of the tracks. The tender was built at the Mill Dam Works, R. M. Bouton, Engineer, who also built "The Yankee," the second locomotive of the Boston & Worcester Railroad.

The weight of the "Meteor" was 18,000 pounds; it had a nine-inch cylinder; stroke of piston seventeen inches. It began to run passenger trains, with Mr. William H. Hovey, now of Springfield, Mass., as engineer, April 16, 1834, from the station near and west of Washington street, Boston, to West Newton, Mass., eight and one-half miles, with from two to eight cars, usually in twenty-eight minutes, including stops at Brighton and Newton Corner.

The cut was made from a drawing made by Mr. William H. Hovey, in August, 1885, and in part verified by notes taken by Mr. Samuel Nott in 1834–5, and all agreeing with his recollection of the "Meteor," the first locomotive engine that he ever saw.

The larger cut shows, on the same scale that the "Meteor" is drawn to, the main outlines of No. 19 of the Cumberland & Pennsylvania Railroad Company, Consolidation Locomotive, built at the Mt. Savage Locomotive Works in May, 1884, N. W. Howson, Master Mechanic. Cylinders, twenty by twenty-four inches ; weight, in working order, 105,782 pounds, and is capable of running twenty-five to thirty miles per hour. It will pass readily over curves of 310 feet radius, and even less, in regular daily service, the rigid wheel base being nine feet four inches only. Takes readily over a grade of 176 feet per mile 215 gross tons at a speed of fifteen to eighteen miles per hour, with a steam pressure of 130 pounds per square inch.

"THE YANKEE," the first locomotive built in New England, was closely like the "Meteor," but was a trifle heavier.

The tender of the "Meteor" was a miniature of the tenders of to-day. No part of railroad apparatus has changed so little as the tender, and that mainly in size only. In the first winter, 1834–5, of the use of the "Meteor," the Yankee novelty of a steam pipe was put into the tender from the boiler, as an aid to keep things moving in our New England winter, but that and other efforts failed to keep the infant locomotive department in motion through the winter, and passengers were carried for about three weeks by horse-power to Westboro, about thirty miles from Boston.

The first turntables were six feet in diameter, and the engine and tender were turned separately. The passenger cars hauled by the "Meteor" are well shown by the cut which represents one used in August, 1831, on the Mohawk & Hudson Railroad. In one trip Mr. Nott was perched on the front outside seat, on a run from Boston to Westboro, and he says "the cut showing a man in that place is a graphic reminder of that midwinter transportation by rail by horse power."

In that winter, the day of small things on that line, now doing an immense business, contracts were made with farmers along the line to clean the snow from specified sections, and one of Mr. Nott's duties was to deliver snow shovels to the contractors between Boston and Westboro. The whole Boston business was then done on one acre of land near and west of Washington Street. The passenger station was ornamented with a dozen or more flaming placards, "OIL UP!" "OIL UP!" to remind the men to oil the journals, as that had to be done before every start in those days before the invention of tight oil boxes.

A Big Magnet.

During a recent visit to Wellets Point, we were much interested, not only in the improvements of the post, and in the practical training of engineer officers and men, going on under the new commandant, Maj. W. R. King, of the Engineer Corps, but also in the numerous evidences of Major King's restless activity in mechanical matters. All sorts of old instruments and machines that had been rusting for years have been brought forth, repaired, adjusted, improved and set at work, to find out what they can do, or (what may be equally important knowledge) what they can not do.

One of the most ingenious experiments to obtain, at trifling cost, scientific results on a large scale, is Major King's huge electro-magnet. He has connected at the trunnions two-15-inch Rodman guns, wound them with about 4 miles (ultimately he will use 6 miles) of old torpedo-cable, and thus obtained, by the use of a 30 horse-power dynamo, an electro-magnet of enormous power. All the materials being already on hand, the means of really valuable experiments are thus provided almost without cost.

The tests have not yet gone so far as to give quantitative results. In fact, only a preliminary trial of the magnet (not yet fully wound) has been made, and its whole strength can not be measured until it has been more firmly anchored. But it shows a tremendous attraction for all things ferruginous.

One of the peculiar phenomena observed is, that a 15-inch shell, weighing 320 pounds, placed in the muzzle of one of the guns is violently forced out when the current passes through the wire, yet it does not leave the gun, but swings around to the lower side of the muzzle, where it remains hanging, like a carpet tack on an ordinary magnet, even with a second shell of equal weight depending from it. Twenty men can not pull an iron rail from the muzzle of the guns while the current is passing. Major King has had an armature made of 11-inch plates, built up to a thickness of 5 or 6 inches, so as to get a more suitable mass for the giant to work on, and a five-ton Duckham dynamometer fails to register a force sufficient to remove it.

We anticipate very interesting results from experiments with this magnet. Unless we are much mistaken, it will be by far the strongest in the world, weighing, as it does, more than 100,000 pounds.—*Engineering and Mining Journal.*

Railway Building in 1887—Nearly 13,000 Miles of Track Laid.

The year 1887 has surpassed all other years in the extent of railway mileage constructed in the United States. When, six months ago, the prediction was made in these columns that the total new mileage for the year "would not be less than 10,000 miles, with the likelihood of surpassing the record of 1882—the year of greatest railway construction in the history of the country," it was not generally believed. But the figures obtained by careful investigation throughout the year and confirmed by official information now prove the prediction to have been more than warranted. Our returns show that during 1887 no less than 12,724 miles of new main line track were added to the railway system of the United States, no account being taken in this of the hundreds of miles of side track built nor of the thousands of miles of main line tracks relaid. While the search has been unusually thorough and the totals corroborate the record kept from week to week it is not improbable that some scattering additions may yet be received; so that it is safe to state that during 1887 nearly, if not quite, 13,000 miles of new main line track were constructed. These are truly astonishing figures. When in 1882, during a period of extraordinary activity, 11,568 miles of new road were built, it was generally believed that these figures would not again be equaled. In the following year, 1883, the new construction fell to 6,741 miles; in 1884, to 3,825, and in 1885, to 3,608 miles. The year 1886 witnessed a considerable revival of activity, and 9,000 miles of new road were built—a greater mileage than in any previous year with the exceptions of 1881 and

1882; and now 1887 has witnessed the building of more miles of railway than 1886 and 1885 combined, and not much less than 1885, 1884, and 1883 together. We compile from our detailed records the following summary showing the number of lines and the mileage laid in each State and territory during the year:

TRACK LAID IN THE YEAR 1887.

	No. Lines.	Miles.		No. Lines.	Miles.
Maine,	2	31	Indiana,	9	115
New Hampshire,	1	23	Illinois,	12	328
Vermont,	...	..	Wisconsin,	11	363
Massachusetts,	5	55	Minnesota,	9	196
Connecticut,	...	..	Dakota,	17	760
Rhode Island,	..	..	Iowa,	10	352
New York,	6	97	Nebraska,	17	1,101
New Jersey,	2	15	Wyoming,	3	133
Pennsylvania,	13	125	Montana,	7	616
Delaware,	..	..	Kansas,	44	2,070
Maryland,	1	18	Missouri,	16	554
West Virginia,	3	53	Indian Territory,	5	499
Virginia,	4	64	Arkansas,	8	153
North Carolina,	10	184	Texas,	19	1,055
South Carolina,	7	104	Colorado,	9	818
Georgia,	8	231	New Mexico,	1	4
Florida,	10	193	Nevada,	...	....
Alabama,	15	515	California,	14	358
Mississippi,	5	99	Idaho,	2	54
Louisiana,	4	65	Utah,	1	6
Tennessee,	10	68	Arizona,	2	70
Kentucky,	8	168	Oregon,	4	48
Ohio,	14	155	Washington Territory,	3	108
Michigan,	13	700			
Total in 42 States,				364	12,724

RECAPITULATION.

	No. Lines.	Miles.
3 New England States,	8	109
5 Middle States,	25	308
10 Southern States,	81	1,691
5 Middle Western States,	59	1,661
6 Northwestern States,	63	3,158
6 Southwestern States,	101	5,149
7 Pacific States,	27	648
42 of the 47 States — Totals,	364	12,724

For the purpose of comparison we reprint the following summary of tracklaying during each of the twenty years preceding 1887:

TRACK LAID IN EACH YEAR FOR TWENTY YEARS.

Year.	Miles.	Year.	Miles.
1867,	2,249	1877,	2,280
1868,	2,979	1878,	2,629
1869,	4,615	1879,	4,746
1870,	6,070	1880,	6,876
1871,	7,379	1881,	9,796
1872,	5,878	1882,	11,568
1873,	4,097	1883,	6,741
1874,	2,117	1884,	3,825
1875,	1,711	1885,	3,608
1876,	2,712	1886,	9,000

Not only is the aggregate mileage thus shown extraordinarily great, but the number of different lines constructed is seen to be surprisingly large, aggregating, after deducting for the duplicating of roads lying in two or more States, no less than 364 lines. Of course the number of companies building these lines was very much less than this; but these figures show that the new mileage is not made up chiefly by a few long lines, but consists of main lines and branches ramifying in all directions and supplying facilities for transportation to innumerable communities and to vastly extended regions.

It will be seen from the table that the greater part of this prodigious increase of railways has taken place in a few Western States. New England and New York contribute scarcely anything to the grand total. The great Middle States add very little, and the additions in the Southern States are not as large as many anticipated; although Alabama presents a fine record with over 500 miles, Georgia adds 230 miles, Florida nearly 200, and Kentucky and North Carolina each, a little less than that. The Northwestern States, including Michigan, Illinois, Iowa, and Minnesota, have shown very considerable activity, but the great rush of railway building has been in the central belt, west of the Missouri River. Kansas leads with the astonishing total of 2,070 miles. Its neighbor, Nebraska, comes next with 1,101 miles, almost equaled by Texas, with 1,055 miles. Then in order comes the following: Colorado, 818; Dakota, 760; Michigan, 700; Montana, 616; Missouri, 554; Indian Territory, 499, and so on. Four States and two territories, namely, Kansas, Texas, Nebraska, Colorado, Dakota, and Montana, together show an addition of over 6,400 miles, or about one-half of the entire year's mileage of the country. This fact speaks very impressively of the great march of civilization in those new and still thinly peopled regions — even yet but partially supplied with railway facilities — which still afford room for the construction of several fold more miles of new road than the grand total which they have acquired during the year. The only States from which no new construction is reported are Vermont, Connecticut, Rhode Island, and Nevada.

What has been the cost of this year's work? Many of the lines have been built through comparatively level country, requiring but little grading and bridge building; but on the other hand many other lines have been very costly; for example, those over the Rocky mountains in Colorado, the Southern Pacific extension in northern California, the Atchison's Kansas City and Chicago extension, the Northern Pacific's work in the Cascade mountains, and others. Moreover, several of the companies have purchased costly terminal facilities in large cities, while nearly all have made extensive purchases of equipment. It is probably fair to assume that the total cost of roadway, bridges, station buildings, terminal facilities, and equipment of these new lines averaged $25,000 per mile; at which rate it appears that not far from $325,000,000 have been expended on the lines completed during the year. But even this prodigious sum does not by any means cover all the outlay for new construction, as a large amount of grading and bridge building has been done on extensions where the track has not yet been laid. Evidently the work of the railway builder in 1887 has necessarily had a powerful influence on the financial condition of the country. The money which has thus been expended has temporarily employed a large army of workmen, and it has also furnished permanent employment to another great army, probably aggregating — at the average of five employes to a mile of road — about 65,000 persons. An industry which in a single year furnishes permanent occupation for 65,000 men, besides temporary work for a still larger number, certainly promotes the prosperity of the people to a wonderful degree.

The railway mileage of the United States at the commencement of 1887, was stated to be 137,986 miles. The extensions for the year here recorded increase it to 150,710 miles, and it may be said that, in round numbers, the United States to-day has 151,000 miles of railway lines. This is indeed a wonderful record, and it gives impressive evidence of the enterprise and prosperity of the people of this great republic.— *The Railway Age.*

Incorporated 1866.

Charter Perpetual.

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The Locomotive.

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The Attachment of Nozzles to Steam Drums.

To the best of our knowledge we have never seen the nozzles of a large steam drum, that is, those forming the connection between the boilers and drum, put on as they should be. This seems to be rather a sweeping statement, and may seem to reflect upon the abilities of our leading boilermakers, steam engineers, pipers, and others who have had more or less to do with the designing of such work, but it is nevertheless true.

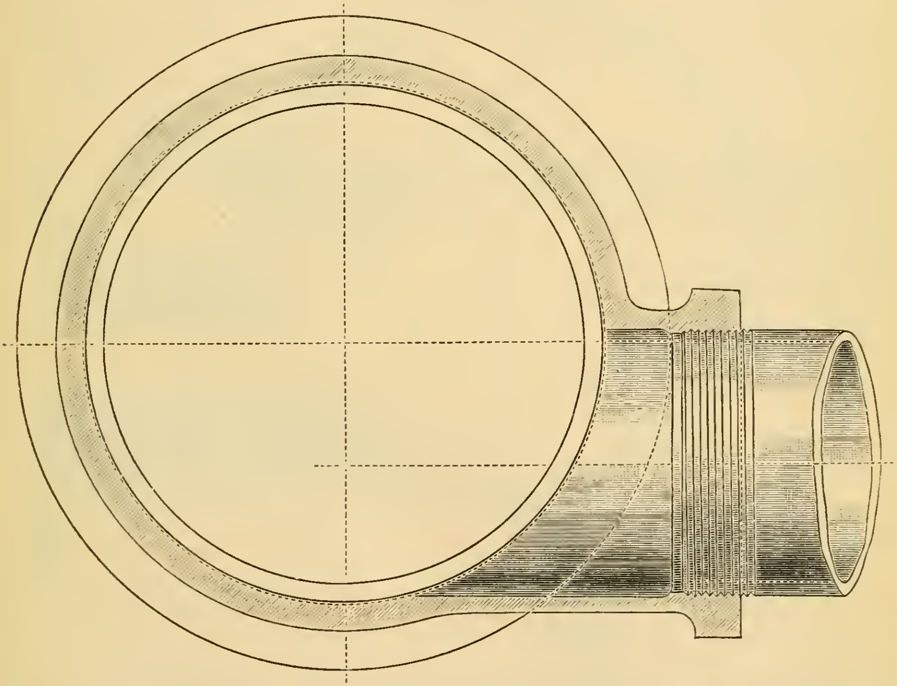

Fig. 1.

For drums up to ten inches in diameter, made usually of ordinary steam pipe, the connections from the boilers are generally by means of the ordinary screwed tee. We will suppose, for instance, that four sixty-inch boilers are set in a battery. Then the drum would be of ten-inch pipe, the steam pipe from each boiler, five inch, and they would connect with the drum with a 10″ x 10″ x 5″ tee with inlet, outlet, and branch all threaded, and the whole screwed together.

So far this is all right.

But the pipes leading from the drum to the engine and other parts of the establishment are not usually the full size of the drum. They will oftener be found not over six inches in diameter, and are taken out by means of the usual forms of fittings. These pipes being led horizontally from the drum, with all centers at the same height, leaves a chance for water to collect in the lower part of the drum. This is apt to cause trouble unless the drum is dripped. This drip must be connected to all the boilers and be furnished with valves so that the water may always be returned when but one boiler is running, and that one, any boiler of the battery.

This arrangement works all right, but it is of the nature of a makeshift, and the work should be done in such a manner that it is not necessary.

The connections to the boilers should be made by means of eccentric fittings. Figures 1, 2, 3, and 4, show in section, fittings adapted to this purpose, which would cost no

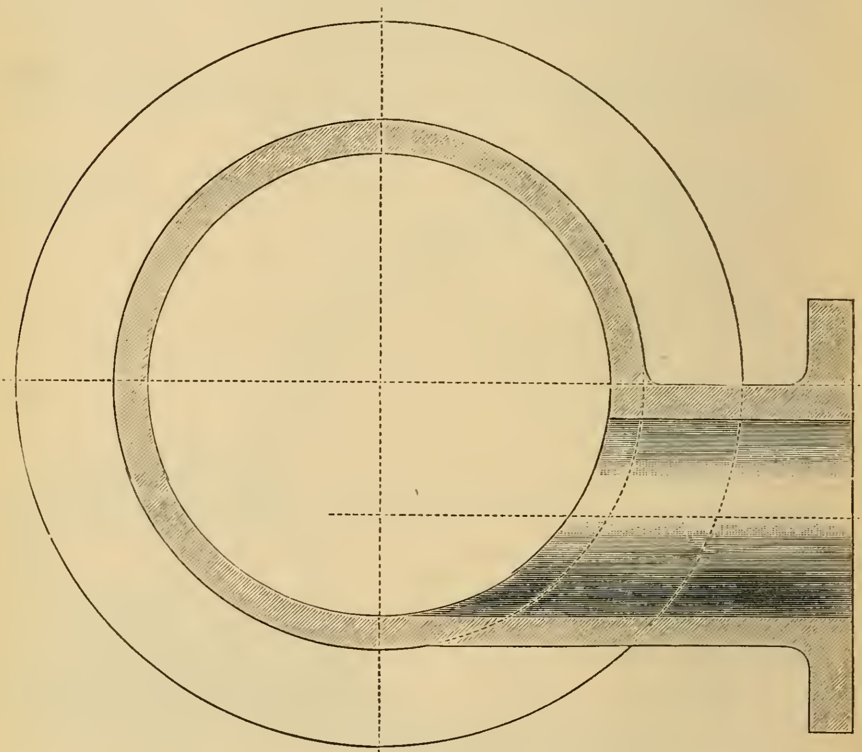

FIG. 2.

more than those of the ordinary pattern, and the expense of the drip connection would be saved.

Fig. 1 shows an ordinary screwed tee with the exception that the branch which receives the steam pipe from boiler is dropped, so that the bottoms of the pipes forming the drum and that leading from boiler are at the same level. Then when connection is made with any boiler in the battery, the drum always has a chance to drip freely back into the boiler. Under no circumstances can water collect in the drum, and no extra piping is required.

Fig. 2 shows a section through the branch of a cast-iron flanged tee, such as would be used in making the connection with a pipe larger than ten inches in diameter. The same remarks apply as in the case of Fig. 1.

Fig. 3 is a section through a nozzle such as would be put on a large drum, either of

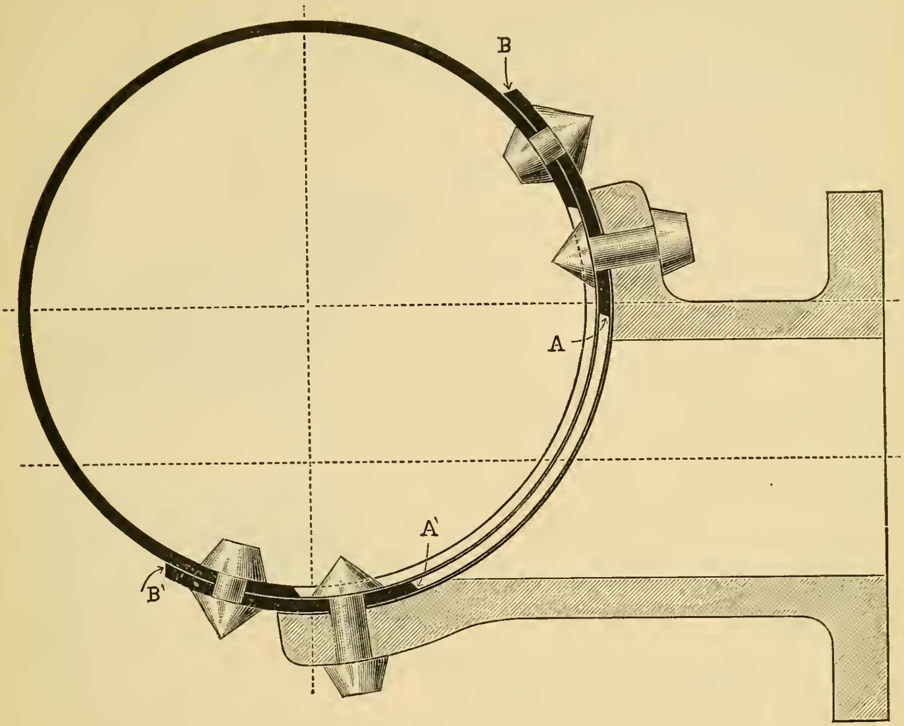

Fig. 3.

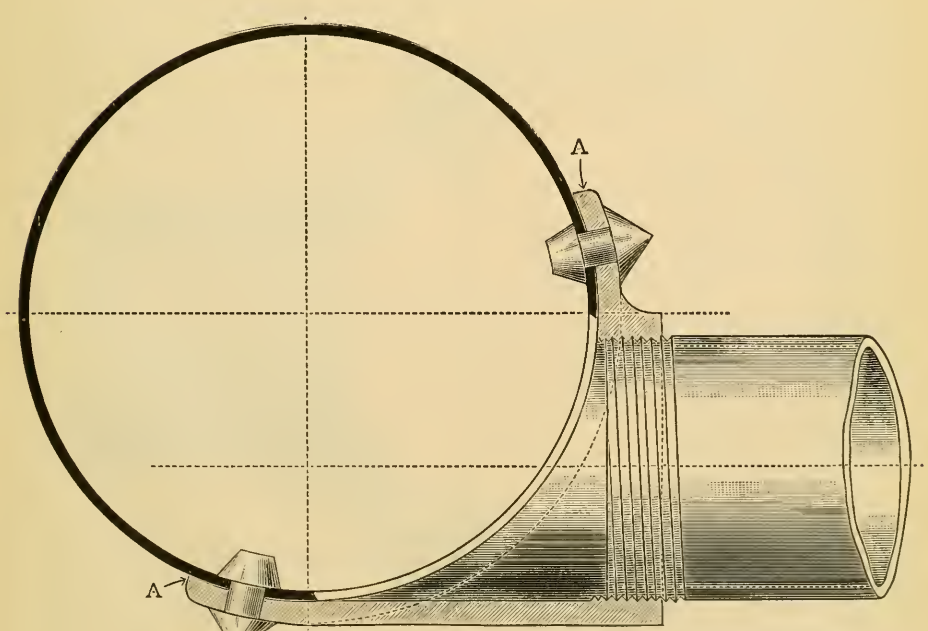

Fig. 4.

lap-welded pipe, or a riveted-up drum. It should be put on eccentrically when connections to the boilers are made. For pipes leading out of the drum this is not essential, and the connection had better be made as shown in Fig. 6 further on.

A word here about putting nozzles of this kind on to drums. A common way of doing

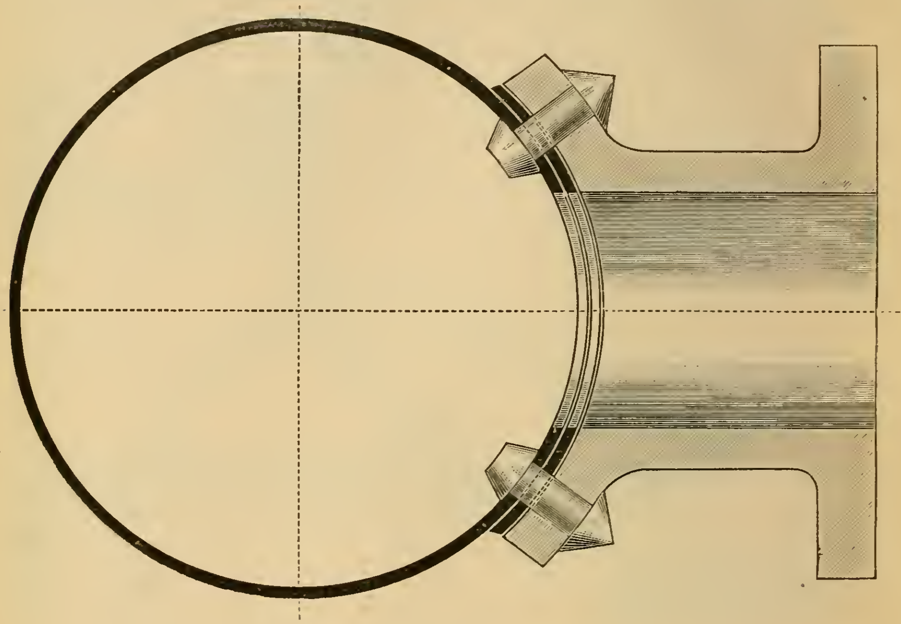

FIG. 5.

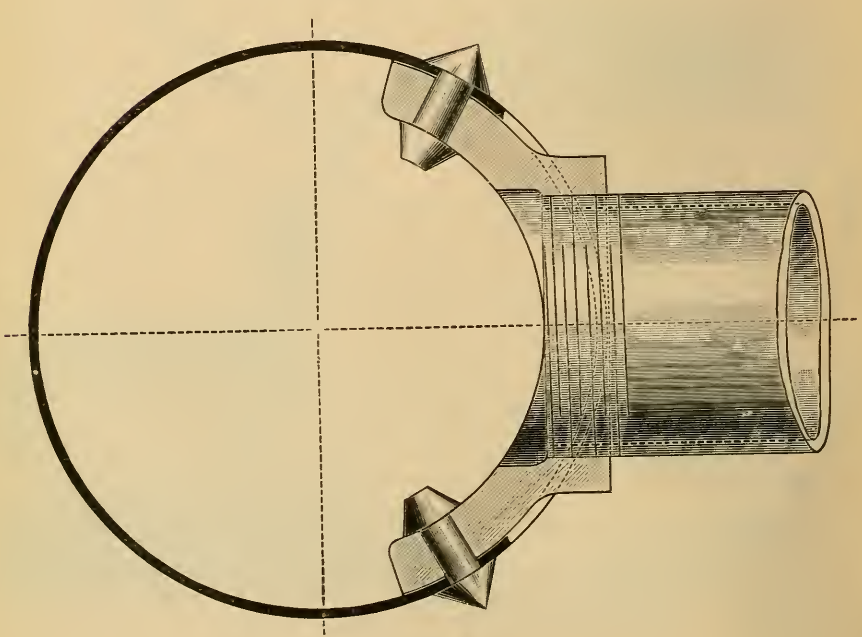

FIG. 6.

it is shown in Fig. 5. A "shim" or caulking piece of wrought iron is put between the pipe and the base of the nozzle, and the rivets extend through pipe, shim, and flange of nozzle, and are driven from the outside. The joint is then made tight by caulking the edge of the shim. As the rivets are driven from the outside against the rigid cast iron flange, it is impossible to bring the flange and pipe into close contact, and very hard caulking is resorted to. Even this generally fails to make a permanently good job, leakage is apt to set in soon, and is difficult to stop. Fig. 3 shows a much better way to do this job. A patch is first riveted to the nozzles, and caulked at "A." This is then riveted to the pipe and caulked at "B." By this means a permanently tight piece of work is secured.

But a better way still to do this work, would be to use a mild cast steel nozzle as shown in Fig. 4. The rivets can then be driven from the outside, the edge of the flange brought down closely to the pipe, and caulked at "A" in the usual manner. This form of nozzle would leave nothing to be desired. We believe that steel castings can easily be obtained at the present time possessing the requisite qualities for a nozzle of this kind.

Fig. 6 shows the best method of making the nozzle attachment to drums of large size, either riveted up or made of welded pipe, when the branch pipe is taken out on the center, although for some reason or other it is seldom used. The cast iron screwed nozzle is simply riveted to the inside, which allows the rivets to be driven from the outside, the iron of the drum is brought closely down to the flange of the nozzle, and the caulking edge is outside, in short a *good job* is *easily* made, whereas, if the nozzle is put on the outside of the drum a *botch job* is made at much *greater cost.* Of course if the drum is large enough to admit men inside to drive rivets, and do efficient caulking, as good a job can be made in one case as in the other, but such large drums cannot be advised. They are useless and expensive appendages.

Inspector's Reports.

December, 1887.

In the month of December, 1887, our inspectors made 3,989 inspection trips, visited 7,890 boilers, inspected 2,955 both internally and externally, subjected 402 to hydrostatic pressure. The whole number of defects reported reached 8,773, of which 1,292 were considered dangerous; 58 boilers were regarded unsafe for further use. The defects in detail were as follows:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	447	20
Cases of incrustation and scale,	751	34
Cases of internal grooving,	73	14
Cases of internal corrosion,	246	25
Cases of external corrosion,	484	31
Broken and loose braces and stays,	279	66
Settings defective,	167	22
Furnaces out of shape,	284	13
Fractured plates,	253	57
Burned plates,	146	26
Blistered plates,	371	17
Cases of defective riveting,	2,825	407
Defective heads,	28	15
Serious leakage around tube ends,	1,315	351
Serious leakage at seams,	503	52
Defective water-gauges,	99	24
Defective blow-offs,	65	19

Nature of Defects.	Whole Number.	Dangerous.
Cases of deficiency of water,	25	9
Safety-valves overloaded,	49	17
Safety-valves defective in construction,	36	17
Pressure-gauges defective,	251	48
Boilers without pressure-gauges,	6	0
Defective tubes,	49	0
Defective hangers,	12	0
Defective man-hole plate,	1	1
Defective fusible plugs,	3	2
Defective re-enforcing rings,	4	4
Defective dome,	1	1
Total,	8,773	1,292

SUMMARY OF INSPECTORS' REPORTS FOR THE YEAR 1887.

We present herewith a summary of the work done by the inspectors during the year past, and for the purpose of ready comparison, the summary for the preceding year.

	1886.	1887.
Visits of inspection made,	39,777	46,761
Total number of boilers inspected,	77,275	89,994
" " " " " internally,	30,868	36,166
" " " " tested by hydrostatic pressure,	5,252	5,741
" " " defects reported,	71,983	99,642
" " " dangerous defects reported,	9,960	11,522
" " " boilers condemned,	509	622

The following is the detailed analysis of defects reported during the year 1887:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	5,566	452
Cases of incrustation and scale,	8,365	452
Cases of internal grooving,	417	103
Cases of internal corrosion,	2,410	245
Cases of external corrosion,	4,212	420
Broken and loose braces and stays,	3,797	535
Settings defective,	2,051	225
Furnaces out of shape,	2,744	151
Fractured plates,	2,228	709
Burned plates,	1,505	345
Blistered plates,	3,106	188
Cases of defective riveting,	35,215	2,529
Defective heads,	544	195
Serious leakage around tube ends,	13,179	3,201
Serious leakage at seams,	7,633	541
Defective water-gauges,	1,225	258
Defective blow-offs,	573	113
Cases of deficiency of water,	164	73
Safety-valves overloaded,	433	139
Safety-valves defective in construction,	423	146
Pressure-gauges defective,	3,048	409
Boilers without pressure-gauges,	93	9
Miscellaneous defects,	711	84
Total,	99,642	11,522

Grand Total of the Inspectors' Work since the Company began Business, to January 1, 1888.

Visits of inspection made,	398,779
Whole number of boilers inspected,	799,582
Complete internal inspection,	290,107
Boilers tested by hydrostatic pressure,	57,960
Total number of defects discovered,	522,573
" " " dangerous defects,	93,022
" " " boilers condemned,	5,296

Errata. — In making our summary of Inspectors' Reports for 1887, the following errata were noted: —

Page 52, for 6,555 defects total, read 6,655.
Page 69, for 818 leaky seams, read 819.
Page 69, for 178 dangerous leaky tubes, read 177.
Page 85, for 125 dangerous leaky tubes, read 425.

Boiler Explosions.

December, 1887.

Agricultural Boiler (183). — A boiler used by Graham & Conley on their stock farm near Lexington, Ky., exploded December 1st, seriously injuring Mr. J. J. Conley, one of the proprietors of the farm, scalding him badly from his hips down, and slightly on face and neck. The employees had just left the engine-house, thus avoiding a serious catastrophe.

Locomotive (184). — The boiler of freight engine No. 253 of the Philadelphia & Reading Railroad exploded at Haak's Switch, eight miles west of Tamaqua, Pa., December 2d. At the time the explosion occurred, five of the crew of six men were on the engine, having gone there to get warm. Three of them were instantly killed, and the other two were so badly injured that it is hardly possible that they can recover. Their names are Alexander Walker, engineer, killed; Albert Guldner, brakeman, killed; Wallace Ettinger, brakeman, killed; Joseph Reifsnyder, fireman, seriously injured about the head and internally; David Pfleger, conductor, badly scalded and shoulder broken. The force of the explosion was terrific. The body of Guldner was found in the woods, a distance of eighty-five yards from the engine. The body had struck a tree, which crushed in the entire back of the head. The man was undoubtedly dead, however, before that blow came, for other injuries necessarily fatal were found on the body. All of the bodies and injured men were found at from twenty to fifty yards from the wreck. The engine itself was a complete wreck, and resembled more a pile of scrap-iron than a locomotive. Guldner and Walker were both married and leave large families. Ettinger was only twenty years of age, and had been on the railroad but a short time. The injured men are both married. No one can offer a satisfactory explanation of the cause of the explosion. No. 253 was an old camel-back engine remodeled, and was at the time of the explosion pushing along a train of empty oil cars. It is said the engine was in extremely bad repair.

Marble Works (185). — Some defect in the boiler used in M. H. Master's large marble works, Shenandoah, Pa., caused its explosion December 2d. The building wherein it stood was entirely demolished and caught fire, but the flames were soon conquered. The men fortunately had not returned from their noon meal, and no one was hurt. Mrs. Mary Bush narrowly escaped death from the boiler head, which was blown over a three-story house, and in falling several hundred feet away tore her dress off her back. The damage amounts to about $1,200.

IRON WORKS (186). — One of a battery of eight boilers exploded at the Hubbard Iron Mill, Hubbard, Ohio, December 5th, wrecking the boiler and terribly scalding Fireman William Siefert, who was buried under the débris. He was extricated with difficulty and removed to his home. His condition is critical. No one else was injured, but if the explosion had occurred one hour later, when the day force was on duty, the loss of life would have been fearful. The accident caused a suspension of work for two weeks.

LOCOMOTIVE (187). — A locomotive standing at St. Ellarton station, on the Inter-Colonial Railway, exploded December 5th, killing William Eastwood, Daniel Robertson, and Alexander Frazer, and seriously injuring Fireman Alexander Murray. The three men killed were riding on the engine on their way to work. The conductor and driver stepped into the telegraph office only two minutes before the explosion, and escaped. The locomotive was wrecked, large sections being thrown a long distance. The station building was badly shattered. The explosion was heard over twenty miles away.

OIL MILL (188). — An eighty-five-horse power boiler in the Hogansville Oil Mill, Troup County, Ga., exploded at an early hour, December 6th, instantly killing three negro employees. The horribly mutilated body of one was blown a distance of 400 feet. The others were disfigured beyond recognition.

SAW-MILL (189). — The boiler of the steam saw-mill owned and operated by Henry, William, and John Harlow, sons of George F. Harlow, president of the Jackson County bank, and situated on their farm, about three miles west of Seymour, Ind., exploded at noon, December 12th, with terrible effect. The boiler was torn to shreds, and the fragments were hurled a long distance. Henry and William Harlow were killed instantly, and David Rose, an employee, had his left arm broken. Henry's head was torn off and his body was horribly mangled. The bodies were thrown a distance of 100 feet. Henry was thirty-seven years of age, and leaves a wife and six children. William was twenty-eight, and leaves a wife and one child. Cause of the accident, an old and defective boiler.

SAW-MILL (190). — The boiler of Lindsay's mill, Mt. Sterling, Ky., exploded December 13th, scattering death and destruction in its path. The mill is located north of the track of the C. & O. Railroad, and about twenty feet east of the Mt. Sterling iron fence foundry and machine shops. The boiler and engine-room of the mill is on the north side of the building, and a little east of the west end. The boiler, weighing about 8,000 pounds, was thrown a distance of 125 yards to the west, and lodged on the bank of Hinkston Creek, on the opposite side of the railroad track. In its course it passed through one corner of the Mt. Sterling iron fence foundry and machine-shops, striking the ties and railing of the railroad, tearing up the one and snapping the other as if they were straws. There were some five or six men in the mill at the time of the explosion. W. D. Stevenson, the sawyer, was standing near the log carriage on the east side of the boiler. He was picked up dead, his neck having been broken by some flying pieces of timber. Ben Lindsay, son of Jos. Lindsay, who was running the engine, was picked up from under the boiler stack, badly scalded and bruised. It is possible he will not recover. One negro was slightly hurt about the head. Stevenson leaves a wife and several children.

ELECTRIC LIGHT STATION (191). — The explosion of an eighty-horse power boiler in the Edison Electric Company's works, Westchester, Pa., December 16th, killed five persons and injured three others. The boiler was carried some thirty feet, passing through the base of a newly erected chimney, ninety feet high, which instantly fell, burying Superintendent Walter Embree and a force of men at work near by. The bodies of Embree and Ellwood Becket, a laborer, were taken out in about an hour. Edward Schofield, a laborer, who was badly scalded by steam from his waist downwards, William Allison, a laborer, and William H. Richardson, the foreman, were found still alive, though more or less injured. Hettie, the ten-year-old daughter of William Jones, who was returning from school, a square distant from the scene of the explosion, was almost instantly killed by a flying beam. Clerk of Courts D. O. Taylor, who was at the works but a few minutes previous to the explosion, was buried beneath the ruins. The bodies of John Bradley and Samuel W. Ebb, a colored laborer, were found during the evening near the demolished stack.

Machine Shop (192). — An explosion occurred at the shops of the Denver, Utah & Pacific Railroad, Denver, Col., December 16th, which shattered the collection of buildings, shops, etc., outside of the boiler-room, carpenter and blacksmith shops, which were entirely destroyed. No one was injured.

Saw-Mill (193).—Just before work was resumed, December 19th, in Winchester saw-mill, Tilton, Ga., the boiler exploded, killing five men and seriously injuring a boy. The names of the dead are: A. Hawkins, colored, Ellison Hembre, Ed. Hogan, William Tennaman, colored, James Walker. At the time of the explosion all the men, having finished their dinner, were sitting in front of the fire doors, warming themselves, and their bodies were frightfully mutilated by the fragments of the boiler. Two were cut entirely in twain, and they were all parboiled by the steam and scalding water.

Steamboat (194).—A small pleasure boat owned by Mr. Edgerton of Little Rock, Ark., was almost totally demolished by an explosion of the boiler, December 19th. The accident occurred about eleven o'clock, near the old skiff landing at the back of the *Press* building. There were four men on board the boat at the time, and all managed to escape with their lives, but the engineer says it was "a close call." How the accident occurred is not definitely known. The engine was a small oil-burner, and it is thought that gas generated in the boiler, which caused the explosion. The whole top of the boat and the entire engine-room were blown into flinders, and in fact there was not enough left to merit the name of boat. The men say that if the explosion had occurred five minutes before, not a mother's son would have been left alive to tell the story. The explosion was heard over the entire city. Though small, the boat was a very elegant one, and was valued at something over $1,000.

Saw-Mill (195). — A terrific boiler explosion occurred at Palestine, Ill., December 21st, completely wrecking the creamery and saw-mill. The boiler shot through Jacob Gross's house, demolishing it, and tearing the heads off two horses. The cause of the explosion is unknown. The damage will probably amount to about $5,000.

—— Mill (196). — A boiler explosion occurred December 22d, in Delhi township, Ohio, a few miles from Cincinnati, in which four persons were killed and five injured.

Portable (197). — The tube-head of an upright steam boiler blew out December 30th, at Eighty-eighth Street and First Avenue, New York, and Talmadge B. Hedges, the engineer, was severely scalded. Bouer & Coomber, contractors, are drilling rock at the point indicated, and use the boiler in their work. Late in the forenoon the upper tube-head went up with a loud report. The smoke-stack was raised 100 feet, and Hedges was knocked senseless. The hot steam scalded his face and hands, and at the Presbyterian Hospital the doctors say he inhaled some of it. He is fifty years old, and lives at No. 1225 Second Avenue. The boiler is seven feet high and forty-two inches in diameter. It was licensed by the Police Department to carry 100 pounds to the square inch, and when inspected last October was in good condition.

——— (198). — Richard Young, a youthful colored lad who works for Samuel Elenger, at 221 North Broadway, Baltimore, Md., started a fire in the range of his employer's house about 10.30 o'clock, December 30th. No sooner had he done so than the hot-water boiler communicating with the range exploded, doing damage to the extent of thirty-five dollars. No one was hurt.

Summary of Boiler Explosions for the Year 1887.

Our usual summary and classified list of Boiler Explosions is given below. The total number of explosions, so far as we have been enabled to learn, was 198, in many cases more than one boiler exploded, but it is reported as one explosion.

The number of persons instantly killed, or so badly injured that they died within a very short time after the accident, was 264; the number injured, many of whom were stated by the reports to be fatally injured, was 388, or a grand total of 652 persons killed and badly hurt. This is a showing of which the people of the country at large are not, in all probability, at all proud. The figures in detail are given in the accompanying table.

Classified List of Boiler Explosions in the Year 1887.

	CLASS OF BOILER.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total per Class.
1	Saw-mills and other Wood-working Establishments, ...	7	4	6	6	8	6	2	3	5	9	13	4	73
2	Locomotives, ...	1	2	1	..	2	1	1	..	1	1	2	2	14
3	Steamships, Tugs, and other Steam Vessels, ...	2	..	..	2	3	.	..	1	1	4	..	1	14
4	Portable Boilers, Hoisters, and Agricultural Engines, ...	2	..	..	..	1	3	5	2	1	1	3	2	20
5	Mines, Oil Wells, Collieries, ...	3	3	..	1	1	2	1	1	..	..	..	1	13
6	Paper Mills, Bleacheries, Digesters, etc., ...	2	1	..	1	1	..	..	..	..	..	..	..	5
7	Rolling Mills and Iron Works, ...	3	1	..	1	..	..	1	2	1	2	2	2	15
8	Distilleries, Breweries, Dye-Works, Sugar Houses, and Rendering Works,	1	..	1	1	..	1	2	.	1	..	2	..	9
9	Flour Mills and Grain Elevators, ...	2	..	..	2	1	..	..	.	1	1	..	..	7
10	Textile Manufactories, ...	..	..	.	.	1	..	..	.	..	.	..	..	1
11	Miscellaneous, ...	3	1	..	3	..	1	2	1	3	3	6	4	27
	Total per month, ...	26	12	8	17	18	14	14	10	14	21	28	16	198
	Persons killed, total, 264, " " "	27	6	7	14	25	15	15	7	11	71	40	26	
	Persons injured, total, 388, " " "	31	17	23	43	39	41	20	19	19	65	53	18	

Nearly 37 per cent. of the whole number of explosions were, as usual, furnished by the lively saw-mill boiler. Portable boilers, hoisters, agricultural boilers come next, but their number was but little more than one-fourth of those occurring in saw-mills. Rolling-mills come next with fifteen, while locomotives and steam-vessels are tied for fourth place. The other classes furnish about the usual number of explosions.

The explosions of the past year do not appear to have been more than usually destructive, or to have killed or injured more than the usual number of people. The whole number reported killed foots up 264, against 254 in 1886, while the injured are 388 compared with 314 the previous year, the increase being in about the same ratio that the number of explosions reported have increased.

The Locomotive.

HARTFORD, FEBRUARY, 1888.

J. M. Allen, *Editor.* H. F. Smith, *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.

So many reasons have been given by various authorities for boiler explosions, among which may be mentioned electricity, the generation of mysterious gases, the decomposition of mysterious gases, the operations of ignorant engineers, water in the spheroidal condition and out of it, sudden evolution of great pressure under impossible conditions, etc., that it may not be out of place to mention a few reasons for the explosion of boilers, that are so plain, and bring the result about in such a natural and matter-of-fact way that they may be perfectly well understood by those most interested in the matter.

First, it by no means follows, as a matter of course, that explosions are impossible when competent engineers are in charge of steam plants. "Accidents will happen in the best regulated families," and explosions will occur occasionally where the best men obtainable are in charge of boilers, though of course the liability of their occurrence is very greatly diminished the more intelligent the engineer. For the boilers under his care may be radically defective in design and construction, or he may be obliged to practice, through circumstances over which he has no control, many things which he knows are vitally wrong and are liable to result sooner or later in disastrous consequences.

For instance, the feed-pipe may be so arranged that cold feed-water (and it should be remembered that perfect heaters deliver water which is *relatively* cold to boilers working at high pressures) is thrown directly on to the hottest portion of the boiler-shell, thus inviting disaster sooner or later, and no representations he can make are sufficient to effect a change. Sometimes the sheet may crack in such a manner that an explosion results, — whose fault is it if it does?

Again, a boiler may be insufficiently braced. The purchaser tries to get, and probably pays the price of, a first-class article. Let us suppose for instance that it is a seventy-two inch boiler of the usual proportions. Some one, and probably it is some one who has a direct interest in the amount of money made on the job, "guesses" that five or six braces on each head above the tubes are sufficient, and it is set at work with the above number. Now, if, after this boiler has been at work two or three years, business increases so that it is necessary to carry a pressure of 110 to 120 lbs. per square inch, and force the boiler to its utmost capacity, and the boiler explodes by simply blowing out that portion of the heads above the tubes, is there any good reason for looking up any sort of gas or electric theory to account for the little unpleasantness?

Here is another case from our own experience. A large manufacturing establishment in one of our largest cities had a battery of boilers which had been put in without regard to expense, and they had a really competent man in charge. The battery had a steam drum, the connections between which and the boilers were of ample size, and as there were no stop-valves between boilers and drum, the safety-valves were placed upon the latter. They were insured. Our inspector in making an inspection at one time found men making repairs, and to prevent water from dripping upon them they had stuffed a lot of old overalls or cloth of some description into the steam connection of one of the boilers. The inspector noted it and asked the engineer to have it removed immediately; he was busy but said he would attend to it before the boiler was closed up. The inspector went home and retired for the night, but soon began to be troubled with the idea that perhaps the obstructions had not been removed as he had requested. The idea kept recurring to him with such force that he could not sleep, and between one and two o'clock A. M., he arose, dressed himself, and started for the mill. On arriving there he found the night fireman in a great quandary. The particular boiler referred to would not make steam, although he had fired it hard for a long time. An instant sufficed to show the inspector that there was a very high pressure on the boiler, and the fires were at once drawn. When the boiler had cooled sufficiently to be opened, the obstructions were found forced tightly into the steam-pipe, thus preventing the escape of steam. Of course it could never be settled satisfactorily whether the engineer had ordered the things taken out and the laborers had forgotten to do it, or the engineer had forgotten all about it himself, but it was certain that they remained there and the boiler was filled with water and fired up, and in a short time it would probably have exploded. In this case the inspector's nervousness was all that prevented another mysterious (?) explosion.

THE past year, 1887, has been one of remarkable activity in the iron trade. The amount of iron ore, pig-iron, and steel rails produced was far greater than that of any previous year. The production of iron ore was about 11,000,000 gross tons; that of pig-iron, 6,250,000 gross tons; steel rails, 1,950,000 gross tons. The total amount of iron and steel imported aggregated about 1,800,000 tons. The prospect for the present year is good, although it is not probable that the business of the past year will be equaled.

SOME recent trials of machine guns by foreign governments would seem to indicate that for accuracy and rapidity of fire, as well as for ease and certainty of action, the automatic gun invented by Mr. Hiram S. Maxim of New York, is far superior to anything else.

The Swiss committee on machine guns made a trial in May last of the Maxim and another well-known machine gun. The Maxim gun operated by one man fired 334 rounds in 34 seconds without the least sort of a hitch. The competing gun jammed at the fifteenth round, and fifteen minutes were necessary to get it in working order again. 300 rounds were fired in sixty-one seconds actual operating time, and four men were required to operate it.

Another set of trials were made in Italy. Two well-known guns were to compete against the Maxim gun. One of them failed to operate. The other, a five barreled Nordenfelt, weighed more than twice as much as the Maxim, and required three men to operate it.

In testing them for rapidity of fire three men succeeded in firing the Nordenfelt gun 200 rounds in twenty-five seconds, while one man fired the Maxim 400 rounds in forty seconds. In the trials for long continued firing it was necessary to stop the Nordenfelt to let it cool off, while the Maxim fired continuously as long as was required.

In testing them for accuracy it was found that at all distances the Maxim gun made a much better target than any other machine gun. The best of the competing guns when fired at a large target at a distance of about one mile, never made a record better than 19 per cent. of hits, while the Maxim scored from 72 to 75 per cent. at the same distance.

The Mechanical Equivalent of Heat.

It is now more than forty years since the work which is the equivalent of a given amount of heat was determined by Joule of England. The results of those experiments were by no means uniform, but Joule, after a long series of experiments, and a patient and laborious discussion of the results, in which he seemed to give more weight to the smaller than to the larger values, finally concluded that the heat energy necessary to raise a temperature of one pound of water one degree Fahrenheit above the melting point of ice was equivalent to 772 foot-pounds of work. This value has been universally adopted by the scientific world, although more recently it has been admitted that that number is too small.

In 1876 a committee of the British Association for the Advancement of Science reported to that body that the mean 60 of the best of Joule's experiments gave 774.1 foot-pounds, but this number has not yet been used, at least to any extent.

Still more recently, about 1880, Professor Rowland made a critical examination of the specific heat of water from about 40° F. to above 90° F., determining the value for each degree and the corresponding value of the mechanical equivalent.

The investigation included the comparison of the air thermometer with the best mercurial thermometer, and a comparison of mercurial thermometers used with the one used by Joule. The results of these experiments were published in the proceedings of the American Academy of Arts and Science, 1880. It is observed that when Joule's experiments are reduced to Rowland's thermometer and for the latitude of Baltimore, they agree almost exactly with those of the latter, the latter being about $\frac{1}{1000}$ of the mechanical equivalent larger.

But the interesting and unexpected discovery was made that the specific heat of water was greater at 40° than at 80°, and that it appeared to be a minimum near the latter point. This was contrary to the law given by Regnault's experiments, for according to the latter, the specific heat of water increases from the melting point of ice as the temperature increases, and as this law was used by Joule in reducing the equivalent from 60°, the temperature near which his experiments were made, to its value at the temperature of ice-cold water, the resultant value would be somewhat less than the value found by direct experiment. The same remark applies to the value given by the committee of the British Association; hence, not only is 772 too small, but 774.1 is also too small.

There are physical reasons for not using the melting point of ice from which to measure the degree of rise of temperature. It is a critical point, and the water at that point may be absorbing heat preparatory to a change of state of aggregation. The condition of maximum density is a much more desirable point of reference. Water under the pressure of one atmosphere has a maximum density at 4° Centigrade, or 39.2° F. Omitting decimals, Rowland's investigations gave 778 as the mechanical equivalent of heat at 39.2° F., according to the mercurial thermometer, and 783 according to the air thermometer. In my recent work on thermodynamics I have used 778, not merely because that was one of the values found by Rowland, but because it agrees fairly well with the result found by other means, and also because we may, when using that number, consider the specific heat of water as constant without much error; whereas if 783 were used, the variable specific heat ought to be taken into account. We also notice that Rowland found 778.4 for the equivalent at the latitude of Baltimore for the air thermometer when the temperature of the water was 60.8° F.

We are confident that the old number, 772, will sooner or later be abandoned and a larger value used, because nearer correct; but it remains to be seen whether 778 will be adopted. It is apparent that for accurate scientific work the value used should be one determined in reference to the air thermometer, and for a particular degree of the scale. and all departures from uniformity — such as a variable specific heat — be determined.— *Prof. De Volson Wood, in R. R. & Engineering Journal.*

Brotherhood of Locomotive Engineers.

At the annual convention in Chicago, October 26th, the opening address of Grand Chief Engineer P. M. Arthur, presented the following facts concerning the Brotherhood:

"A mighty army of men, representing 365 divisions, has gathered about a nucleus of 12 men, who, 24 years ago, assembled in the city of Detroit and started an organization destined to be more than they knew or dreamed.

"To-day we number 25,000 men, and, while our numbers are great, we would not have you consider only the quantity, but the quality as well. To be a Brotherhood man, four things are required, namely, sobriety, truth, justice, and morality. This is our motto, and upon this precept have we based our practice. At last year's convention we deemed it best to slightly change our plan of insurance, so as to bring it within the reach of all. We now claim to have at once the cheapest and the best, the most satisfactory, insurance in existence. We have paid out during the fiscal year just closed, to widows and orphans, $259,500, making a total of $2,244,669 that we have paid since the organization was established in December, 1867.

"At the close of the last fiscal year we had 4,444 members. Died during the year, 77; disabled, 11; forfeited, 183; and had on September 1st last, 6,287, showing a net gain of 1,843. Our *Journal's* circulation has now reached 22,000, from which we derive a revenue of $8,922 per year. During the year our Chief Executive has traveled over 50,000 miles of territory, adjusting grievances and attending union meetings.

"Taking all things into consideration, our relations — both to ourselves and with various railroads employing Brotherhood men — are amicable. When we consider the dissatisfaction which is everywhere manifested about us (almost can we feel it in the air which surrounds us) our few troubles pale into insignificance."

A PALACE STREET-CAR.— The Gilbert Car Manufacturing Company has nearly completed a street car for Dom Pedro of Brazil, which is to be the most expensive car of that description ever built. The body of the car is of paneled mahogany inside and out, and all metal work showing is gold plated. The car is about the size of an ordinary street car, and has four windows on each side, the glass being very heavy French plate. The windows have curtains of brocatel inlaid with cloth-of-gold. The roof is surmounted by a dome which is of jeweled glass, furnished by Tiffany of New York. The furniture of the inside consists of two divans upholstered with cloth-of-gold, and four large armchairs of rattan gilt, and provided with curtains of silk plush. The wooden panels inside are covered handsomely, the crown of Brazil being a prominent feature. The floor is covered with the finest Wilton carpet, and all the accessories are of the finest kind, even the water-cooler being gold-plated. This car is probably the finest specimen of work of the kind ever turned out.

EVERY one, says the *American Architect*, has seen some of the wide planks of red wood which occasionally appear in the Eastern markets, but few persons outside of California know the gigantic dimensions in which redwood lumber may easily be obtained from mills which possess machinery capable of sawing it. We remember seeing once a solid redwood plank five feet wide, which was the admiration of the building portion of the town for a time; but, according to the California *Architect*, this was small compared with some to be had in the vicinity of the redwood forests. Not long ago the managers of a State fair in California sent circulars to the saw-mills, inviting exhibits of redwood planks. In response to this a certain mill sent a "good-sized" plank, which measured six feet in width. Hearing of this, the proprietors of another mill worked up some planks eighty inches wide, and sent samples for exhibition; and soon after a third establishment, the McKay mill, forwarded a lot of perfectly clear, sound planks and boards, varying in width from ten to eleven feet. If there were any special demand for such enormous pieces of this unrivaled timber, they would be more frequently seen, but the wood construction of the world has for a thousand years been based on the assumption that sawed sticks measuring more than twelve inches in breadth or depth of section would be costly, and difficult to obtain; and a new system must be made to suit the materials of the Pacific Coast, or the redwood logs will continue to be sub-divided into pieces approaching in size the Eastern lumber. On the other side of the water, the standard of size for framing timber is still smaller than with us. If we are not mistaken, few mediæval cathedrals on the Continent contain a stick larger than eight inches square in cross-section, and although English timber was of larger dimensions a thousand years ago, there would be little difference now.

Excavation by Dynamite.— *Le Genie Civil* gives an interesting account of the use of dynamite for sinking holes in wet ground for foundations. It has been successfully used in building the fortifications around the city of Lyons. The foundations for the walls were to be built in an alluvial soil, constantly inundated by the River Rhone, and composed of shifting sand. It was necessary to sink two meters to find good ground on which to build. Eight cartridges of dynamite, containing each 100 grammes, were exploded together, resulting in a hole 1.10 meters diameter. In this a metal cylinder was sunk, the hole then cleared out, the concrete filled in, and the cylinder withdrawn.

Three points are especially interesting in this matter.

1. The explosion makes a hole shaped like the frustum of a cone, 1.00 to 1.20 meters in diameter, with a depth equal to 75 per cent. of that required, on account of the earth falling in.

2. The explosion compresses the surrounding earth to such a degree that the walls of the hole remain vertical long enough to clean out the hole and put in the concrete.

3. The water is driven back so far that it does not begin to again filter through the walls for half an hour.

This operation was so expeditious that in a single day of 10 hours, 5 holes 2 meters deep were sunk, cleaned out and concreted, and the work of laying foundations on them was begun. The foundation was 24 meters long.

Finding a Lost Car.— A very singular loss and recovery occurred recently on the Union Pacific, near Laramie. A special freight, running passenger time, broke in two on the hill, and the front section ran around a sharp curve so fast that it whipped off the rear car, filled with choice Chinese silks, into the gulch, where it disappeared from sight in the heavy brush. The break was so clean that the two sections were coupled without the single car's absence being noticed. For two months that car lay there, while the entire road was being searched far and near for it. The other day a cowboy rode into a small station on the line and casually asked when they were going to clear up that wreck down in the gulch. The agent knew of no wreck, and thought the cowboy was fooling with him, but at last, convinced he was in earnest, went with him to the spot. There, at the bottom of a very deep fill, behind a huge pile of boulders and a mass of sage brush, lay the missing car, No. 99. It was resting on its side, and strange enough, the trucks were in proper place. The doors were sealed, and there was nothing beyond a few bruises and dents in the roof and sides to show that there had been any rough treatment experienced.— *Omaha Republican.*

Railroad Accidents in Switzerland.— The Swiss railroad companies report for the year 1886, on 1,734 miles of railroad, 59 train accidents, 42 being derailments and 17 collisions. Of these collisions, 10 were caused by misplaced switches or mistakes in signaling. Six derailments resulted from defects of rolling stock, and 11 from misplaced or defective switches. The report shows an improvement over 1885, when there were 23 collisions and 63 derailments.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

New Series—Vol. IX. HARTFORD, CONN., MARCH, 1888. No. 3.

Eccentric Steam Fittings.

The application of the eccentric principle to the main steam-pipe connections, described in our last issue, can be extended with advantage to couplings for long lines

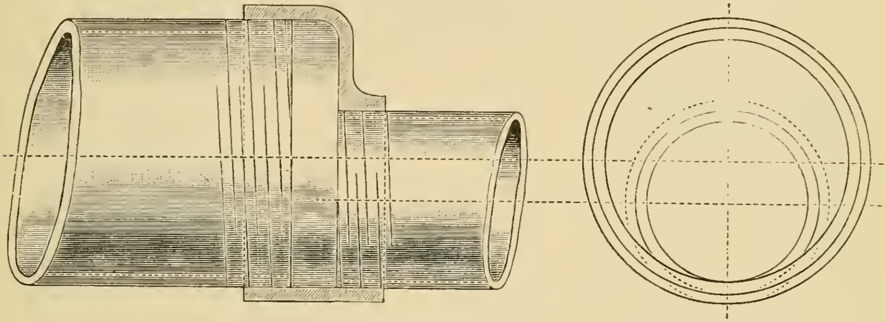

Fig. 1.

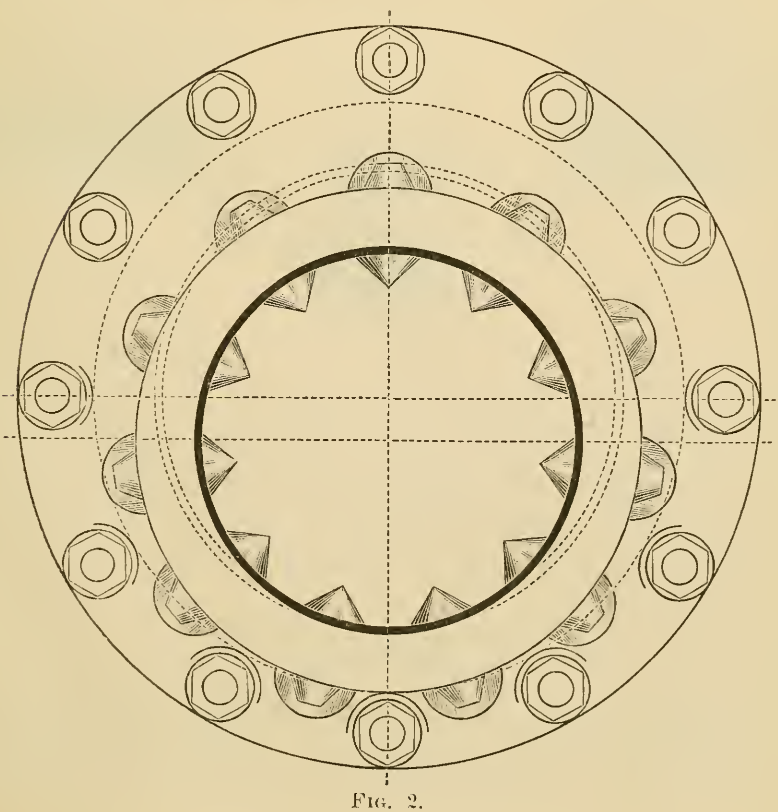

Fig. 2.

of pipe, and with especial advantage to fittings used in steam-heating systems. With the ordinary style of couplings, when the size of a steam main is reduced, it is necessary to put in a relief or drip pipe, sometimes at considerable expense and trouble, whereas if an eccentric reducing coupling were used, which would cost no more than one of the ordinary kind, the water of condensation would flow freely onward.

Figure 1 shows in section a form of reducing coupling which could be used with advantage on all sizes of pipe up to eight or ten inches in diameter. Figures 2 and 3, end and side views, of flange coupling for the larger sizes of pipe. The construction

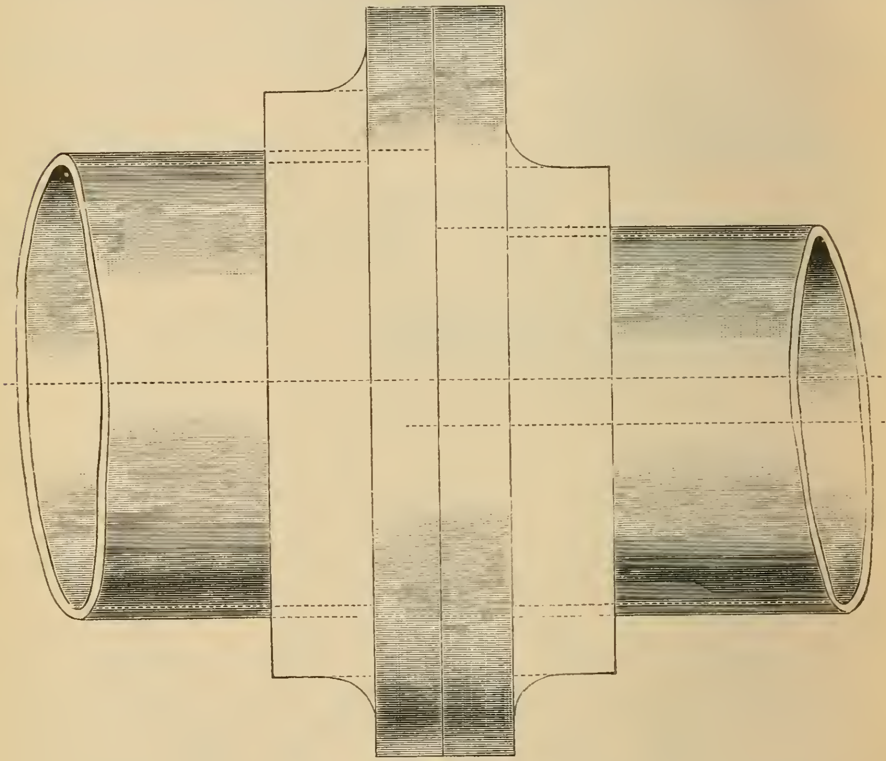

FIG. 3.

will be readily understood from an inspection of the cuts. The offset is just sufficient to bring the under sides of the pipes on the same level.

It will probably be urged as an objection to this style of fitting that they are not made and kept in stock by manufacturers of pipe fittings. This objection will vanish as soon as there is any *demand* for them. They will be found of far more use, and would probably be used a hundred times at least where a cross-valve is used once, still the latter is a standard fitting because it is occasionally called for.

Inspector's Reports.

JANUARY, 1888.

In the month of January, 1888, our inspectors made 4,080 inspection trips, visited 8,125 boilers, inspected 2,810 both internally and externally, subjected 410 to hydrostatic pressure. The whole number of defects reported reached 8,515, of which 1233 were considered dangerous; 34 boilers were regarded unsafe for further use. The defects in detail were as follows:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	550	48
Cases of incrustation and scale,	796	32
Cases of internal grooving,	39	7
Cases of internal corrosion,	293	26
Cases of external corrosion,	604	31
Broken and loose braces and stays,	208	38
Settings defective,	160	14
Furnaces out of shape,	200	15
Fractured plates,	239	75
Burned plates,	161	26
Blistered plates,	322	14
Cases of defective riveting,	2,322	184
Defective heads,	56	20
Serious leakage around tube ends,	1,600	537
Serious leakage at seams,	484	54
Defective water-gauges,	72	15
Defective blow-offs,	42	13
Cases of deficiency of water,	22	6
Safety-valves overloaded,	41	14
Safety-valves defective in construction,	49	22
Pressure-gauges defective,	206	27
Boilers without pressure-gauges,	2	2
Unclassified defects,	47	13
Total,	8,515	1,233

Caulking is something that is not always done as it should be. In fact, in some sections of the country it is done as it *shouldn't* be, about as emphatically as it is possible to do anything. The thing most particularly referred to in this connection, and the practice of which should bankrupt any boiler-maker, is known as "split caulking." It is, so far as the records show, an invention of the devil, and is kept alive by slouchy workmen who don't care whether work is done properly or not, so long as they get their pay for doing it.

To do caulking in the best manner, and as it should be done, the edges of the plates should be planed. They are planed in all first-class shops, and trouble caused by bad caulking is something very rare with such work. But of course this refers to new work. Repair jobs, and boiler work turned out of the shops in remote sections of the country where planers are unknown, afford the demon of split caulking a chance to get in his most effective work. He rarely neglects a chance that is offered him.

Some one may inquire, what is split caulking? To which we would reply, split caulking consists in driving a thin caulking tool, scarcely one-sixteenth of an inch thick, against the edge of a sheet so that a thin section of the plate is driven in between the two plates, with the idea of making a joint tight. The result generally is that the plates are separated from the edge of the lap back to the line of rivets, sometimes as much as one thirty-second of an inch, the only bearing surface outside of the rivets being the portion split off from the plate and driven in by the caulking tool. This bearing surface *may* be an eighth of an inch wide, but it is apt to be much less, and no patent medicine yet discovered will keep the seam tight for any length of time.

When a boiler thus caulked gets to leaking so badly that it can't be run, the boiler-maker is sent for, and he usually proceeds to do more split caulking, and in a short time the boiler leaks worse than ever.

In one instance one of our inspectors examined a boiler and found one of the girth seams leaking badly. It had repeatedly been caulked in the above manner; so many times, in fact, had the process been repeated, that there was not enough of the lap left to perform another operation on. He therefore gave instructions for putting on a patch, with a special caution to the owner, to whom he explained the cause of the trouble, to allow no split caulking to be done on it. On his next visit he examined the patch, and he declares that the boiler-maker had put in on it the worst job of split caulking he ever saw in his life. It is necessary to stand over some men with a shot-gun to get work done properly.

Boiler Explosions.

January, 1888.

Saw-Mill (1).— The boiler in Burnham's mill, in Cassadaga, N. Y., a small village twelve miles from Dunkirk, exploded Jan. 4th. The mill was leveled to the ground, and a large amount of property in the vicinity was damaged. George Burnham, fireman, was found about three rods from the mill, covered with the débris. He was badly cut and bruised, both legs were broken, and he cannot live. Herman Burnham, proprietor, was badly hurt about the face and body. Walter Whitney, a mill hand, was thrown a long distance, and badly but not fatally injured. A passer-by, Harrison Gleason, was hit on the head by a portion of the boiler and knocked down. He is badly injured. A large amount of glass and fragile property in houses within a mile of the mill were destroyed. Pieces of the boiler were sent through the air for hundreds of feet, and, falling, crashed through buildings.

Pile-Driver (2). — For some time every pile-driver on Puget Sound has been pressed into service in piling in the tide-flats in Seattle harbor. Among these was the old pile-driver Avalanche, which was brought to the Sound from San Francisco in 1858. About 11.30 o'clock a. m., Jan. 4th, the boiler of the engine on this driver exploded with terrible force, completely demolishing the engine-house and scattering débris in every direction. Seven men, who were on the driver at the time of the explosion, were hurled into the water, but, strange to relate, only three were injured. James Livingston was thrown 400 feet, and was so badly injured that he died that evening. J. G. James, the engineer, was badly scalded, and Henry Niemans, a laborer, was slightly hurt. The cause of the explosion is unknown.

Saw-Mill (3).— A boiler at Worshie & Sons' mills, Jonesboro, N. C., burst Jan. 5th, instantly killing Richard McIver, the colored fireman, and seriously injuring Henry Dark and Peter McIver. The fireman had chained the safety-valve down to prevent a loss of steam and filled the furnace full of pine-knots. He was blown through a house, a distance of seventy-five feet, and his body was torn into fragments. The loss of property is about $2,000.

Rope Factory (4). — The boiler in the building used by Cable & Tucker as a rope factory, on Classon avenue, Brooklyn, N. Y., burst Jan. 5th, and badly scalded the engineer, George Cunningham, and a laborer named Andrew Meeham. Both men were taken to the Catherine Hospital.

Sewer-Pipe Works (5). — The boiler at the sewer-pipe works of Angus Lamond, at Lamond's Station, on the Metropolitan branch of the Baltimore & Ohio Railroad, six miles from Washington, D. C., exploded Jan. 5th, soon after 8 o'clock a. m. Henry Gorham, a colored man about thirty-four years of age, who was the fireman, was in the boiler-room at the time, and was instantly killed. The boiler was a large one, and was thrown straight up by the force of the explosion, and was then propelled forward with great velocity on a nearly straight line about eight feet from the ground. The boiler-house was entirely demolished, and the fireman was found in a tangled mass of brick and wooden beams. The boiler was hurled through the adjoining frame building, used as a drying-house, on about a level with the floor of the second story, ripping and twisting the joists out, and, after traveling about seventy feet, buried itself in a mass of clay. Albert Martin, a white man, was standing in the frame building, and the boiler passed directly over his head. He escaped unharmed, with the exception of some cuts and bruises about the head from the flying pieces of timber. Mr. Lamond was standing just outside the building, and six men were in the second story of the frame addition waiting to go to work. They happened to be on the opposite side of the building from that through which the boiler passed. The loss of life would otherwise have been much greater.

Saw-Mill (6).—At N. F Hollis' saw-mill, about seven miles south of Blue Mound, Macon County, Ill., at 3.20 p. m., January 5th, the boiler exploded with a terrible report, filling the air with flying timbers and pieces of machinery and building, and instantly killing Joseph Henderson, the engineer. His head was literally blown off, or rather torn from the body and his mutilated remains consisted merely of an almost unrecognizable mass. Mr. B. A. Adams was at the mill at the time, and he was lifted bodily by the force of the concussion and carried about forty yards; being considerably bruised, but fortunately avoided being struck by any of the flying debris. Others were hurt and stunned but not seriously injured. The entire mill was rebuilt all new three weeks ago, and the building as well as all the machinery is now a total wreck, parts of the latter being missed entirely. The cause of the calamity (not an accident) was "a lack of water in the boiler."

Rolling Mill (7).—One of a battery of two boilers on furnaces Nos. 13 and 14, located in the north end of the Central rolling-mill, in Brazil, Ind., exploded Jan. 9th, blowing down the north end of the mill. The boiler, which was twenty-six feet long by forty-two inches in diameter, parted, one piece eighteen feet long being hurled projectile-like to the west. It cut through a large brick smoke-stack whose walls were two feet thick, and landed on the furnace-switch, crossing the iron-yard of the blast-furnace, a distance of sixty yards. The smaller piece was hurled in the opposite direction, bringing up against a brick smoke-stack, which it completely demolished. Fortunately many of the employees were at dinner. Matt Mortimer, puddler, was buried under two or three feet of red-hot brick, and his remains were in a horrible condition when exhumed. Wm. E. Williams, puddler, escaped badly scalded and bruised about the head, but may live. The other injured are J. G. Lewis, puddler, struck on the head by a brick; Peter Dolan, puddler, left leg broken and crushed below the knee, also head injured: John E. Tobin, badly scalded; Elias Davis, struck with a missile and scalded; John Kauffman, at work in the blast-furnace, iron-yard, struck on the head with a brick. Tobin has since died.

Machine Shop (8).—At exactly one minute before 7 o'clock a. m., Jan. 9th, the employees of Pettit & Dripps' machine-shop, corner 14th and B streets, Washington, D. C., including about thirty machinists, blacksmiths, apprentices, and laborers, were startled by hearing a loud noise, followed by a crash, as a portion of the building fell in. The noise was caused by the explosion of the boiler, which was a 25-horse-power boiler of the Ellis patent. Several employees were slightly injured, and one or two were badly hurt, but it is not thought that any will die. The building was badly shaken, and almost every pane of glass was broken.

DOMESTIC BOILER (9).— Jan. 9th, at about 7.30 A. M., the hot-water boiler and brick furnace in Mr. Read's kitchen, Washoe, Nev., exploded with tremendous force, demolishing boiler and furnace and hurling pieces of the stove in all directions with terrible effect. The flying pieces struck Mrs. Read, knocked her down and broke her right arm above the elbow, and burned and scalded her lower limbs badly, and almost blew all her clothes off. A daughter of John D. Winters, aged eight years, was passing through the room when the explosion occurred, and received terrible injuries. She received a compound fracture of both bones of the left leg below the knee, with a deep and ugly flesh wound. The left arm received a terrible compound fracture of both bones, about half-way between the wrist and elbow, with a deep ugly gash where the break is. Another piece struck her check and cut a triangular wound clear through to the inside of her mouth; one of her ears was badly burned; also her hands were scalded and burned. The cause of the explosion is believed to be the running of ice-cold water into the boiler of boiling water, which was only partly filled.

FLOURING MILL (10).— The boiler in Miller's flour mill, at Grandville, Ala., exploded Jan. 10th, killing Harry Miller, James Smith, and Thomas Myers. Two others were badly hurt.

LOCOMOTIVE (11).— The boiler of an engine attached to a construction train exploded between Santa Anna and San Juan Capistrano Jan. 10th. The fireman's face was injured considerably by jumping from the engine. Little other damage was done.

SAW-MILL (12).— By the explosion of the boiler of a saw-mill at Rush, Pa., Jan. 16th, two men were killed and three others badly injured.

DOMESTIC BOILER (13).—A stationary boiler in the kitchen of the Garfield-House, Portland, Oregon, exploded Jan. 15th as the boarders, thirty in number, were sitting down to supper. A half-breed Indian girl employed in the kitchen was struck by a piece of the boiler and had her ribs stove in, and was blown toward a window through which she crashed, cutting her face and hands badly. She was taken to a hospital, and may recover. The explosion completely wrecked the kitchen, and so alarmed the boarders in the adjoining room that they ran over the landlady, Mrs. St. Clair, and trampled her severely in their hurry to escape. Mrs. St. Clair's husband dropped dead of heart disease two weeks ago, on the day they took possession of the house. The cause of the explosion was lack of water in the boiler on account of the pipes being frozen.

SOAP-WORKS (14).— A large rendering-tank in the soap-works of the G. A. Shoudy Company, at Rockford, Ill., exploded Jan. 7th with terrific force, the roof of the large building being demolished, besides doing great damage to the works.

MACHINE SHOP (15).— Several men were injured in New Haven, Conn., Jan. 17th, by a boiler explosion in the hardware factory of W. & E. T. Fitch.

LOCOMOTIVE (16).— The boiler of a locomotive on the Chicago, Milwaukee & St. Paul road exploded Jan. 18th. Joe Powell was engineer, and Bob Stewart, fireman. The fireman at the time of the explosion was oiling the machinery at the side of the engine. Pieces went through the depot, but doing no other injury. Bob Stewart was found one hundred yards off in a snow-drift, mangled. Joe Powell jumped from the cab and escaped with slight injuries.

MINE (17).— A boiler used at a coal mine in Staunton, Ill., exploded Jan. 20th. No one was injured, and the damage was slight.

GRAIN ELEVATOR (18).— The boiler at the Novelty elevator, at Santa Fe and Ninth streets, Kansas City, Mo., blew up Jan. 20th. The engine-house was blown into atoms and the boiler was carried across the Missouri Pacific tracks, ripping up the rails as it went, demolishing a box-car and finally striking the end of a sleeping-coach attached to a Wabash train. It was a vicious explosion, but nobody was injured.

——— Mill (19).— Kastner & Gagan's mill and warehouse, Janesville, Wis., was wrecked by the explosion of the steam-boiler Jan. 20th. The concussion shook the city like an earthquake. Nothing was left of the brick building in which the boiler stood but scattered débris, under which were the mangled bodies of Engineer Byron Kennedy and Fireman James Bracken. When recovered what remained of the men was almost an unrecognizable pulp of flesh and bones. The fire was communicated by the explosion to several warehouses adjoining, and raged fiercely. The loss will be over $5,000, with very little insurance. The boiler which caused the disaster had been considered unsafe for a number of years. It was literally torn into fragments, one piece being blown through a brick wall a distance of 500 feet.

Creamery (20).— The boiler of a creamery at Palestine, Ill., exploded Jan. 21st, killing one man and injuring three others.

Tugboat (21).—At 4 o'clock p. m., Jan. 22d, as the tugboat Zouave was about to enter off Fort Hamilton, N. Y., preparatory to towing the ocean steamer Nova Scotia up the bay, the crew were startled by hearing the hissing of escaping steam. Immediately afterward a deafening explosion took place. The boat was soon enveloped in a cloud of steam which continued to escape from a break in the boiler. Four of the crew were frightfully scalded. They were John Parmelee, the engineer; Patrick Healey and John McKinney, deck hands; and Barney Rooney, the steward. A passing tug steamed up to the Zouave after the steam had all escaped, and took the injured men aboard and went to the Marine Hospital, where it was found that all the men were seriously but not dangerously injured.

Saw-Mill (22).— A saw-mill boiler exploded at Coles Creek, Pa., Jan. 23d, killing one man and injuring another one.

——— Mill (23).— At Strassburgh, Ohio, Jan. 23d, an exploding boiler killed two men and severely injured three others.

Elevator Engine (24).— The boiler of the engine that is used to run the elevator at the store of Yale, Bryan & Co., wholesale grocers, New Haven, Conn., exploded Jan. 24th, damaging the goods in the store to a slight extent. Albert M. Ritter, an employee of the firm, was so seriously injured that he was taken in a carriage to his home on Howe street.

Saw-Mill (25).— A boiler exploded in a lumber-mill at Middlesex, Ontario County, N. Y., Jan. 4th, blowing off the head of a young man named Gilbert, and seriously injuring Allison Blanchard and Geo. Brown.

Saw-Mill (26).— The boiler of a saw-mill at Barnesville, Ohio, exploded Jan. 26th, killing two men and fatally injuring four others.

Saw-Mill (27).— Jan. 27th an explosion at Downs Mills, Ga., resulted in the death of two men and severe injuries to another.

Ice-House (28).— The boiler that furnishes steam to the engine at the Knickerbocker Ice Company's house, Marlborough, N. Y., exploded Jan. 27th. William H. Purdy, a field boss, and a laborer named Welch, were scalded by escaping steam.

Towboat (29).— The boiler of a towboat exploded at Marietta, Ohio, Jan. 31st. killing the fireman.

The Locomotive.

HARTFORD, MARCH, 1888.

J. M. ALLEN, *Editor.* H. F. SMITH, *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.*
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THE facts which might be brought out by a well-directed examination of the persons in charge of steam-boilers in some sections of the country would be amusing, were it not for the fact that a steam boiler in charge of a *too* ignorant person is always an element of great danger.

Not long since a boiler exploded in one of our cities, and as such a thing had not occurred in that vicinity for some time, people were somewhat stirred up over the matter, and an examination of the engineers and boilers was of course in order. The following are some of the incidents reported as a result of the examination:

In one place a pile of ashes about four feet high was found banked up against the side of a boiler. The engineer was asked why they were there, and he replied that "the boiler was sweating a little," and that he had put them there to keep the water from coming out of it. The ashes were immediately removed, and four or five holes were found in the boiler through which the water was oozing. The boiler was under a pressure of sixty pounds at the time. Over thirty people were employed in the immediate vicinity of the boiler.

Some ludicrous answers were made by candidates for engineers' licenses. For instance, one candidate when asked the dimensions of the boiler he was running replied, "two and one-half feet high, one foot in diameter, and 120 one and one-half inch tubes in it." It was afterward ascertained that the boiler was forty-eight inches in diameter and eleven feet long. No license was given in this case.

Another applicant averred that the boiler he was running "was twenty-four feet high, eight inches in diameter, and had a three foot square grate under it." This boiler proved to be about ten feet high and forty inches in diameter.

In one place where there was a battery of five boilers the steam-gauges were found indicating all the way from 38 to 100 pounds, when the pressure on the boilers was about eighty pounds. Many other instances of gross ignorance and neglect might be cited, but the above are sufficient to show the alarming state of affairs which prevails in some places.

THE disadvantages under which many good boilers are compelled to labor is well illustrated by the following report of one of our inspectors on a boiler proposed for insurance:

"I found the boiler well constructed, of good material, and well stayed and braced. It was fairly clean inside and free from defects, but some of the attachments I found in a dangerous condition.

"The stem of the safety-valve was bent out of shape so I could not move it or release the valve from its seat until I stripped the connection off and straightened out the stem.

"The three gauge-cocks were completely stopped up. The plugs in them were corroded fast in their seats. The engineer said he had not used them for a long time. I took them all out of the boiler and destroyed them, and recommended new ones with larger openings.

"The waste-cocks of the glass water-gauge (the only water indicator left them), was stopped up and fast, this I disconnected, and recommended the owner, who was present, to have it put in working order before starting the boiler again, which he promised to do, and seemed pleased to have the defects pointed out that he might remedy them before an accident occurred."

To Manufacturers who contemplate putting in the incandescent electric light, on representations that the amount of power required to drive the required dynamo or dynamos is quite insignificant, not worth considering, etc., we would say: go slow. The lights are generally wanted at the precise time of the day and the year when the amount of steam required for other purposes, especially heating, is a maximum, and the power required to furnish them is very considerable. Not more than ten incandescent lights worth having can be furnished continuously for one horse-power at the engine, and some of them require more power than this.

A word as to the illuminating power of the arc lamps now so extensively employed for street-lighting. They are generally supposed to give a light of about 2,000 candle-power; as a matter of fact, 800 candle-power is about the correct figure. It is unnecessary to state here the reasons which lead the electric light companies to make the above claim, as they are all in the same boat, and the lights as furnished now have all the intensity that is desirable, and more than is pleasant to many eyes; we merely wish to call attention to it as an interesting fact.

The current number of the *Journal of the Franklin Institute* contains a very interesting and instructive article by John L. Gill, Jr., on Screw Threads. Mr. Gill recommends for a standard thread one having the resisting side at an angle of 90° to the axis of the bolt, the receding side 45°, the top and bottom flat, the width of the flat part equal to one-half the difference between the pitch and the altitude of the thread.

While the above form of thread is very strong, and excellent for many purposes, especially for presses and similar machines where great power has to be exerted in one direction only, for which the same form was used by the writer many years ago, we believe practical considerations would render its adoption as a standard thread for general purposes not only impossible, but positively undesirable. The ordinary V thread, having its sides at an angle of 60° with each other, is without question a weak form of thread, but it has practical advantages which make it, or some modifications of it, such as the Sellers thread, the most desirable form for ordinary uses that has ever been designed.

Those boiler-makers who have tried the pitches for riveting recommended and urged in The Locomotive during the past six years have, without exception, found that they could do better work for less money than they could when adhering to the old system of two-inches pitch for everything, whether single or double riveted. In some cases, where they have held off for a long time on the score that "all their old racks would be of no use if they changed their pitches," it has been amusing to see how quickly they have been brought to see the benefits of wide pitches when the lesser number of rivets that would have to be driven has been pointed out to them. But such cases as this are rare, and most boiler-makers have adopted these proportions as soon as they were really convinced that they could make tight work, which is no longer a matter for discussion, being now a well-demonstrated fact.

It is claimed that a process has been discovered whereby fuel gas can be manufactured from coal at a cost of but 2 cents per thousand cubic feet. If this is true it would be very pleasant to be connected with the butt end of a pipe from some such gas works when there is a strike on in the Lehigh coal region.

Production of Steel in the United States in 1887.

Complete statistics of the production of steel in the United States during the past year, published by the American Iron and Steel Association, show that the total amount made of all kinds was 3,739,760 net tons, or 3,339,071 gross tons, which exceeds by about 30 per cent. the production of the year 1886, in which year we made more steel than Great Britain. The production in 1886 was 2,870,003 net tons.

Something more than seven-eighths of the total amount of steel produced in 1887 was made by the Bessemer process, being 3,288,357 tons, of which amount 68,679 tons were made by the Clapp-Griffiths process.

The production of Open-Hearth Steel was 360,717 net tons, 47 per cent. more than was made in 1886.

The production of Crucible Steel was 84,421 net tons, and that by various miscellaneous processes, other than the three principal ones noted above, 6,265 net tons against 2,651 net tons in 1886.

The following tabular statements will be found interesting:

Production of Bessemer Steel in 1886 and 1887.

	1886. Net Tons.	1887. Net Tons.
Pennsylvania,	1,507,577	1.752,445
Illinois,	535,602	857,513
Other States,	498,314	678,399
Total,	2,541,493	3,288,357

Production of Open-Hearth Steel in 1886 and 1887.

	1886. Net Tons.	1887. Net Tons.
Pennsylvania,	172,144	270,710
New York, New England, and New Jersey,	23,382	18,442
Other States,	49,724	71,565
Total,	245,250	360,717

Production of Crucible Steel in 1886 and 1887.

	1886. Net Tons	1887. Net Tons.
Pennsylvania,	61,792	65,766
New Jersey,	8,046	7,499
New York,	4,870	5,006
New England,	2,661	2,925
Western States,	2,340	2,371
Southern States,	900	860
Total,	80,609	84,421

Various Useful Notes.

Specific heat of water, ... 1.
" " " air at constant pressure, ...2377

The specific heat of water thus being 4.1733 times greater under ordinary circumstances, than that of air.

The volume of one pound of air at the ordinary atmospheric pressure and a temperature of

0°	Fahr.,	is	11.58	cubic	feet.
32°	"	"	12.39	"	"
62°	"	"	13.14	"	"
70°	"	"	13.34	"	"
80°	"	"	13.59	"	"

A pound of water losing 1 degree of heat, or 1 thermal unit, will raise the temperature of 4.17 pounds, or, at ordinary temperatures, say 50 cubic feet of air, 1 degree.

A pound of steam at atmospheric pressure, having a temperature of 212° Fahr., in condensing to water at 212° Fahr., yields 965.7 thermal units, which if utilized would raise the temperature of $50 \times 965.7 = 48,285$ cubic feet of air one degree, or 690 cubic feet from 0° to 70° Fahr.

In ordinary steam-heating probably not over $7\frac{1}{2}$ pounds of water is converted into steam from the temperature of the return. Thus the combustion of 1 pound of good coal would suffice to raise the temperature of 5,175 cubic feet of air 70°.

The air in a house artificially heated will be what may be called destructively dry unless it is moistened. The proper degree of moisture can easily be indicated by the wet and dry bulb thermometer. At say 70° F., the temperature at which houses are kept in winter, the wet bulb thermometer should indicate from 6 to 8 degrees less than the dry bulb exposed to the same temperature. (See the *Locomotive*, February, 1885.)

In heating water by steam: The number of thermal units available in a pound of steam is 1147. Suppose it is required to bring water to boiling point, 212°, from a temperature of 40°. Then each pound will have added to it $212-40=172$ thermal units, and the quantity which can be utilized in each pound of steam will be $1147-212=935$ thermal units, hence the number of pounds of water to be heated divided by $935 \div 172 = 5.43$ will give the number of pounds of steam required to bring it to a boil. Hence the following general rule:

From 1147 subtract the temperature to which the water is to be raised; set the difference aside for a dividend.

From the temperature to which the water is to be raised subtract the original temperature of the water; set this difference aside for a divisor.

Divide the dividend by the divisor; the quotient will be the number of pounds of water which one pound of steam will heat under the required conditions.

Divide the whole number of pounds of water to be heated by the above quotient; the result will be the number of pounds of steam required to do the work.

For rapid approximate mental calculations allow five pounds of water "brought to a boil," by one pound of steam.

To represent the above operations more briefly, by symbols:

Let a denote the required temperature of the water.
" b " " original " " " "
" c " " number of pounds of water to be heated.
" d " " " " " " steam required.

Then $b = \left(\frac{a-b}{1147-a}\right) \times c.$

Table of Temperatures.

Minimum and mean temperatures of each month, compiled from observations of the Signal Service, U. S. A., and Blodgett's Climatology of the United States.

Note: — In the United States, the comfortable temperature of the air in occupied rooms is generally 70°, when walls have the same temperature.

STATION.	Minimum and mean temperatures of each month.																								No. of mos. fire is required.	Mean temp. of fire mos.	Ave. No. of degrees temp. to be raised.	Max. No. of degrees temp. to be raised.
	Jan.		Feb.		March.		April.		May.		June.		July.		Aug.		Sept.		Oct.		Nov.		Dec.					
	Min.	Mean.	Min.	Mean.	Min.	Mean.	Min.	Mean.	Min.	Mean.	Min.	Mean.	Min.	Mean.	Min.	Mean.	Min.	Mean.	Min.	Mean.	Min.	Mean.	Min.	Mean.				
Albany, N. Y.,	—16	24	—18	25	—4	35	13	47	29	60	40	68	48	72	45	70	33	61	23	49	—10	39	—17	28	7	35	35	87
Baltimore, Md.,	—2	31	3	32	9	39	23	52	34	61	49	71	59	75	52	75	40	67	30	55	16	44	1	34	6	39	31	72
Boston, Mass.,	—3	27	—5	28	2	36	11	46	32	57	44	66	46	72	50	69	35	62	26	51	—2	40	—11	30	7	37	33	81
Buffalo, N. Y.,	—5	28	—13	28	3	30	13	34	29	52	41	64	47	69	46	68	21	65	25	48	2	31	—6	30	8	35	35	83
Burlington, Vt.,	—16	20	—20	20	1	31	10	42	30	55	43	65	47	70	45	68	32	60	22	48	—10	36	—18	24	7	32	38	90
Chicago, Ill.,	—20	24	—13	25	5	32	17	46	27	56	40	63	50	71	52	68	37	60	25	48	0	38	—14	29	7	35	35	90
Charleston, S. C.,	26	52	28	52	28	60	39	68	47	71	60	81	67	79	63	79	57	76	39	64	28	55	23	51	3	52	18	47
Cincinnati, O.,	—7	33	—1	34	13	43	18	54	36	64	49	71	60	76	55	74	41	66	27	53	6	42	—6	34	7	42	28	77
Cleveland, O.,	—13	33	—11	33	0	37	15	39	28	60	42	70	50	72	46	70	38	67	26	51	8	37	—5	37	7	38	32	83
Detroit, Mich.,	—15	27	—20	27	—2	35	8	46	29	56	38	66	50	70	45	67	35	60	22	48	4	38	—9	27	7	35	35	90
Duluth, Minn.,	—38	13	—34	16	—26	24	3	33	26	50	36	58	46	68	45	64	34	59	21	43	—29	24	—30	20	8	28	42	108
Indianapolis, Ind.,	—18	36	—8	36	9	42	19	46	31	66	45	77	54	78	48	76	35	70	25	51	—2	37	—15	37	7	41	29	88
Key West, Fla.,	50	68	55	74	54	76	61	78	63	80	73	83	73	83	73	84	72	75	65	76	52	73	44	71	0	0	0	26
Leavenworth, Kan.,	—20	28	—9	29	2	40	20	49	31	67	37	77	54	83	55	81	37	67	19	57	3	42	—4	32	6	37	33	90
Louisville, Ky.,	—10	37	0	39	16	46	21	49	36	68	49	81	58	81	56	79	42	72	28	54	10	41	—5	39	6	42	28	80
Memphis, Tenn.,	2	45	13	45	18	53	35	55	44	72	55	81	62	83	63	83	44	73	30	56	25	49	3	44	5	39	31	68
Milwaukee, Wis.,	—25	25	—22	29	—3	35	12	41	25	51	40	65	50	70	42	67	32	61	23	51	—14	38	—19	23	8	37	33	95
New Orleans, La.,	26	56	32	59	36	66	48	66	56	76	67	81	70	81	70	84	59	79	40	68	39	61	28	57	0	0	0	44
New York, N. Y.,	—6	30	—1	30	8	38	20	49	34	59	49	68	57	75	53	73	42	66	31	54	7	43	—2	33	7	40	30	76
Philadelphia, Pa.,	—5	32	—1	33	9	42	21	51	36	59	49	69	60	73	55	71	45	64	31	51	8	41	4	33	7	40	30	75
Pittsburgh, Pa.,	—12	29	—10	31	2	39	14	50	27	61	43	69	52	73	49	71	36	64	28	51	8	40	—6	31	7	39	31	82
Portland, Me.,	—7	20	—7	21	1	30	14	40	34	50	42	59	51	66	48	65	37	57	28	46	—6	35	—12	24	8	33	37	82
Portland, Or.,	3	43	24	44	31	45	28	54	36	60	39	60	46	68	43	65	39	61	32	50	27	47	17	37	6	43	27	67
San Francisco, Cal.,	36	49	41	51	41	51	40	55	45	58	48	59	49	59	50	59	50	61	49	59	44	57	39	51	4	53	17	34
St. Louis, Mo.,	—16	33	—3	35	8	44	22	58	32	66	48	74	57	78	55	76	40	69	25	55	11	41	—5	34	5	37	33	86
St. Paul, Minn.,	—30	14	—32	14	—15	24	7	37	24	62	39	69	46	75	43	70	30	61	21	41	24	26	—27	19	7	25	45	102
Washington, D. C.,	—3	34	—2	37	12	45	22	56	33	66	46	74	58	78	50	76	40	68	26	57	16	45	3	37	5	40	30	73
Wilmington, N. C.,	17	50	15	48	22	57	28	63	38	70	53	80	63	79	56	77	50	74	32	61	28	52	15	49	4	50	20	55

The New South.

The industrial map of the United States is undergoing a silent but most astonishing transformation. When the old abolitionists used to tell the apologists of slavery that the death of slave labor would find a new South in the cradle, the assertion was met by an incredulous sneer. Seldom has liberty found so memorable a vindication as in the progress of the South since the war.

During the past five years 8,000 miles of finely-equipped road has been added to the former dilapidated and disconnected railroad system of the South, at a cost of over $300,-000,000. Northern capital and Northern management have entirely regenerated the means and methods of communication, and nearly obliterated the former odious distinctions in passenger service.

Cotton manufacture has made surprising strides. There are at present 327 cotton-mills in operation, with an invested capital of over fifty million dollars. The State of Georgia alone has erected eighty-seven cotton-mills during the past year.

The iron-mills of the South represent a capital of over $45,000,000. The last annual output of iron ore in the State of Alabama was more than 700,000 tons. In that State, as also in Tennessee and Virginia, iron, coal, and limestone are found contiguous, and promise to be developed in inexhaustible quantities in the near future. Everything thus far confirms the belief that the coal deposits of Pennsylvania extend south in an immense unbroken line to Alabama. In the latter State a coal area is found covering 5,300 square miles and containing seven qualities of bituminous coal, each having a distinct excellence for purposes of manufacture. The Southern output of coal for the current year will not fall short of 6,000,000 tons.

The above simply gives an idea of what the South is doing in the line of raw material and staple manufacture. A whole chapter might be added on what she has developed in the direction of diversified mechanical industries and in new fields of agriculture. Taken for all in all, it is the most important and far-reaching drift in the tide of American industrial and commercial life that remains to be recorded in our history. — *The Boston Globe.*

Engineering, says: — "The recent accident to the steam pipe of the steamship *Elbe* lends a special interest to the electrolytic process for the manufacture of copper now being practiced by Mr. W. Elmore at Cockermouth. According to the method, such an article as a steam pipe can be produced without weld or joint, and having a tensile strength from fifty to one hundred per cent. in excess of first-class brazed pipes. Further, this result can be attained with the use of a very inferior quality of copper, and at a cost which will enable the electrolytically made article to compete in the market with the customary varieties. Of course there is nothing new in depositing copper in a tubular form, but hitherto such metal has been too brittle to render it reliable for use in circumstances under which it is exposed to great stress. For copying engraved plates, and for the rollers of calico printing machines, deposited copper has been used with great success, and when it has been thrown down very slowly it has been possible to produce very satisfactory qualities of metal for these purposes. The novelty introduced by Mr. Elmore, however, lies in breaking down the crystals almost immediately they are formed, and pressing them out in a fibrous form in which they are interlaced and matted together. To this end the iron core or mandrel on which the metal is deposited is kept constantly rotating in the bath, and an agate burnisher is slowly wound backwards and forwards lengthwise of the cylinder as if to put a screw thread upon it. The speeds are so arranged that a layer of copper $\frac{7}{1000}$ of an inch thick is deposited between each reciprocation of the burnisher. When the required thickness has been attained the mandrel is lifted out of the bath and placed in a vessel supplied with superheated steam. In a few moments the expansion of the copper detaches it from the iron, and the shell can be stripped off."

Pieces cut from such tubes have been submitted to breaking tests by Messrs. Kirkaldy & Co., Professor Kennedy, and Professor Unwin, and have broken at strains varying from twenty-seven tons to forty-one tons per square inch, with an extension varying from five to seven and one-half per cent. in a length of ten inches. The metal can be very easily worked under the hammer, and can be drawn, bent, or compressed without annealing and without any tendency to crack. Specimens polished and submitted to the microscope show that the electrolytic metal has a perfectly compact and homogenous structure, while drawn copper is a honey-combed mass of crystals, only connected together at points. The success which has attended the experimental stage of Mr. Elmore's process encourages the belief that absolute security from burst copper steam pipes can be secured in the future, and that we are on the eve of being supplied with a greatly improved quality of copper for all purposes.

The Electric Light and Our Eyesight.

Dr. Sous, in our French contemporary, the *Revue Internationale de l'Electricité*, presents an interesting article treating of the injurious effects of electric lights. The injury, he says, is a disease, and as is the case with all diseases of the human body the physician must find the cause before he can hope to effect a cure.

In preceding papers he has admitted that the ultra-violet rays are the cause of all the harm, but other writers hold the intensity responsible, and in this paper he undertakes to prove the fallacy of their views.

They say, "When we compare the injuries to the eye, resulting from the sunlight, and those resulting from the electric light, we are struck with their great similarity: the effects of the sunlight, direct or reflected, are the same on the eyes as those of the electric light."

The author then proceeds to show, by facts alone, the falseness of this statement. He first describes the disease produced by intense sunlight, and then follows this description by the symptoms of the disease from exposure to electric lights. The symptoms of the two cases are entirely different. Hence: "It results, from the comparison of facts, that the sunlight and the electric light do not act upon the eye in the same manner, and that, in consequence, they do not act in virtue of the same principle, or from the same cause."

The holders of this theory of the luminous intensity, however, do not admit the possibility of the theory of the ultra-violet rays, for they say, "An ordinary, polished, transparent glass globe containing a voltaic arc has power to arrest the ultra-violet radiation."

It now remains to refute this statement, and Dr. Sous does this in a very few words. "If glass absorbs the ultra-violet rays we should never have known of them; we could not even have imagined their presence in the spectrum, for in all experiments to prove their presence, and to study their properties, glass is used, and glass lets these rays pass."

The writer then goes on to say, — that which is gratifying to know, — that injury to the eye from the electric light is always of a temporary nature, and that recovery soon follows without other treatment than rest, and protection from further injury.

—*Modern Light and Heat.*

Ancient Microscopes.

Mr. Frank Crisp, vice-president and treasurer of the Linnæan Society, and secretary of the Royal Microscopical Society, gave a lecture at the Royal Institution on February 3d, on "Ancient Microscopes." In the library, on specially-placed stages in the theatre, and on the lecture table, were some six hundred microscopes of early dates, while on the tables of the library were shown many early books containing figures of microscopes. Among the works were those of Robert Hook, 1665, Adams, with a plate of a solar microscope, Pierre Lyonet, with a plate of a dissecting microscope, and a practical work by Adams, a maker, dated 1747. The first reference made by Mr. Crisp in his lecture was to one of the latest productions of Powell and Leland, as a type of our present perfection. Turning from this to the odd shapes of the early works, Mr. Crisp said he meant in his title by the word "ancient" any microscope made earlier than one hundred years ago. We now look for clearness of vision, stability, and absence of all needless adornment. It is interesting to see from what our present work has been evolved. One striking point is that, though we now make only of brass, the "ancients" made of wood, ivory, tortoise-shell, and papier mache. But they also excessively ornamented their microscopes. To illustrate this there was held up an elaborate stand for a really weak microscope made for Cardinal Lambartin, afterwards Pope Benedict XIV, where the silk linings and the large space for the papal insignia made the whole affair ludicrous in the eyes of a man of science. After others belonging to popes and distinguished people had been shown, a strange green-colored one for George III was held up. But, it was remarked, no good recorded work had come from any of these. They were like toys. In tracing stability for a microscope it was shown how long it took to acquire this. Some were placed on the table which a puff of breath blew over. At length there seemed to be acquired stability to such an excess that adjustment was difficult. It appeared to us now strange that it took so long for the right use of a mirror to be understood. The old way of getting a focus was really barbarous. Some drawings of old microscopes were shown on the screen, odd pictures with tubes five feet long, and men standing on hillocks to use them. The explanation was that where an eye was at first used to indicate the point of observation subsequent draughtsmen put in the entire human figure, and so lengthened tubes for artistic effect. On the whole, however, we have to be thankful for what the ancients did, as from their work has come our modern powerful instrument.

—*Iron.*

A Tough Story.—We never saw the equal of the following bit of vivid and intricate mendacity:

Jack Smith's old roan hen has recently developed considerable mercantile ability. The other day Jack heard some notes in the chicken-house, and went down to investigate. In one corner of the yard the roan hen Bettie was standing by a matchbox full of bugs. These she was peddling out to the other fowls, a bug for four grains of corn. The big Dorking rooster, Jim, was standing by to see fair play. The way the count was made was laughable. The purchasing fowl would place a grain of corn by each of Bettie's toes. Bettie would examine it critically, rake it to one side, and then pass out the bug. When Jack got there she had only two bugs left. The corn received would have filled a pint cup.

It comes from the columns of our esteemed contemporary, the Eustis Lake Region, and suggests the thought that an enterprising boy, small in stature but big in enterprise, took charge of things during the editor's temporary absence. —*Jacksonville News-Herald.*

The Locomotive.

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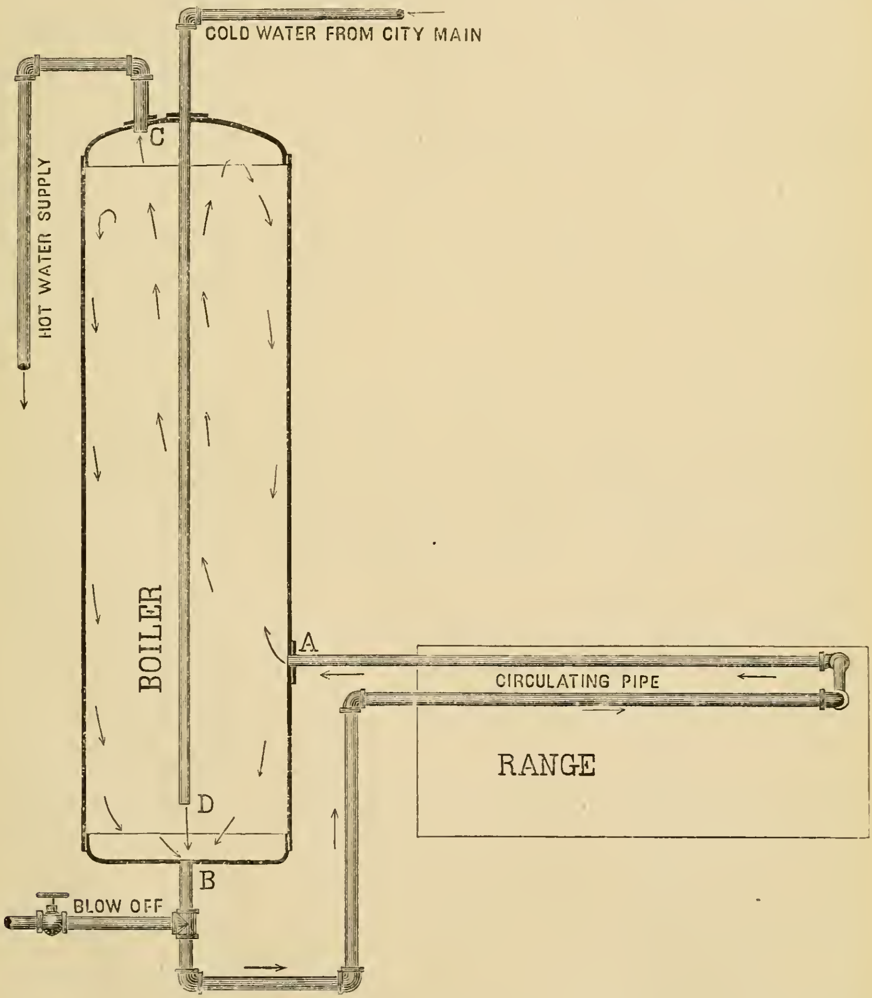
Explosion of a Domestic Hot Water Boiler.

Explosions of domestic hot water boilers attached to cooking ranges, water-backs in ranges, etc., through freezing up of the pipes in cold weather, are becoming so fre-



quent that it may not be out of place to give an account of one of the most destructive ones that has occurred recently, and point out its cause.

The boiler in question was used in a hotel in a large city in one of the northwestern

States, where the temperature is very low at times. It was connected to the kitchen range; the range was a large one, and the heating surface was furnished by a coil of 1½ inch pipe placed near the top, instead of the cast-iron front or back such as is commonly used in the smaller ranges in private dwellings. The connections to the boiler were made in the usual manner; the accompanying cut shows its essential features.

The operation of all boilers of this sort is as follows:

The connections being made as shown in cut, the water is turned on from the main supply and the entire system is filled with water. When it is filled and all outlets are closed, it is evident that no more water can run in, although the boiler is in free connection with and is subjected to the full pressure of the source of supply. When a fire is started in the range, and the water in the circulating pipes or water-back is heated, the water expands, is consequently lighter, and flows out through the pipe into the boiler at A, as this connection is placed higher up than the one at B; this starts the circulation, and the water as it becomes heated constantly flows into the boiler at A, and rises to the upper part of the boiler, while the cooler water at the bottom of the boiler flows out into the circulating pipes at B, and if no water is drawn a slow circulation goes on, as heat is radiated from the boiler, in the direction indicated by the arrows, the water at the top of the boiler always being much hotter than that at the bottom. When the hot water cock is opened, cold water instantly begins to flow into the boiler at D, by reason of the pressure on the city main, and forces hot water out of the boiler at C. Thus it will be seen that hot water cannot be drawn unless the cold water inlet is free, and it is equally evident that cold water cannot enter the boiler unless the hot water cock or some other outlet is open.

The above points being understood we are in a position to investigate the cause of the explosion referred to, which killed one person and badly injured twelve or thirteen others, besides badly damaging the building.

On the morning of the explosion fire was started as usual in the range about 4 o'clock A. M. It was found on trying to draw water that none could be had from either cold or hot water pipes; it was rightly judged that the pipes were frozen. The fire was continued in the range, however, and the breakfast prepared as best it could be, and a plumber sent for to thaw out the pipes. He arrived on the premises about 7 o'clock, as would naturally be the case. He opened both hot and cold water cocks, and getting neither steam nor water, *concluded there was no danger*, and proceeded to thaw out some pipes in the laundry department first. About an hour afterward the explosion occurred. The lower head of the boiler let go, and the main portion of the boiler shot upward like a rocket through the four stories of the hotel and out through the roof.

The coroner held an inquest on the remains of the person killed, and some of the testimony given, as reported in a local paper, would be amusing were it not for the tragic nature of the affair which called it out. The usual expert, with the usual vast and unlimited years of experience, was there, and swore positively to statements which a ten year-old boy who had been a week in the business ought to be ashamed to make. He had examined the wreck with a view of solving the mystery (?) The matter was as much of a mystery now as on the day of the explosion. His theories were exploded as fast as he presented them. The boiler must have been empty. If it had been full of water it could not possibly have exploded, etc., etc. And then a lot more nonsense about the "peculiar" construction of the boiler. As a matter of fact there was nothing peculiar about the boiler or its connections. Everything was precisely like all boilers of this class, of which there are probably hundreds of thousands in daily operation throughout the country, and moreover they were *all right*.

Now let us inquire what caused the explosion. Everything was all right at 8 o'clock the previous evening, for water was drawn at that time. The fire was built in the range at 4 o'clock A. M. It is admitted that the cold water supply pipes were frozen, for no water could be had for kitchen use. It is also proved absolutely that the *hot water supply was frozen or otherwise stopped up*, by the fact that at 7 o'clock the plumber who came to thaw out the pipes opened the hot water cock and got "neither water nor steam." Here was his opportunity to prevent any trouble, but he let it pass. Any one who understood his business would have known that there must have been a tremendous pressure in the boiler at this time, as the range had been fired steadily for three hours; there were about eight square feet of heating surface exposed to the fire by the circulating pipe in the range, and there had been no outlet for the great pressure which must have been generated during this three hours' firing. The blow-off cock should have been tried at once; if this were clear, and the probability is, from its proximity to the range, that it was clear, the pressure could have been relieved and the disaster averted. If the blow-off proved to be stopped up, then the fire should have been at once taken out of the range. At the time the plumber opened the cocks connecting with the boiler, it probably was under a pressure of four or five hundred pounds per square inch. An ordinary cast-iron water-back such as is used in small ranges in private houses, would have exploded shortly after the fire was built, but it will be noticed that the heating surface in this case was furnished by a coil of 1½ inch pipe; this was very strong, and the boiler was the first thing to give way, simply because it was the weakest part of the system.

Accidents of this sort can be easily avoided by exercising a little intelligence and care. The hot water cock should always be opened the first thing on entering the kitchen every cold morning. If the water flows freely, fire may then be started in the range without danger. If it does *not* flow freely, don't build a fire until it *does*.

Inspector's Reports.

February, 1888.

During the month of February, 1888, our inspectors made a total of 4,137 inspection trips, examined 8,250 boilers, 2,688 both externally and internally, and tested 427 by hydrostatic pressure; 7,803 defects were reported, of which number 697 were considered dangerous, and led to the condemnation of 36 boilers. Our usual summary of defects is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	429	24
Cases of incrustation and scale,	694	21
Cases of internal grooving,	23	6
Cases of internal corrosion,	194	11
Cases of external corrosion,	425	24
Broken and loose and defective braces and stays,	110	23
Settings defective,	180	14
Furnaces out of shape,	250	11
Fractured plates,	137	37
Burned plates,	152	21
Blistered plates,	199	11
Cases of defective riveting,	2,424	149
Defective heads,	101	12
Serious leakage around tube ends,	1,234	221
Serious leakage at seams,	527	15
Defective water-gauges,	82	23
Defective blow-offs,	50	13

Nature of Defects.	Whole Number.	Dangerous.
Cases of deficiency of water,	16	5
Safety-valves overloaded,	39	10
Safety-valves defective in construction,	37	9
Pressure-gauges defective,	205	24
Boilers without pressure-gauges,	8	3
Unclassified defects,	287	10
Total,	7,803	697

Settings may be defective from a variety of causes. They may be of defective design originally, so that, no matter how well the work of putting them in is done, they may never give satisfaction or work properly; in fact, they may be dangerous from the day they are started up, although the brickwork may be in first-class shape. Among settings of this class may be mentioned all those having a free communication between the furnace and the top of the boiler.

Another form, but one which is not necessarily dangerous while the brickwork is in good order, is that where a flue is carried back over the top of the boiler shell. As we have often pointed out, trouble from this form generally arises from distortion of the walls whereby the fire takes a short cut from the furnace up the sides and over the top of the shell, without the formality of first passing under the shell and back through the tubes. Many boilers have been seriously damaged in this manner. The trouble generally occurs suddenly, so that the mischief is done before harm is suspected. It must also be conceded that where the water is bad and the right conditions prevail, injury may be done to the shells of boilers with this form of setting, even when it is kept in first-class order.

Other settings which may be justly considered defective in design are those which are so constructed that an abnormal quantity of air is admitted to the fire, or those where air is admitted in the wrong place. It is a settled question, and one which has been settled for years, that the admission of an unlimited quantity of air into a boiler furnace above the fire is very detrimental to economy. Still, in spite of this fact, there periodically spring up settings based on the principle that there must be an enormous quantity of air admitted above the fire or there will be most imperfect combustion, and many boiler owners are convinced by glib-tongued agents that such is the case, and proceed to sink money in such traps. Anyone can demonstrate its fallacy by experimenting with a common stove at home. In fact, we don't believe there is one man in a hundred but knows perfectly well that to deaden the fire in his stove or furnace, nothing is so effective as the admission of air above the fire; why then should it not apply equally well to a steam-boiler furnace? Experiments have demonstrated that it does.

Boiler Explosions.

FEBRUARY, 1888.

LOCOMOTIVE (30). — The boiler of a locomotive on the Beech Creek Railroad exploded at Hawk's Run, Pa., February 2d, killing the fireman.

SAW-MILL (31).— A boiler driving a saw-mill near Belmont, Ohio, exploded February 3d. Abraham Arnold was firing heavily to get up steam, when a peculiar noise came from the boiler. Becoming frightened, Arnold went to his father, who was at the saw, and told him to go to the boiler room. Hardly had they exchanged places when the explosion occurred. The elder Arnold was struck by a piece of the boiler and had his head torn from his shoulders. A neighbor, named Charles Sullivan, was thrown fifty yards, half of the boiler falling on him. He was literally crushed to a jelly. Benjamin Travis had the side of his face crushed, both legs and arms broken, and soon died. Joseph Stubbs, an employee, was struck in the head by a piece of heavy timber and almost instantly killed. Frank Warrick, Samuel Stubbs, and Martin Gildow were terribly scalded, one of them having both eyes put out. Stubbs has since died. The other two cannot recover. The mill, which was owned by the elder Arnold, is a total wreck. About twenty other persons were at the mill when the peculiar noise before referred to caused them to scatter. Young Arnold was uninjured.

Saw-Mill (32).— The boiler of a saw-mill at Burton's Station, Ohio, exploded February 3d, killing two men and badly injuring five others.

Saw-Mill (33). — The boiler of a saw-mill at Gaines' Landing, Miss., exploded February 2d, killing two persons and fatally injuring two others.

Heating Boiler (34). — At Ashland, Wis., a cast-iron sectional heating boiler exploded February —; no one was injured, but many were frightened, and some glass was broken.

Steam Launch (35). — The boiler of a steam launch at Algiers, La., exploded February 6th. Two persons were fatally scalded, and the engineer jumped overboard and was drowned.

Domestic Boiler (36). — While Mrs. O. H. Ness, of Uniontown, twelve miles from Akron, Ohio, was cooking breakfast February 10th over a hot fire, frozen water pipes in the stove exploded and blew it to pieces. Mrs. Ness was hurled across the room and fatally injured. Her husband was also seriously hurt. The house took fire and was partially consumed.

Saw-Mill (37). — On the farm of John Spence, in Liberty Township, Ind., two men, named Jacob Sutton and Joel Hale, were engaged on a wood-sawing job, and on the 10th of February they placed their traction engine in position in the woods preparatory to beginning the work. At 2 o'clock p. m. the engine was started, when instantly there was a fearful explosion, and the air was filled with fragments from the wrecked boiler and engine, which were hurled with deadly effect. The bodies of J. T. Smith, a workman, and Hale, were riddled, and several of the bystanders were injured. The fact that there were a number of trees in close proximity saved the lives of a number of spectators, of which there were a dozen. Smith was instantly killed, one leg being torn off, and the body otherwise mutilated by the flying iron. Hale had the back part of his head blown off, but lived an hour after the explosion. He was twenty-five years old, and unmarried. Smith was a married man, and leaves a wife and several children. The two men were working at the saw, fifty feet away from the boiler, when it let go.

Locomotive (38). — A frightful accident, which may result in the loss of two lives, took place at Secaucus, N. J., February 9th. A six-wheeled locomotive which was engaged in drawing a heavy coal train from Hoboken to Boonton, on the Delaware, Lackawanna & Western Railroad, jumped from the track a short distance from the station at that place, and a moment later the boiler exploded with a report that was heard miles away. Pieces of flying iron and machinery seemed to fill the air, and great consternation prevailed among the people of the village. Several persons who stood at the station hurried to the scene of the accident and found two brakemen on the train, fearfully injured and unconscious. The locomotive after the explosion stood on the side of the track and was almost a total wreck, the boiler and cab being demolished. How the engineer and fireman escaped is a mystery, but it is supposed that they received some warning and jumped from the train, which was moving slowly. The men on the train who escaped uninjured were reticent over the affair, and it was impossible to ascertain any facts from the railroad officials.

Laundry (39). — The boiler attached to the engine in the City Laundry, at 1329 and 1331 Washington avenue, St. Louis, Mo., exploded February 9th with a terrific report, demolishing the boiler house at the rear of the building. The steam scalded the engineer, William J. Hicks, badly about the face, hands, and hips. The building was injured to the extent of about $500, and the machinery was very badly wrecked. Hicks' escape was miraculous, and is explained by the direction of the explosion, which was upward. As the boiling water scalded his right hand and he noticed that his clothes had been set on fire by the coals blown against him, he ran out of the wreck and stripped off the burning garments. The north brick wall of the engine room was blown completely out, and there was very little of the roof left. The big smoke-stack was broken into three pieces, the top of it flying over the building and alighting on Washington avenue, the second section falling in a tilted position on the roof and the lower piece hanging through the roof in a threatening manner. The inside of the boiler room, where Hicks had stood, was piled full of débris broken in all shapes, and the boiler and engine were splintered and twisted beyond recognition. The boiler was a new one and supposed to be safe.

Locomotive (40).—The boiler of engine No. 3, on the Rumford Falls & Buckfield railroad, exploded February 13th, at Canton, Me. Three workmen near narrowly escaped injury. Switchman G. D. Gammon stood at the head of the engine, Fireman Jones Bonney in the cab, and Engineer M. R. Davis was oiling at the side, and was blown 15 feet away, but escaped with only slight burns.

Saw-Mill (41). — At Carthage, Tenn., February 17th, a saw-mill boiler exploded; one killed, two badly injured.

Cotton Plantation (42). — The explosion of a boiler on a plantation at Bastrop, La., February 17, killed two white men, named Reems and Johnson, and two colored men. Four other men were so badly scalded that they are not expected to recover. The boiler was blown to atoms, and the gin house in which it stood was demolished.

Saw-Mill (43). — A boiler in a shingle mill at West Mellville, thirteen miles from New Orleans, La., on the Texas & Pacific Railroad, exploded February 20th, instantly killing Charles Hill of Toledo, O., John Stephenson of Beaumont, Tex., both white, and Seymour Banks of Plaquemine, La., colored. Thirteen others were seriously hurt. The cause of the explosion is unknown. The loss is $10,000.

Saw-Mill (44). — At Alano, Ky., February 20th, a saw-mill boiler exploded; the man in charge was killed, no others injured; the gauge-cocks were plugged with mud and lime, and the safety valve could not be moved.

Saw-Mill (45). — At Adrian, Mich., February 20th, a saw-mill boiler exploded; engineer killed, proprietor and two employees badly injured.

Saw-Mill (46). — The boiler in the saw-mill of Levi Newell, four miles east of Morenci, Mich., exploded February 21st, killing the fireman, William Smith, and terribly injuring Levi Newell.

Saw-Mill (47). — A boiler in a saw-mill at Golden, Mich., exploded February 23d, killing Fireman Lamb and severely injuring another man.

Locomotive (48). — The boiler of a locomotive on the Georgia Central Railroad exploded near Creswell, Ga., February 26th, completely demolishing the engine and injuring the fireman.

Jute Mill (49). — A rotary steam boiler in the third story of the Dolphin Jute Mill, Paterson, N. J., exploded February 29th. The boiler was one of a series of four, each 36x60 inches in size. They were certified to bear a pressure of 50 pounds, but are never run at more than ten pounds, and at the time of the explosion there were only 6 pounds indicated. The other three cylinders of the series were badly injured and will have to be replaced. Every window in the building was shattered by the explosion, and the damage will be $500. James Bandolf, an employee, was badly scalded.

Saw-Mill (50). — The boiler of a saw-mill at Houghton, Mich., exploded February —, wrecking the mill. Fortunately no one was injured. The explosion was caused by overpressure, the safety-valve being overloaded.

Steamer (51). — A disastrous explosion occurred February 27th at South Vallejo, Cal., on the ferry steamer Julia, plying between South Vallejo and Vallejo station, and it is believed that from 30 to 40 lives were lost. The steamer was about to leave her moorings, a few minutes after 6 o'clock, and had about 70 persons on board, many of whom were going across the strait to work in the lumber yards on the other side. Just as the deck hands were hauling in the lines, there was a loud explosion, and a sheet of flame shot into the air. Those who were on deck at the time were killed outright by flying pieces of the débris. Most of the passengers were below the decks at the time of the explosion, and were either killed outright or drowned when the water poured in on them. To add to the horrors of the scene, large vats of petroleum stored on the wharf caught fire, and the flames spread rapidly. Fifteen minutes after the explosion about 600 feet of wharf, freight depot and telegraph office, were burning, and not till noon was the fire under control. While the firemen and others were trying to save the wharf a large number of boatmen were rowing around the wreck seeking to recover bodies. Soon after the explosion occurred the steamer, having burned to the water's edge, sunk, carrying to the bottom many of the victims, who were buried under the débris in the cabin. Up to a late hour in the afternoon 12 bodies had been recovered, two of which were burned beyond recognition. The names of the other 10 victims are as follows: Melvin Hodgkins, Joseph Fragas, William Saman, Olef Nelson, Alfred Madison, Michael Branley, John Braverick, William Stark, Edward Rule, and a man named Higgins. The names of probably less than half of the passengers who were on the steamer at the time of the explosion are not known, making it impossible to tell how many sunk with the wreck, but at least 15 who are known to have been on the steamer are missing. Capt. Gedge of the Julia was severely injured, as was also Charles Heath, the pilot. Twelve others were also very badly hurt. The record of the Julia is a bad one, and this is not the first terrible accident on the steamer. In September, 1866, the head of her boiler blew out, instantly killing nine of the crew and fatally scalding the clerk and another officer. The cause of the disaster to-day is not known, though it is generally believed that the explosion occurred in the boiler. The impression also prevails that the fire was in some way communicated to the petroleum tank, and that the explosion occurred in that quarter. The steamer burned petroleum for fuel. Vallejo is 29 miles from San Francisco. Later advices say: 29 persons were instantly killed and 27 others injured of which 5 have since died, making the total number of deaths, 34.

Other People Sometimes Have 'Em. — A South American explosion which killed thirty people. The Atlas steamship Athos, which arrived recently from Carthagena, South America, brought some details of the terrible explosion of the boiler of the river steamer Rafael Reyes on February 21st, some miles above Carthagena. The Rafael Reyes ran aground. A boat was sent for assistance. Meanwhile the captain endeavored to float his steamer. The engineer put on an excessive pressure of steam and the boiler exploded, killing about thirty persons, or almost every one on board. The Rafael Reyes was an old boat owned by a brother-in-law of the President of Colombia.

The Locomotive.

HARTFORD, APRIL, 1888.

J. M. Allen, *Editor*. H. F. Smith, *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.

What is Success in Life?

Written for the Young Men's Christian Association of Hartford, Conn., by J. M. Allen.

This is a question that interests every young man, no matter what his family surroundings may be. A respectable and honorable ancestry are great helps, but these alone are not sufficient. Being heir to a fortune does not guarantee success, nor does society always bring success to its votaries. There must be certain qualities in the young man himself, independent of favorable surroundings. What are these qualities? He must have a respect for work, and willingness, yes, a determination to faithfully perform whatever he undertakes, even if the task is not in all respects in accordance with his tastes. Unswerving integrity and fidelity win confidence, because a person possessing these can be trusted. Truthfulness lies at the foundation of all personal excellence. There must be truth not only in word but in work. It must manifest itself in the whole life. A young man becomes of consequence when it is known that he can be relied on — when he says he can and will do a thing, and does it. These qualifications lie at the foundation of character, and it is character that tells on the affairs of life and business. Genius without character will not win in the race. It may be brilliant and for a time attract attention, but lacking the fundamental principles of industry and truthfulness it will shine out spasmodically, and accomplish little that is lasting or beneficial. Genius with industry and integrity is a power. But there are other qualifications essential to success. There must be a right mind. A man may be industrious and truthful and yet be selfish and unsympathetic. He may lack the qualifications of helpfulness to others, and bend his energies entirely to advance his own interests. A right mind contemplates no such selfish motives; while it keeps in view the principles of economy and thrift, it lends a helping hand to the unfortunate and weak, and to the discouraged who faint and fall by the way. Another point: While it is well to set the standard high, and honestly strive to work up to it, many lamentable failures have occurred by striving to get to the top round of the ladder at once. Confidence and eminence cannot be attained in a day or in a year. The discipline of patience and self-control under trying circumstances, and the development of good judgment and good sense, are necessary to round out the man and fit him for great and good deeds. It is fidelity to the little things, doing what we do well, that ultimately brings success. It is not dreaming of great things to be accomplished by-and-by; but it is faithfully attending to the duties of to-day. If we are faithful in these, the great things will come in due time.

"True worth is in being, not seeming;
In doing, each day that goes by,
Some little good; not in dreaming
Of great things to do by-and-by."

Communication with the good is productive of good. "Evil communications corrupt good manners." Seek good companions, for the life of every person is influenced, for good or evil, by the companions they choose. The society of the good is elevating and strengthening, and communion with the educated and refined is next to a liberal education. But above all, and to attain the highest success, there must be a pure heart, made so by the Divine touch. It ennobles the whole person as nothing else can. It teaches one to "be diligent in business yet fervent in spirit." We are placed in this world to be active, not slothful, and all our efforts, whether in business, social, or religious life, should be put forth with a determination to serve the Master. A business life is not by any means incompatible with an earnest Christian. The latter will lighten the burdens of the former. Young men should not overlook these things in forming their plans for life. Remember that the highest success is attained by industry, truthfulness, faithfulness to duty, and having a right mind, well stored and seasoned with the teachings of Him who knew the cares, temptations, and burdens of life, and who, knowing our infirmities, ever stands ready with a helping hand.

PROBABLY the greatest boiler explosion that ever took place occurred at an iron works at Friedenshütte, in Upper Silesia, last July. Twenty-two boilers of the "Elephant" type, which consists of one large cylinder above and two smaller ones below, connected to the large one by necks, exploded simultaneously. The large upper cylinders were each 5 feet 2 inches in diameter and 40 feet 2 inches long; the two lower cylinders were each 31 inches in diameter, and 37 feet 7 inches long,—each boiler having over 1000 square feet of heating surface.

The fuel used was gas from the blast furnaces, with just sufficient coal on the grates to keep the gas ignited. A careful examination of the case by representatives of the boiler inspection companies of Germany led them to the conclusion that the primary cause of the accident was an explosion of unconsumed gases in the flues. The large cylinder of every one of the boilers was literally torn into fragments and scattered broadcast, while the smaller cylinders remained nearly intact, and remained in most cases in or near their original positions. The boiler house and adjoining buildings were completely demolished, and three men in attendance upon the boilers were instantly killed.

A FRENCH writer, Dr. Sous, in a recent article upon the effect of the electric light upon the eyesight, says the injury is a disease, and, as is the case with all diseases, the cause must be found before a cure can be looked for.

He maintains that the ultra violet rays are the cause of all the trouble. Other investigators of the subject have maintained that the intensity of the light was the cause of the disease, and that it is exactly the same as that produced by intense sunlight. Dr. Sous says the symptoms of the two cases are entirely different, and a comparison of observed facts shows that sunlight and the electric light act in an entirely different manner upon the eye, and that this is proof that they act upon an entirely different principle. He concludes his article by saying that the effect of the electric light is always of a temporary nature, and recovery is certain to follow without other treatment than rest and protection from further injury.

WE would call especial attention to the article in this issue by Mr. J. H. Cooper of Philadelphia, on riveted joints for boiler plates. The formulæ for so proportioning the pitch and diameter of rivets that the strongest form of joint is obtained are original with Mr. Cooper, and are now published for the first time. The article is of great value, and should be well studied by all interested in the subject.

THE Cornell University Register for 1887-88 is at hand, and contains more than the usual amount of interesting matter relating to the organization and government of the University, its equipment, methods of instruction, expenses of residence, &c., &c.

A MANUAL of Steam Boilers, their Design, Construction and Operation, by Prof. R. H. Thurston, M. A., Director of Sibley College, Cornell University, is a very full and complete exposition of the subject treated, and is designed as a manual for Technical Schools and Engineers. It is an octavo volume of 671 pages, with 183 illustrations. It contains chapters devoted to the history of the steam boiler; materials of steam boilers; fuel and combustion; the nature, production, measurement and transfer of heat; steam, vaporization, condensation, pressure, and temperature; conditions controlling boiler design, construction, operation, and explosions, besides various useful tables. Altogether it forms a very complete exposition of the subject, and should be in the hands of all interested in steam engineering. Published by Wiley & Sons, 15 Astor Place, N. Y., at $6.00.

THE genius who has invented a method of welding steel rails by electricity, and who proposes by this means to make rails a quarter of a mile long will have a good chance to further exercise his ingenuity in overcoming that 7½ inches in variation of length during the summer and winter seasons. It is our impression that he will find this a more difficult thing to do than the welding.

Development of the Locomotive Turn-Table.

Editor LOCOMOTIVE:

DEAR SIR, — In the January LOCOMOTIVE, six feet was named as the diameter of the turn-tables first used with the Locomotive *Meteor*, then referred to. The enlargement of diameter was rapid; for when the *Meteor* reached Westboro, as it did late in the fall of 1834, a table was ready to turn it coupled with the tender. That table was twenty-four (24) feet in diameter, built by Paine Aldrich, of Worcester, Mass., running on wheels, with axles radiating from the center of the table, on a circular track, and so acting as friction rollers. It was an ingenious and useful table, and the general features of it were applied by Mr. Aldrich to tables up to fifty feet in diameter and more, and was the kind in general use, in New England at least, until superseded by the simpler and less costly iron and steel tables now in general use, which began to come into use about twenty-five years ago.

Yours truly,

Hartford, Conn. SAMUEL NOTT.

On the Riveted Joints of Steam-Boiler Plates.

BY JOHN H. COOPER.

The experiments of Fairbairn, conducted in the year 1838, proved that: — "as respects the area of the rivets, we find it is nearly equal to the area of the plate through the rivet-holes."

Subsequent experiments by Clark in connection with the Britannia and Conway Tubular Bridge, fully corroborate the above statement, which may be expressed by the following words: — "the collective areas of the rivets is equal to the sectional area of the plate taken through the rivet-holes."

This principle of proportioning the joints of iron plates for steam-boilers is embodied in the Philadelphia Ordinance regulating the Inspection of Steam Boilers, in effect since 1882, and which may be most briefly expressed in the following: —

FORMULAE FOR EQUALITY OF SECTIONAL AREAS OF PLATES AND RIVETS IN THE JOINTS OF STEAM BOILERS.

(The Notation is given by Initial letters.)

Let a = area of rivet-hole in □″
d = diameter of rivet-hole in inches.
n = number of rows of rivets.
p = pitch of rivets in inches.
t = thickness of boiler plates in inches.
R = internal radius of boiler " "
T. S. = ultimate tensile strength of the boiler-plate in lbs. per □″.
5 = the factor of safety.

The ultimate shearing strength of a given sectional area of rivets is assumed to be equal to the ultimate tensile strength of the corresponding sectional area of the punched plates.

Let A = relative area of the punched plate to the solid plate.
" B = relative area of the rivet section in the plate to the solid plate.

The least of these to be inserted in the following formula, where,

C = the working pressure of steam in lbs. per □″ for the boiler to carry.

The formulae then, will be as follows, which are simply mathematical relations of quantities.

$$A = \frac{p-d}{p} \qquad B = \frac{a \times n}{p \times t}$$

$$C = \frac{t \times (\text{A or B}) \times \text{T. S.}}{\text{R} \times 5}$$

The above formulae, as intended, enable the Inspector to find exactly what percentage of strength each and every joint possesses; to give credit to each as he finds them, and to ascertain and fix the pressure of steam which the boiler may safely carry, but they do not enable the boiler-maker to determine directly the proper proportions for making the strongest joint.

To do this I have devised the following rules, using the same notation as already given for those of the City Ordinance:

1, $p = \frac{a}{t} + d$, for single riveted joints when plates and rivets are of iron.

2, $p = \frac{2a}{t} + d$, for double riveted joints, when plates and rivets are of iron.

3, $p = \frac{2a\,5}{t\,6} + d$, for double riveted joints when plates are of steel and rivets of iron.

Formula No. 1 may, to some readers, be more clearly expressed by saying: — that the pitch is equal to the area of the rivet-hole, divided by the thickness of the plate and to the result of which the diameter of the rivet-hole must be added.

Formula No. 2 differs from No. 1 only in doubling the area of the rivet-holes.

In formula No. 3, the figures 5 and 6 represent the relative sections of plate and rivets, to be provided in the joints, following their capacities to resist rupture, but any other figures which will express the relative strengths of rivets to shear and plates to tension, of whatever material, according to the results of experiments or to the opinions prevailing, may be used in place of 5 and 6 in this formula.

The English Board of Trade rules say: "Iron rivets in steel boilers should have a section of 1⅗ times the net section of the plate."

The Philadelphia Boiler Ordinance and the English Lloyd's rules alike impliedly say: "The shearing strength of the rivets is just equal to the tensional strength of the plates, in boilers made of iron plates and iron rivets."

If any one takes exception to the data here given, the formulae permit him to introduce his own figures into their make-up, by which he can get the correct result required, according to his belief; but of the mathematical base, embodied in the formulae, we are sure.

In other words, these formulae when proper substitutions are made and when worked out will give such pitch as will secure equality of capacity, in the components of the joint, to carry the load required which pitch must be used with the plates and rivets expressed by the letters t and d.

The *rivet-hole* determines the size and measure of the rivet after it is driven, because it is then filled by it, and in making calculations with the aid of these formulae, the trade sizes of the rivets *must not* be taken.

In punching holes for rivets in boiler plates, it is the usual practice to use punches $\frac{1}{16}$ of an inch greater in diameter than the trade diameter of the rivets, and it is also usual to make the dies which are used with the punches $\frac{1}{32}$ of an inch larger in diameter than the punches to be used with them. The result of this method is to make conical holes in the plates, corresponding to the sizes of punch and die.

If the punched holes are net to the dimensions of the punch and die here given, and if the material of the plate immediately around the hole has not suffered in the act of punching, then the proper size of holes to be used in the formula would be the *mean* diameter of the conical holes so made, instead of $\frac{1}{16}''$ larger than the punch, as they are usually assumed to be.

It is well known, however, that the material of the plates bordering the holes is weakened by the detrusion of the punch: to what distance this reaches from the surface of visible separation of the metal may not be definitely known, and must necessarily be different with different materials and punches — but it is certain to be a small measurable distance into the plate around the hole.

If we take the diameter of the punched holes to be equal to that of the die, we will not be far from the actual state of the case; especially as some of this disturbed metal is removed by the reamer or crushed by the drift-pin.

We are safe in this assumption in so far as the ultimate strength of the joint is concerned, because, as usually happens in rupture, the plates give way while the rivets rarely fail, and again, the plates suffer loss of substance by wear and waste while the rivets are preserved against deterioration, and therefore the initial strength of the plates ought to be favored.

In view of these facts I would suggest that when we wish to determine pitches from given plates and rivets that we use the *greater diameter* of the punched hole, whatever that may be, for the quantity expressed by a, in all of these formulae, and that we assume the rivet diameter to be that of the lesser diameter, or reamed-out diameter, of the rivet hole.

The result of this apportionment of the material will be to effectively strengthen the plates, which all experience has proven to be necessary: so that while this decision appears to be against reason and the isolated facts of experiment — the resistance to shearing always proving less than that to direct tension, in the same material — it must be constantly borne in mind that the strains on the plates and rivets are not *direct* in the ordinary lap-joint, as they are used in a boiler; the plates being subjected to some transverse strain while under tension, and the rivets to some tensile strain while under shear.

Furthermore, in reference to the rivet-holes and rivets, the ordinance says: —" Area of the hole filled by the rivet," the English Lloyd's rule says: — "let *d* equal the diameter and *a* equal the sectional area of the rivets." Strictly speaking the plate loses what is punched out of it, together with the metal destroyed around the punched hole, and the rivet gains by whatever increased diameter it gets in the process of riveting. They should be estimated upon what they actually are when the joint is made up.

PHILADELPHIA, Feb. 27, '88.

Do Strikes Pay?

Intelligent leaders of labor organizations have at last plucked up courage, after recent great defeats, to squarely raise the issue, Do strikes pay? A review of the history of labor troubles during the past two years shows a long record of extravagant demands, at first weakly conceded, until, flushed with temporary success, the minor labor officials committed a series of fatal errors. Victorious over individuals and small groups of employers, they silenced the voice of the more reasonable class of men and cowed the ostensible chiefs of their organizations. They were coddled by politicians and by a great part of the press, who recognized the advent of a new power. Their professions of good faith and their lofty declarations of principles enlisted the approval and sympathy of all earnest men who acknowledged the necessity of an early amelioration in the condition of the workingmen. But one by one the illusions of those were dispelled who had hoped to lead to, or to witness, the establishment of more mutually satisfactory relations between employer and employee. A calm insistence upon real or imaginary rights developed into imperative demands for concessions out of all reason. Every petty walking delegate or district officer became a senseless tyrant, listening to no law but his own unbridled will. Strikes multiplied in an unprecedented manner; the boycott was resorted to until its most ardent devotee could not hope to keep track of its mandates. There were curious instances of a conflict of authority between the leaders of rival factions of laborers, and the demands for the support of rash strikes grew more and more numerous and exacting. The industries of entire sections were paralyzed or driven away to more peaceful sections, and in a number of great contests an utter disregard was shown for the rights of the public, while scenes of violence were not infrequent.

Slow to abandon earlier hopes and to modify its first favorable impressions, the public has finally been thoroughly aroused. One by one the most fearless public men have denounced the course taken by the class of minor leaders who have come into power during the past few years. Bombastic speeches have lost much of their persuasive powers over the members of labor organizations. Their grip over their former constituency has decidedly weakened. The general public has ceased to regard the announcement of a strike as *prima facie* evidence that the employers are in the wrong. The directors of great corporations have had their hands strengthened by the tacit support of their stockholders and by the sympathy of the people and the press. On the other hand, every great strike of national importance during the past two years has ended in the defeat of organized labor, confessedly in most instances because the contest was entered into by the men with a weak cause, and because the management of the fight was poorly conducted. Even the most conservative and powerful body of this character — the Brotherhood of Locomotive Engineers — has been thoroughly discredited lately. Mr. Powderly has recently taken an unusual step by appealing directly to the members of the Knights of Labor, with a view to obtaining the verdict of that body on the question of diverting the policy of the order more in the direction of supporting educational measures rather than supplying funds for carrying on contests with employers. As fighting machines the unions have proved expensive failures. It remains to be seen whether loftier aims can command enough attention to keep the ranks filled. It is probable that for some time to come our country will continue its industrial progress with less frequent interruptions from wanton strikes or lockouts. Employers, while the end has proven the justice of the position which they have on the whole taken, have felt keenly what power for mischief the ascendancy of the worst element among the men has. When once assured that ignorant outsiders do not aspire to take their business out of their hands to run it in their own way, they will be more willing to make reasonable concessions. The signs are multiplying that that spirit is spreading. There is some promise, therefore, of peace for some time to come. It is to be hoped that a crushing defeat of the strike in the West will be the beginning of a new era. — *The Iron Age.*

A Clever Piece of Engineering.

On the 26th ult. quite a feat was accomplished at Chicago under the direction of Charles L. Strobel, consulting engineer of the Keystone Bridge Company. Mr. Strobel took a contract some time since to remove the Wells street drawbridge to Dearborn street, two blocks down the river, with the Clark street bridge intervening. He very carefully figured out the problem, and the splendid success of the achievement is proof of the correctness of his calculations. The bridge structure weighed 110 tons, but Mr. Strobel denuded the framework, which is of iron, of all the wood flooring and superfluous hand-rails and other incumbrances, so that the frame only remained, and this weighed 90 tons. Every bolt and nut was carefully examined, oiled and tightened. Then four huge scows were secured, partially sunk by being filled with water, and horses or scaffolds erected on each pair. These were floated under the bridge at each end, and the water pumped out of the scows by the tugs Alert and Allen. It was 5 o'clock when the bridge began to feel the scaffolds rising underneath, and it was 5.25 when the bridge swung free from its moorings at Wells street, where it has been since 1872. The iron structure was in first-class condition, and is a credit to its builders, Fox & Howard. The novel vessel floated gently with the current, one end being held until the other had gotten straight with the river. The tug Allen went to the bow, and the trip to the Dearborn street pier began. There were thousands of people on the wharfs, docks, and street intersections watching the strange craft. It reached Clark street at 5.55 o'clock, and 25 minutes later it safely passed the drawbridge at that point. It took some careful steering to get the craft down the river across the Dearborn street pier, and it was just 6.55 o'clock when the feat was fully accomplished, and the Wells street bridge was henceforth to be known as the Dearborn street bridge. It took just 1 hour and 30 minutes to make the trip, and there was not the slightest hitch in the job from first to last. Mr. Strobel rode on the bridge, and had entire charge of the work. Work has begun on a new bridge for Wells street, which is to be of double the capacity of the old one, the change being demanded by the great increase in traffic in that portion of the city.— *The Iron Age.*

THE enormous equipment demanded by a first-class railroad these days appears from a few figures relating to the Philadelphia and Reading. On December 1, 1887, the rolling stock and motive power equipment of the company consisted of the following: Total number of locomotives, 604, of which 150 were passenger engines and 362 freight and coal engines; total number of cars, 26,458, of which 7,444 were four-wheeled, 18,997 eight-wheeled, 16 twelve-wheeled, and 1 sixteen-wheeled. The above figures include 17,985 coal cars, 7,001 freight cars, 571 passenger cars, besides over 1,000 additional cars of various kinds used in the maintenance of roadway and other departments of the company's service. The Reading Company now own 11 steam colliers, 5 steam tugs, 2 schooners, 58 barges, and 4 car floats used between Philadelphia and Camden. There are also in use on the Schuylkill Canal 310 barges, 2 steam tugs, and 1 packet-boat. On November 30th there were, in addition to the above-enumerated rolling stock, out of service to be replaced, 17 locomotives, 396 eight-wheeled cars, and 403 four-wheeled cars, and there were besides 1,442 four-wheeled iron coal cars out of service, to be replaced by other kinds of cars. The Car Trust rolling stock, built prior to December 1st last, included in the above, numbers 100 locomotives, 3,492 coal cars, 1,697 freight cars, and 67 passenger and baggage cars. — *The Iron Age.*

Manufacture of Window Glass by Machinery.

In Germany, during several years past, especially in Bavaria, the manufacture of plate has grown enormously, and very heavy glass is being blown with the old-fashioned blow pipe at great risk to the health of the workmen employed, at a very small advance on the wages for single strength. For grinding and polishing the swift-running streams of the country furnish abundant water power at a trifling cost. So much has this branch of the German sheet glass trade been developed that Belgium and England are being met by it on what have heretofore been considered home markets. In Belgium, however, the introduction of machinery in the manufacture of window glass is seriously contemplated. The movement is different from any yet attempted elsewhere. The object is not simply to assist the blower with the help of a machine, so that he may be able to make larger, heavier, and more glass with greater ease and less exhaustive toil, but it aims at abolishing the cylinder blowing altogether by the substitution of a process of rolling. The main difficulty is to roll the glass thin enough so as to save material and avoid expense in grinding it down to the desirable thickness. At the Besson works a series of rollers have been placed between the tank furnace and the annealing ovens and leers.

Through these rolls, similar to sheet mill rolls in iron mills, the molten glass is conducted on to a cooling table by means of a sluice or canal from the tank furnace, the mouth of which is opened and closed at the will of the operator, much the same as the flow of liquid steel is controlled in the ladle used to fill the ingot molds in Bessemer steel manufacture. From this table the glass passes through the sheet rolls, and, after being rolled to the desired thickness (which can be regulated by powerful screws, same as in iron mills) the sheet is conveyed on rollers between two large cylinders, where it is divided into required lengths by means of an ingenious shearing apparatus. All this is done before the sheet cools sufficiently to lose plasticity, and it is thence conveyed by means of rollers (much the same as those now used to convey steel rails from their rolls to the stretchers) to the annealing leer. No human hand touches the glass, and labor compared with the machines used is but a vanishing quantity. — *Oil, Paint, and Drug Reporter.*

Ancient Microscopes.

In a recent lecture before the Royal Institution, Mr. Frank Crisp, the Secretary of the Royal Microscopical Society, gave an interesting account of some ancient microscopes. It was illustrated by about six hundred instruments of various dates, and various books containing many illustrations of other forms. Among the works were those of Robert Hook, Adams, Pierre Lyonet, and a practical work by Adams, a maker of instruments, dated 1747.

Mr. Crisp first referred to one of the latest productions of Powell & Lealand as a type of the present perfection of microscopes, and then turned to the ancient instruments. By ancient, he meant any instrument over a hundred years old. We now look for clearness of vision, stability, and absence of needless adornment. It is interesting to see from what our present instruments have been evolved. One striking difference is the fact that while stands are now made entirely of brass, the ancients made them of wood, ivory, tortoise shell, and papier mache, and ornamented them to an excessive extent. In illustration of this the lecturer showed an instrument made for Cardinal Lambartin where the silk linings and the large space for the papal insignia made the thing appear ludicrous to a scientific man. After others belonging to popes and various other distinguished people had been shown, a strange green-colored one made for George III. was exhibited. But all these were toys, and no good results had ever been accomplished by any of them.

In tracing the development of stability of the stand it was noted how long it took to acquire it. This would seem to be rather discreditable to the makers. Some were shown which could be blown over by a puff of the breath. Finally an excess of stability was reached, and drawings of instruments with tubes four and five feet long were shown.

The Locomotive.

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Bracing Boiler Heads.

The proper bracing of flat surfaces exposed to pressure, which are necessarily present in almost all forms of boilers, is a matter of the greatest importance, as the power of resistance to bulging possessed by any considerable extent of such a surface, made as they must be in the majority of cases of thin plates, is so small that practically the whole load has to be carried by the braces. This being the case, it is evident that as much at-

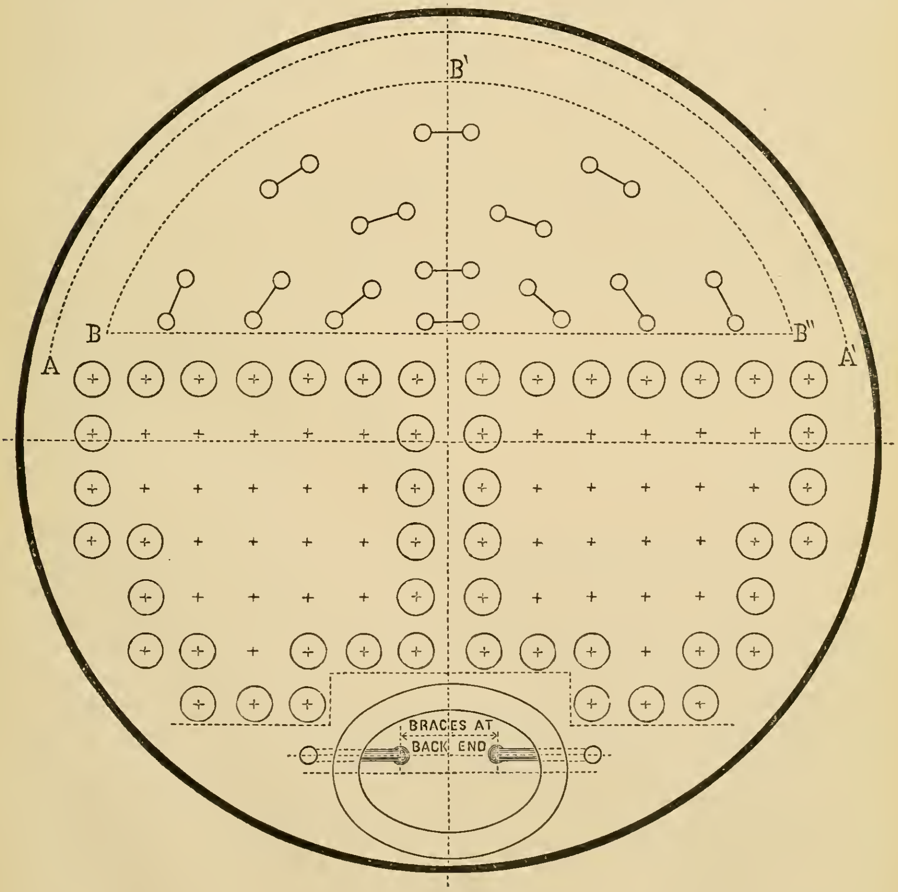


FIG. 1.

tention should be given to properly designing, proportioning, distributing, and constructing the braces as to any other portion of the boiler. This is not, however, always done, and it is no uncommon thing to subject new boilers to hydrostatic pressure well within the limit of strength of the shell, and so strain the bracing that the heads are bulged to quite an appreciable extent, and when the pressure is released the braces are found to be loose and badly strained. The prevalent idea regarding bracing is, that it should be just sufficient to prevent "vibration" of the heads. There is no objection to regarding it in this light if we consider properly just what is required to effectually do it.

The subject might be profitably discussed in a general manner, but we think more advantage will be derived from the consideration of an actual example, such as would arise in daily practice.

Suppose, for example, we are designing a boiler 72 inches in diameter. How many braces shall be put on the heads above the tubes?

We first arrange our tubes. Let us assume that they are $3\frac{1}{2}$ inches in external diameter; then a good arrangement of them, paying due regard to a free circulation of the water, will admit about 86, and will leave a clear height from the top of the upper row to the top of the shell of 29 inches. (See Fig. 1.) Then it is evident that this segment, 29 inches high, of a circle 72 inches in diameter, constitutes the surface to be braced, and we must next ascertain the strength of bracing required to render it safe.

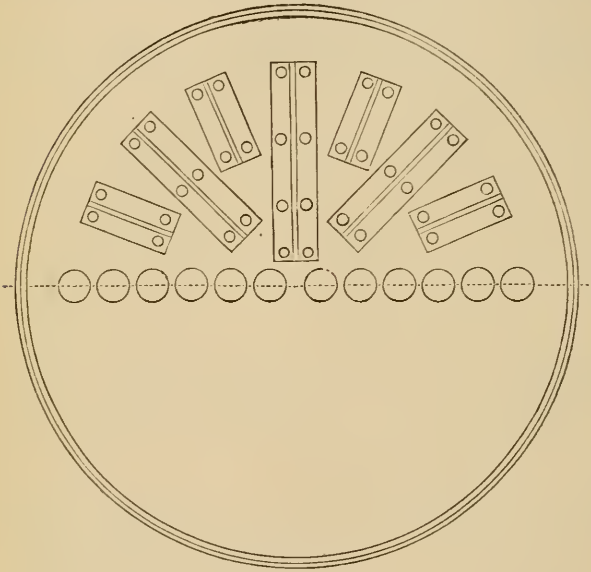


Fig. 2.

Let us consider first just how much of the pressure on this segment must be carried by the braces, and how much shall be allotted to the flange of the head and the top row of tubes. For it is evident that as the area to be braced is bounded by these parts, and they possess ample strength, they may be calculated to sustain their due share of the load.

The flange of the tube sheet may be assumed to have a radius of two inches. This curved portion will take care of itself, and, if it had a chance to do so, a great deal more besides. So we draw the line A–A′ with a radius of 34 inches, and disregard the portion outside of it.

Now we know that on heads or flat surfaces of ordinary thickness the pitch of stays should not be much more than 8 inches from center to center. In the fire boxes of locomotives and similar boilers they must be much closer, but the head of an ordinary boiler is not exposed to such intense heat, and they may be placed much further apart with safety. So we draw the line B B′ B″, with a radius equal to 30 inches, and consider that the load on the area between it and the flange may safely be borne by the flange itself.

Now, how much of the load on the head above the tubes may be safely carried by the tubes themselves? We know by experiments that the tubes, if well put in, have a great holding power when new. We also know that if the water used is corrosive, or the fuel is of such a nature that its gases attack the ends of the tubes externally, they may in time corrode and lose much of their holding power. If this were not so then we should be justified in keeping away from the tubes 8 inches or so with the nearest brace; but for the reasons above stated it would be deemed judicious to brace closer down to the top of the tubes, so that if a portion of them lose their holding power, the boiler will still be perfectly safe. So we would put the line of braces as nearly as might be 4 inches above the top of the upper row of tubes, and drawing the straight line from B to B″, 2 inches above the tubes, put in braces enough to carry safely the pressure on the segment of the head B B′ B″.

The area of this segment is easily computed by means of the table given in the LOCOMOTIVE of December, 1886, page 184. In this case it is a segment 21 inches high of a circle 60 inches in diameter, and its area is 882 square inches. The braces should be sufficient to carry safely the entire pressure coming on this surface. If the boiler is intended to carry a pressure of 100 pounds per square inch, it would aggregate on this segment 88,200 pounds, and the braces should be sufficient to safely sustain this pressure. The number of braces required will depend upon their form. If of the ordinary crow-foot pattern, which if well made is as good as anything yet devised, and one inch in diameter, they could safely be allowed to sustain a tensile stress of 7,000 pounds each. This would give 88,200 ÷ 7,000 = 13 braces, which should be distributed as uniformly as possible over the surface to be braced, about as shown in Fig. 1, making the arrange-

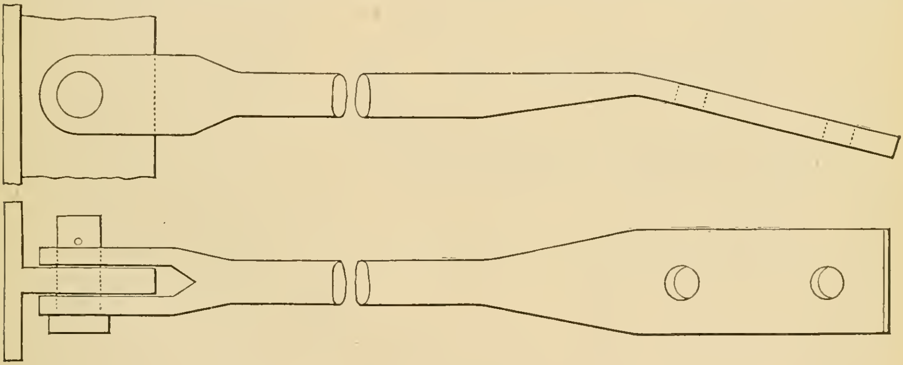


FIG. 3.

ment as symmetrical as possible, grouping them slightly closer to each other near the center of the head than we do out toward the flange. The braces should be attached to shell and head by two rivets at each end. The rivets should be of such size that the combined area of their shanks will be at least equal to the body of the brace, and their length should be sufficient to give a good large head on the outside to realize strength equal to the body of the brace. We have seen cases where the rivet used was so short that when hammered down outside the head was so thin and weak that it stripped off under the test pressure. Such scrimping of material is very poor economy in the long run.

Figure 2 shows an arrangement for a different form of brace. Four-inch T irons are riveted to the heads, and the braces, with forked jaws, are attached to the web by a turned pin or bolt. The T irons are, so far as practicable, so arranged that the rivets which secure them to the heads will fall in about the same position that they would if crowfoot braces were used, that is, they should be distributed as uniformly as possible. This enables a less number of braces to be used, but they should be somewhat larger. Owing, however, to the stiffening of the heads by the T irons, which act as girders and transfer the stress due to the pressure to the flange and the tubes, it is usual to make these braces but one inch in diameter. We have never known the least trouble to occur where a boiler was braced in this manner and the work was well done, and recommend it as a very superior form. Fig. 3 shows the detail of this brace and its connection. Two angle irons are sometimes used instead of the T irons with this form, but the T irons are to be preferred, as they are free from the "claw hammer" strain which is unavoidable when the angles are used.

Many boiler makers prefer to arrange the T or angle irons horizontally across the portion of the head to be braced instead of radially. This form is shown in Fig. 4, and there is no objection to it provided the braces are swung horizontally to the point of attachment to the shell. Where they are swung upward, as they are in the majority of cases, an awkward bend is necessitated in the brace, and a square pull on the jaws is impossible, and the consequence is they do not remain taut for any great length of time. They should never be put in in this manner. When we wish to resist a direct pull a straight piece of material is the best thing to do it with, and there is no reason for using anything else to brace a boiler head with.

Another favorite style with some makers consists in riveting heavy forged bars horizontally to the heads above the tubes. These bars are provided with projections, to which are attached heavy braces extending from head to head. The objection to this form of brace is, that it offers a very serious obstruction to a proper examination of the boiler, and is very much in the way when cleaning and repairs to the inside of the boiler become necessary. The principle embodied, that of tying the heads of the boiler together, is all right, but it should be remembered that boiler shells have an excess of strength in a transverse direction to carry *all* the pressure that can come on the heads, and so ample strength is secured by bracing back well on the shell. We have yet to learn of a case where braces attached to the shell have *caused* an explosion by the strain on them tearing it apart transversely.

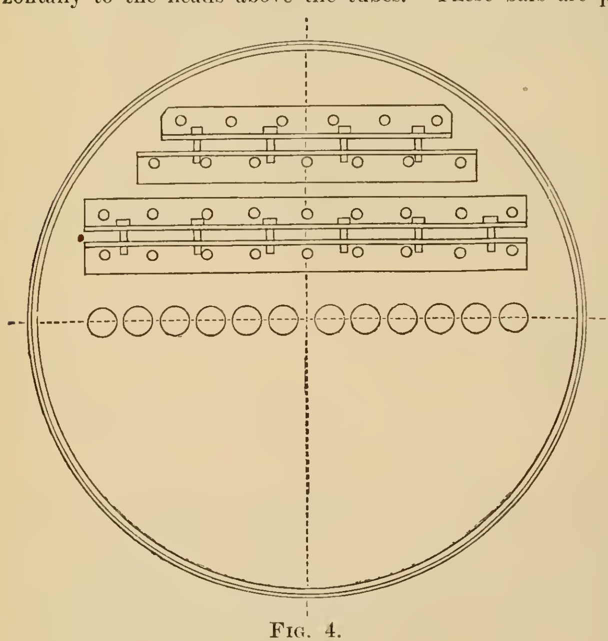


Fig. 4.

In localities where the water available for use in boilers is very bad, a man-hole in the front head below the tubes will be found very useful to enable the bottom of the shell to be kept clean. Now, it is evident that a portion of each head equal at the least to the area of the man-hole frame [see area below dotted line on lower part of Figure 1], will be deprived of the supporting power of the tubes, which must be displaced to admit the man-hole, and this unsupported area should be properly braced, more especially that at the back end. This is done in a variety of ways. Some run crowfoot braces from the head back on to the shell. The objection to this is, the foot of the brace where it is attached to the shell is apt to form a lodging place for sediment, which will accumulate until there is danger that the shell may be burned at this point. The better way is to put in through braces here, extending from head to head, leaving the bottom of the shell entirely clear. Various methods are practiced of attaching these braces to the heads, but the most preferable would seem to be: make the brace of round iron $1\frac{1}{8}$ inches in diameter; upset the ends to $1\frac{1}{2}$ inches diameter, and cut a *full smooth* thread on them; drill and tap the heads for this thread, and screw the braces through, making them just long enough to enable the ends to be headed down nicely outside, after the manner of an ordinary screw stay. This will leave no chance for sediment to accumulate.

Where this form of brace is used they should not be run through parallel with the direction of the tubes; if they are, they will be of very little account as braces of the back head. For their ends must be separated at the front end by a distance of at least two or three inches more than the greater outside diameter of the man-hole frame, or say about 24 inches; if they are run through parallel this same distance on the back head will be wholly unsupported, and will be apt to bulge sooner or later.

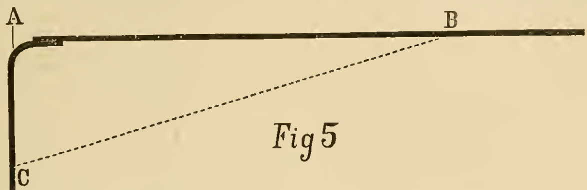


Fig 5

The braces should therefore be brought closer together on the back head; from 9 to 10 inches apart will generally be found to give a better and more uniform support to the back head where a man-hole of ordinary size is used in the front head. This is shown in Fig. 1 with sufficient clearness to render further explanation unnecessary.

A few words concerning the frames usually put around the man-holes in boiler heads may not be amiss. The common practice is to rivet on a wrought-iron ring about half an inch thick and as narrow as can be used and get a rivet through it. This is entirely insufficient for the purpose, and the practice may be described as entirely too economical, or some stronger name may perhaps be profitably applied to it. This ring should under no circumstances be less than $2\frac{1}{4}$ inches wide ($2\frac{1}{2}$ inches would be better), and one inch thick (from $1\frac{1}{4}$ to $1\frac{1}{2}$ inches thick would be much better). Then a degree of stiffness would be imparted to the front head, if a suitable plate were used, which would insure perfect freedom from trouble. It is no uncommon thing for these thin, narrow rings to give out under the hydrostatic pressure while the boilers are being tested.

On a diagonal brace, which term will apply to any brace which is not parallel to the direction of the stress applied to it, such as gussets, braces attached to heads and having the other end attached to the shell, etc., the strain is theoretically somewhat greater than it would be if the brace were parallel to the direction of the stress applied. The actual stress on the brace may be found by dividing the total pressure on the area supported by the brace by the cosine of the angle between the brace, and the direction of the stress. Or to arrive at the result without resorting to calculation, lay out the brace in correct proportions, as shown in Fig. 5. Then, if the pressure on the area to be braced is represented by the length of the line A–B, the length of the brace B–C measured by the same scale will represent the actual stress upon it. With the ordinary proportion of braces, this difference is so small it may be neglected, but where the brace makes a comparatively large angle with the shell, as may be the case with gusset stays, it should be taken into account, and the brace made correspondingly larger.

The matter of stay-bolts will be discussed in a future article.

Inspector's Reports.

March, 1888.

During the month of March, 1888, our inspectors made a total of 3,732 inspection trips, examined 7,682 boilers, 3,160 both externally and internally, and tested 485 by hydrostatic pressure; 9,232 defects were reported, of which number 837 were considered dangerous, and led to the condemnation of 32 boilers. Our usual summary of defects is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	378	26
Cases of incrustation and scale,	616	45
Cases of internal grooving,	29	3
Cases of internal corrosion,	206	16
Cases of external corrosion,	395	23
Broken and loose and defective braces and stays,	74	28
Settings defective,	190	12
Furnaces out of shape,	216	8
Fractured plates,	193	60
Burned plates,	161	15
Blistered plates,	190	9
Cases of defective riveting,	3,497	186
Defective heads,	53	10
Serious leakage around tube ends,	1,607	225
Serious leakage at seams,	641	36
Defective water-gauges,	108	29
Defective blow-offs,	61	7
Cases of deficiency of water,	22	12
Safety-valves overloaded,	33	6
Safety-valves defective in construction,	75	29
Pressure-gauges defective,	233	22
Boilers without pressure-gauges,	10	10
Unclassified defects,	244	20
Total,	9,232	837

An electric railway, which is to reduce the time between New York and Chicago to two hours,— making a speed of about 450 miles per hour — is now the dream of a Baltimore inventor. As the question will naturally arise what device is provided for restoring their breath to the passengers by this very rapid conveyance, it will relieve our readers' minds to know that, so far at least, the inventor does not contemplate rushing human beings across the continent at this speed, but only proposes to send letters, valuable parcels, perishable fruit, and special express matter on his lightning train, which is to consist of a single small car without engine or trainmen. The car will be simply fired off like a cannon-ball from one terminus, and will shoot along through the air on a light elevated track, until it reaches a point say ten miles from the New York or Chicago terminus, when the current will be cut off and it will gradually slow down until, by means of a trip-lever, brakes are applied, bringing it to a stand. The cost of this remarkable railway is figured out to be the exact sum of $5,079 per mile for a double track, and $3,366 per mile for a single track. Inventions that seemed much more wild than this are now in successful operation. It is not safe, in this age of the world, to undertake to draw the line between impracticable theory and actual practice.— *The Railway Age.*

Boiler Explosions.

March, 1888.

Locomotive (52). — Delaware & Hudson Railroad engine, No. 35, exploded its boiler March 2d, between Pleasant Valley and Pittston, Pa., while drawing a train of sixty loaded coal cars. Engineer Wescott and Fireman Colvin, both of Scranton, were hurled from their seats in the cab into the tender, the former tumbling off and down an embankment without serious injury, but the latter was pinned down with an iron bar and could not be released until help arrived, the escaping steam spreading over him, but not burning him badly. He was also cut by glass from the cab windows. The head brakeman, David Dourick, was slightly injured in jumping from the train.

Brewery (53). — As two gas-fitters were at work, March 2d, upon a steam tank in the Bartholomay brewery, Rochester, N. Y., the cover was blown off, and the two workmen were scalded about the arms, one only slightly, but the other somewhat seriously.

Iron-Mine (54). — The boiler at the ore mine of the Thomas Iron Company, operated by Uriah Bicrey, at Kline's Corner, near Topton, Pa., exploded March 8th. Three of the workmen were severely injured. They are: William Bloch, the engineer, aged thirty-five, and married; Ambrose Schweyer, aged thirty-seven, married, and George Bott, eighteen years old. The men were very badly scalded by hot water and steam. The engineer was struck by a piece of the boiler, and had his neck and body badly injured in addition to the scalds. The report of the explosion was heard for a great distance. It is said the boiler was not in good order, but that it contained plenty of water. The engine and machinery were completely wrecked, and pieces were hurled promiscuously for a considerable distance. One portion of the boiler was thrown four hundred feet from the boiler-house.

Portable Boiler (55). — At Pella, Iowa, an old portable boiler that had been condemned, exploded March 8th, while all hands were at dinner. No one killed or injured.

Saw-Mill (56). — A terrible casualty occurred at Kavanaugh, in the Choctaw Nation, Indian Territory, March 10th. The boiler in Tucker's saw-mill exploded and killed one man instantly, while ten others were injured so severely that their recovery is doubtful. The saw-mill is a large one, and as its proprietor does an extensive business, furnishes employment for nearly twenty men. They had finished their morning's work and were sitting together eating lunch when the explosion took place. William Patterson, the fifteen-year-old son of James Patterson, the engineer, was blown through the roof of the building, and his body torn to fragments, his head being found nearly thirty feet away, while a portion of his body was carried some distance in the other direction. The boy's father was blown against a lumber pile, which, falling upon him, crushed his arms and limbs, inflicting injuries from which he cannot recover. The other employees were at some distance from the boiler-room, and were struck by pieces of the flying débris. George Walker was badly cut about the head, but will recover.

Coal Mine (57). — A boiler used by the Coal, Iron & R. R. Co., South Pittsburg, Tenn., exploded March 13th. The engineer was badly but not fatally injured. Much damage was done to property.

Saw-Mill (58). — A terrific boiler explosion occurred March 14th, at Deere's saw-mill, near Burlington, south of Logansport, Ind., instantly killing Frank and Moses Whitsell and Edward Everman, and injuring three others, one of whom will die. The bodies were mangled beyond recognition, and fragments of the boiler were blown fully half a mile.

Locomotive (59). — On the Susquehanna Railroad, March 14th, an effort was made to run a passenger train westward. It started from New Durham, N. J. Two engines were attached to a number of passenger coaches, and all went well until near Bogota station, when the whole train went off the track and was wrecked. As one of the engines went over the boiler exploded. Elmer, the son of Paymaster Demarest, was on one of the engines, and was instantly killed. A number of others were hurt.

Locomotive (60). — At Snell Station, C. & N. W. R. R., a locomotive exploded March 15th, killing the fireman and injuring the engineer.

Saw-Mill (61). — Mill No. 3, of the St. Regis Lumber Company, at Santa Clara, N. Y., exploded one of its boilers March 15th, killing two men and injuring three others quite badly. The boiler was carried about fifty feet from the mill, striking a house occupied by Mr. George McNeil, injuring Mrs. McNeil severely; also two children slightly. The names of the men killed were S. S. Harvey and Amos Lanchance. Both bodies were badly mangled. The injured were Jerry Meacham, injured about the head and legs; George Berry badly scalded about the head, neck, and face; Eli Compo, also scalded about the head.

Electric Light Station (62). — The bursting of a flue in the furnace of the boiler of the Edison Electric Light Company in the basement of the building at the northwest corner of Fourth and Vine, Cincinnati, Ohio, March 15th, at a few minutes past 9 o'clock p. m., caused a panic among the workmen, but no one was injured. All the lights that were fed by the plant were instantly extinguished. There were five men in the room at the time of the accident, three pipe-fitters, and the Engineer, William Pogue, and Fireman Henry Swann. The bursting of the flue filled the basement with steam, and the floor was partly submerged with scalding water. The front doors of the furnace were open at the time, and the coals were thrown out upon the floor, setting fire to some rubbish and barrels that were immediately in front. The incipient blaze was easily extinguished by the night watchman of the Western Union Telephone Exchange, John Scofield. The men who were in the basement at the time of the accident made a rush for the windows, and were quickly drawn up into the street by many ready hands. Engineer Pogue said there were but seventy pounds of steam in the boiler when the flue burst, and it was generally their custom to carry ninety. Some six months ago a similar accident happened at the same works, but was attended by far more serious results, as the fireman was badly scalded.

Locomotive (63). — Locomotive No. 24, on the New Brunswick Railway, which brought the Boston train to St. John, N. B., March 16th, exploded soon after being taken into the shed at Fairville. Douglas Clark, John Smith, and Andrew Hamm, who were in the cab, were frightfully scalded and mutilated by flying fragments of the boiler. The engine was wrecked and 100 feet of shed blown out. One fragment crashed through the window of a dwelling-house some distance off, and lodged in a bed where a man named Cameron was sleeping. The explosion was due to a defect in the boiler.

Saw-Mill (64). — A saw-mill boiler exploded at Pine Grove, Ala., March 17th, killing two men and injuring four others.

Saw-Mill (65). — The boiler of a saw-mill at Van Buren, Ark., exploded March 18th, killing three men and injuring another one.

Stationary Shop Boiler (66). — The explosion of a boiler in the shop of the Pennsylvania Railroad at Camden, N. J., March 19th, broke doors and windows of houses in the immediate neighborhood. The boiler was temporarily put in the repair shop two weeks ago, while the regular boiler was being overhauled. Eleven men who work in the shop had knocked off shortly before the explosion occurred. The boiler was thrown into the air a distance of 150 feet, and landed between the shops and the passenger depot and the ferry houses. One end of the shops was damaged to the extent of about $1,000. No one was hurt.

Rolling-Mill (67). — A boiler of one of the heating furnaces of the Columbia Iron Company's Rolling Mill, at the foot of Union street, Columbia, exploded March 19th, slightly injuring two men. Brick and pieces of iron were hurled a distance of fifty feet, and it was fortunate no one was seriously injured. The sound of the explosion was heard six or seven squares away.

Coal Mine (68). — On Saturday evening, March 24th, Campbell's Creek, W. Va., experienced the greatest sensation that she has enjoyed for years. It has always been customary for the men employed at the Pioneer coal works to quit work about an hour earlier on Saturdays than on other days, and this doubtless prevented the loss of several lives on this occasion. About five o'clock, shortly after the employees had quit work and when there were fortunately only four men at the works, the mine boiler suddenly exploded and tore down the building, scattering the timbers in every direction, some of them being thrown a distance of twenty-five or thirty yards. The four men, who were standing within ten feet of the boiler at the time of the explosion, were uninjured. The cause of the accident is unknown, as the boiler was carrying plenty of water at the time. A night watchman had just come on duty and had scraped out all the fire and built a new one when the explosion occurred. The escape of the men who were standing near was almost miraculous. The loss is estimated at about $1,000.

Saw-Mill (69). — By the explosion of a boiler of Luce's saw-mill at Cookeville, Tenn., March 27th, two white men and a negro were killed and several wounded.

Locomotive (70). — The boiler of a locomotive attached to a passenger train on the New York & New England road, exploded at North Manchester, Conn., March 28th, killing the engineer and fireman.

Steam Yacht (71). — The boiler of a small pleasure yacht on East Lake, near Birmingham, Ala., exploded March 30th. No one was hurt, and the damage was slight.

Flouring-Mill (72). — The boiler in Payne, Johnson & Co.'s flouring-mill, Madison, Ind., exploded March 30th, killing Engineers M. L. Snodgrass and Tom Stewart, and seriously injuring Charles and T. Parsons. The mill is badly wrecked, and the loss is estimated at $15,000.

Car-Heater (73). — An explosion occurred March 31st, about 5 o'clock P. M., in a passenger car on the Eastern Division of the Boston & Maine Railroad, near the Chelsea depot. The car had been brought up from the repair shops in Salem, and the heating apparatus exploded from some unknown cause. The top of the car was blown off, all the windows broken, and the windows in the depot were also smashed.

An Ancient Church. — The church of Chester-le-Street, England, will attain its millennium next year, and it is proposed to commemorate the event by a restoration of the present edifice. The rector, the Rev. W. O. Blunt, says: "It was in the year 883 that the monks of Lindisfarne brought the body of St. Cuthbert to the ruins of the Roman camp at Cuneacestre, the modern Chester-le-Street, and built a cathedral of wood, establishing here the See of Lindisfarne. For 112 years the cathedral remained ruled by nine bishops, until the See was removed to Durham. Chester-le-Street then became rectorial, until 1286, when Bishop Bell made the church collegiate, under a dean and seven prebendaries. In 1547 the college was dissolved. The present church was built in 1260, and is the third building that has been erected on the site."

The Locomotive.

HARTFORD, MAY, 1888.

J. M. ALLEN, *Editor.* H. F. SMITH, *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.

AT the last meeting of the directors of The Hartford Steam Boiler Inspection and Insurance Company the following officers were elected for the ensuing year: J. M. Allen, President; Gen. William B. Franklin, Vice-President; Francis B. Allen, 2d Vice-President; J. B. Pierce, Secretary and Treasurer. Mr. Francis B. Allen, who has for five years been Supervising General Agent, will have charge of the Agency Department. He will be ably assisted by Mr. A. S. Ferry, who has been in the company's employ for several years.

WE would call the attention of engineers to the article in this issue on safety-valves. If they will study it carefully and file it away for reference, it will save us much trouble and time in answering questions by mail. Many do not seem to comprehend the principle upon which the necessary calculations, which are very simple, are made. To make this plain we will say: neglecting the weight of the valve itself and the lever, which do not affect the results obtained by more than about three per cent. with ordinary pressures and common lever valves (but which of course must be taken into account if absolute accuracy is desired), it need only be remembered that the area of the valve in square inches multiplied by the pressure in lbs. per square inch and the distance from valve to fulcrum, will just equal the product of the weight of the ball in pounds multiplied by its distance from the fulcrum. In fact, there are simply two forces or weights opposed to each other, one of which is the total steam pressure on the valve, and the other the weight on the lever, and when they are in equilibrium the length of the lever, or distance of weight from fulcrum, will have the same ratio to the distance of valve from fulcrum that the total pressure on the valve bears to the weight of the ball. These are the governing quantities, and when three of them are given the other is at once easily computed. There is nothing occult or mysterious about it, as some seem to think, any more than there is in the fact that if two boys of unequal weight are playing see-saw, the heavier one must sit nearer than the lighter one to the point of support of the board to make the game a success.

VENTILATION AND HEATING, PRINCIPLES AND APPLICATION, is the title of a seventy-six page pamphlet received from Mr. B. F. Sturtevant, Boston, Mass., the well known manufacturer of blowing apparatus. In it the subject of warming and ventilating mills, shops, halls, schools, theaters, etc., is treated in a rational and sensible manner, and the only method by which large buildings can be properly heated and ventilated is very fully exemplified. The pamphlet contains forty-nine illustrations of large heating systems in actual use, and the apparatus used, and much valuable data deduced from practice and not obtainable from other sources. Those interested in the subject should procure a copy.

FRANK A. FOSTER, ex-President of The National Association of Stationary Engineers, has been appointed to a position on the Engineers Corps of the Inspection Department of The Hartford Steam Boiler Inspection and Insurance Co.

The Edison system of Central Station Lighting, 16 Broad Street, New York, has issued a pamphlet, through its Engineering Department, called "A Few Notes on Boilers." It contains some very good advice, and shows that the officers are wide awake to the importance of proper boiler setting and inspection, as well as proper care of boilers. It is entitled to a careful reading.

Some very interesting rivet heads received from one of our inspectors will be illustrated in our next issue. They are almost "as thin as wafers," and were detached or broken off by two or three blows of a very light hammer; and it would be of interest to know how many boilers there are running under very high pressure in this country that are riveted in the same manner.

Safety-Valve Calculations.

Some changes which the U. S. Board of Supervising Inspectors have recently made in the rules for granting licenses to engineers of steam vessels may render the following article of use to some who contemplate applying for such licenses:

To find the weight required to load a given safety-valve to blow at any specified pressure.

First — Measure the diameter of the valve, if it is not known, and from this compute its area exposed to pressure.

Second — Weigh the valve and its spindle. If it is not possible to do this, compute their weight from their dimensions as accurately as possible.

Third — Weigh the lever, or compute its weight from its dimensions.

Fourth — Ascertain the position of the center of gravity of the lever by balancing it over a knife-edge, or some sharp-cornered article, and measuring the distance from the balancing point to the fulcrum.

Fifth — Measure the distance from the center of the valve to the fulcrum.

Sixth — Measure the distance from the fulcrum to the center of the weight.

Then compute the required weight as follows:

First — Multiply the pressure in pounds per square inch at which the valve is to be set by the area of the valve in square inches; set the product aside and designate it "quantity number 1."

Second — Multiply the weight of the lever in pounds by the distance in inches of its center of gravity from the fulcrum; divide the product by the distance in inches from the center of the valve to the fulcrum, and add to the quotient the weight of the valve and spindle in pounds; set the sum aside and designate it "quantity number 2."

Third — Divide the distance in inches from the center of the valve to the fulcrum by the distance, also expressed in inches, from the center of the weight to the fulcrum; designate the quotient "quantity number 3."

Fourth — Subtract quantity number 2 from number 1, and multiply the difference by number 3. The product will be the required weight in pounds.

To find the length of the lever, or distance from the fulcrum at which a given weight must be set to cause the valve to blow at any specified pressure.

The area of the valve in square inches, the weight of the valve, spindle, and lever in pounds, the position of the center of gravity of the lever, and the distance from the center of the valve to the fulcrum must be known, as in the first example.

Then compute the required length as follows:

First — Multiply the area of the valve in square inches by the pressure in pounds per square inch at which it is required to blow; set the product aside, and designate it "number 1."

Second — Multiply the weight of the lever in pounds by the distance in inches of its center of gravity from the fulcrum; divide the product by the distance in inches from the center of the valve to the fulcrum; add to the quotient the weight of the valve and spindle; set the sum aside and designate it "number 2."

Third — Divide the distance in inches from the center of valve to fulcrum by the weight of the ball in pounds, and call the quotient "number 3."

Fourth — Subtract "number 2" from "number 1" and multiply the difference by "number 3"; the product will express the distance in inches that the ball must be placed from the fulcrum to produce the required pressure.

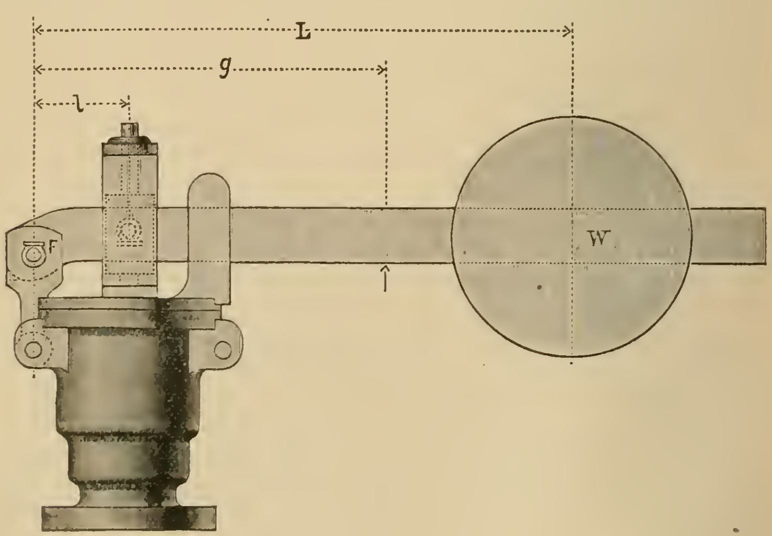
To find at what pressure a safety-valve will commence to blow when the weight and its position on the lever are known.

The weight of valve, lever, position of center of gravity of lever, etc., must be known as in both the preceding examples.

Then compute the pressure at which the valve will blow, as follows:

First — Multiply the weight of the lever by the distance of its center of gravity from the fulcrum; add to this product that obtained by multiplying the weight of the ball by its distance from the fulcrum; divide the sum of these two products by the distance from the center of the valve to the fulcrum, and add to the quotient so obtained the weight of the valve and spindle. Divide this sum by the area of the valve; the quotient will be the required blowing-off pressure in pounds per square inch.

To those who are accustomed to the use of symbols to represent quantities in making calculations, the use of the following notation, and a reference to the cut, will much simplify matters.



W denotes the weight on the lever in pounds.
L " distance from center of weight to fulcrum in inches.
w " weight of the lever itself in pounds.
g " distance between center of gravity of lever and fulcrum in inches.

l denotes the distance between center of valve and fulcrum in inches.
V " weight of valve and its spindle in pounds.
A " area of valve in square inches.
P " pressure in pounds per square inch at which valve blows.

We append a few practical examples for illustration, reproduced from the LOCOMOTIVE of October, 1884:

To find the weight required to load the valve for any given pressure, L, l, g, A, V, and w, must be known. Then

$$W = \left\{ (P \times A) - \left(V + \frac{[w \times g]}{l} \right) \right\} \times \frac{l}{L} \quad . \quad . \quad . \quad . \quad (1)$$

Or, multiply P by A and call the product a; then multiply w by g and divide the product by l and add V to the quotient; call the sum b.

Divide l by L and call the quotient c.

Subtract b from a and multiply the difference by c. The product will be the required weight in pounds.

Example. Diameter of valve = 4″. Distance from fulcrum to center of weight = 36″. Distance from fulcrum to center of valve = 4″. Weight of lever = 7 pounds. Distance from fulcrum to center of gravity of lever = $15\frac{1}{2}$″. Weight of valve = 3 pounds.

What must be the weight at the end of the lever to make the blowing-off pressure 80 pounds?

Area 4″ valve = 12.566 square inches.

$a = 80 \times 12.566 = 1005.28.$ $\quad b = \frac{7 \times 15.5}{4} + 3 = 30.125.$ $\quad c = 4 \div 36 = .111.$

Then $(1005.28 - 30.125) \times .111 = 108.3$ pounds.

To find the length of lever or distance from fulcrum at which the weight must be placed for any required blowing-off pressure, W, w, g, l, V, and A must be known. Then

$$L = \left\{ (P \times A) - \left(V + \frac{[w \times g]}{l} \right) \right\} \times \frac{l}{W} \quad . \quad . \quad . \quad . \quad (2)$$

Or, proceed as in the first case for the quantities a and b. For the third quantity, c, divide the distance from fulcrum to center of valve by the weight. Subtract b from a as in the first case and multiply the difference by c. The product will be the required length.

Example. Take the same data as given in the above case. How far must the weight be placed from the fulcrum to make the blowing-off pressure 75 pounds?

Area 4″, valve = 12.566 square inches.

$a = 75 \times 12.566 = 942.45.$ $\quad b = \frac{7 \times 15.5}{4} + 3 = 30.125.$ $\quad c = 4 \div 108.3 = .037.$

Then $(942.45 - 30.125) \times .037 = 33.7$ inches.

To find at what pressure the valve commences to blow when the weight and its position on the lever are known.

$$P = \left\{ \frac{(w \times g) + (L \times W)}{l} + V \right\} \div A \quad . \quad . \quad . \quad . \quad (3)$$

Example. Take the data in the first of the above cases, where $w = 7$, $g = 15\frac{1}{2}$, L = 36, W = 108, V = 3, $l = 4$, and A = 12.566.

Then we have $\left\{ \frac{(7 \times 15.5) + (36 \times 108.3)}{4} + 3 \right\} \div 12.566 = 80$ pounds.

And in the second case where the weight is 33.7″ from fulcrum we have

$$\left\{ \frac{(7 \times 15.5) + (33.7 \times 108.3)}{4} + 3 \right\} \div 12.566 = 75 \text{ pounds.}$$

Long Distance Telephoning.

In considering the progress made in this country during the past ten years in introducing the telephone to commercial uses, an unprecedented development is at once apparent. Taken up in the beginning as an incomplete experiment, a wonderful toy, the telephone has developed into an indispensable adjunct of commercial business. No city or town of prominence is now without its telephone exchange, furnishing a quick and certain means of intercommunication to the business community, and its radial system of suburban lines connecting the surrounding territory with the commercial centers. Thousands of miles of wire connect the busy instruments, and more than a million "Hellos" sound the preludes to as many messages and their consequent replies transmitted daily by means of the telephone. Although of necessity a delicate and sensitive piece of apparatus, the telephone is probably used by one hundred times as many people as any other known electrical appliance. It is one of the wonderful features of the instrument that it has stood so successfully the test of such varied usage. During the earlier years of their introduction, the great and continued demand for telephones and exchange connections necessarily led to the introduction of operating appliances which, although representing the best knowledge of their time, proved inadequate to the growth of the business. Exchanges were built, reached their limit, and were rebuilt many times over in a space of a few years. Still the network of wires and cables increased, until to-day the large exchanges, representing in many respects the aggregations of past years, are clogged with inductive and retarding influences, which experience only could have developed, and so labor along performing their local functions under a burden of intricate detail which can by no means be appreciated by the uninitiated.

One by one, however, the many difficulties have been met, and, by patient effort and extending experiments, the remedies have been discovered, until, at last, there have been developed means of providing a perfect telephone service, limited in extent only by the cost of suitable lines and equipment. The pioneer work in this new development has been undertaken by the American Telephone and Telegraph Company, of New York, whose lines now radiate in all directions from New York, reaching Philadelphia, Albany, Troy, New Haven, Springfield, Worcester, Providence, Boston, and all important intermediate points. Their construction has occupied nearly three years, and they represent to-day upward of 15,000 miles of undoubtedly the most perfect lines of electrical conductors in the world. White cedar or Norway pine poles, from 50 to 90 feet long, are erected along the most direct highways, there being between 40 and 50 poles to the mile, according to the character of the country. A No. 6 iron guard wire is first strung between the poles from the iron-bound pin in the top of each. White pine cross-arms each 10½ feet long, and provided with ten pins and insulators, are bolted to the poles, and held firmly in place by iron braces. The line wires are of No. 12 hard drawn copper wire, weighing 170 pounds per mile. Each lot of this wire is specially tested for tensile strength and conductivity before leaving the factory. An expert force of men is employed in stringing the wire and in perfecting all the details of the construction work. The present lines of poles carry from 10 to 80 wires, the full capacity of the heavy lines being estimated at 100. Testing stations are located along the various routes from 30 to 50 miles apart, at each one of which a competent repair man is stationed. Rivers and bays are cabled by heavily insulated and armored conductors, terminating in snug cable houses on the banks. The experience in the operation and maintenance of these lines during the past year has been unprecedented. Days, weeks, and months have passed on a number of the main lines without marking a single interruption. All wires being tested at an early hour each morning, any portion of the system can be reached and repairs made before the opening of business hours. In hail and sleet, wind, rain, and floods, the long distance lines have held their own and answered promptly to the call for service. No system of intercommunication heretofore devised has provided so perfect a means for the transaction of business between distant points as the long distance telephone. By means of it, conversation is readily carried on between the parties present at the instruments, and all the benefits of a personal interview are secured without travel or loss of time.

Appreciating the great benefits to be derived from the use of such valuable facilities, the public response to the tender of service has been most gratifying. Representative bankers, brokers, and manufacturers, and even great railway corporations, have found in the long distance telephone a service which has never before been approximated. Great factories are brought into the closest relationship with their city offices. Important business transactions, heretofore requiring hours or days of time, and dozens of telegrams or letters, are concluded definitely and satisfactorily in five minutes' conversation by telephone. It has been said, if we have no haste in our communication, we may write a letter; if a short or direct message only is to be sent, we may telegraph; but now, if we have urgent business to transact, and wish to secure the advantages to be derived only from personal conversation, we may telephone. Here, therefore, is the growing and fruitful field for the perfected service. Successful to-day over many hundreds, who can predict how many thousands of miles shall mark its limitations? — *Electrical Review.*

Bill Nye on the Speed Recorder.

In Franklin there is an old wheelbarrow which Mr. Gould used on his early surveying trips. In this he carried his surveying instruments, his nightshirt and manicure set. Connected with the wheel there was an arrangement by which at night the young surveyor could tell at a glance, with the aid of a piece of red chalk and a barn door, just how far he had traveled during the day. This instrument was no doubt the father of the pedometer and the cyclorama, just as the boy is frequently father to the man. It was also, no doubt, the avant courier of the Dutch clock now used on freight cabooses, which not only shows how far the car has traveled, but also the rate of speed for each mile, the average rainfall, and whether the conductor had eaten onions during the day.

This instrument has worked quite a change in railroading since my time. Years ago I can remember when I used to ride in a caboose and enjoy myself, and before good fortune had made me the target of the alert and swift-flying whisk broom of the palace car, it was my chief joy to catch a freight over the hill from Cheyenne on the mountain division. We were not due anywhere until the following day, and so at the top of the mountains we would cut off the caboose and let the train go on. We would go into the glorious hills and gather sage hens and cotton tails. In the summer we would put in the afternoon catching trout in the Dale creek, or gathering maidenhair ferns in the bosky dells.

It was a delightful sensation to know that we could loll about in the glorious weather, secure a small string of shark, varnished trout with chapped backs, hanging aimlessly by one gill to a gory willow stringer, and then beat our train home by two hours, by letting off the brakes and riding 20 miles in 15 minutes.

But Mr. Gould saw that we were enjoying ourselves, and so he sat up nights to oppress us. The result is that the freight conductor has very little more fun now than Mr. Gould himself. All the enjoyment that the conductor of "Second Seven" has now is to pull up his train where it will keep the passenger of No. 5 going west, from getting a view of the town. He can also, if he be on a night run, get under the window of a sleeping car at 1:35 A. M., and make a few desultory remarks about delinquency of "Third Six" and the lassitude of Skinny Bates, who is supposed to break ahead on No. 11 going west. That is all the fun he has now. — *Letter in St. Louis Post-Dispatch.*

The Locomotive.

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The Great Boiler Explosion at Friedenshütte.

At the request of several members of the *Union of Societies for the Inspection of Boilers in Prussia*, a general meeting of the whole Union was held at Berlin last February, to investigate the terrific explosion of twenty-two steam boilers, which occurred

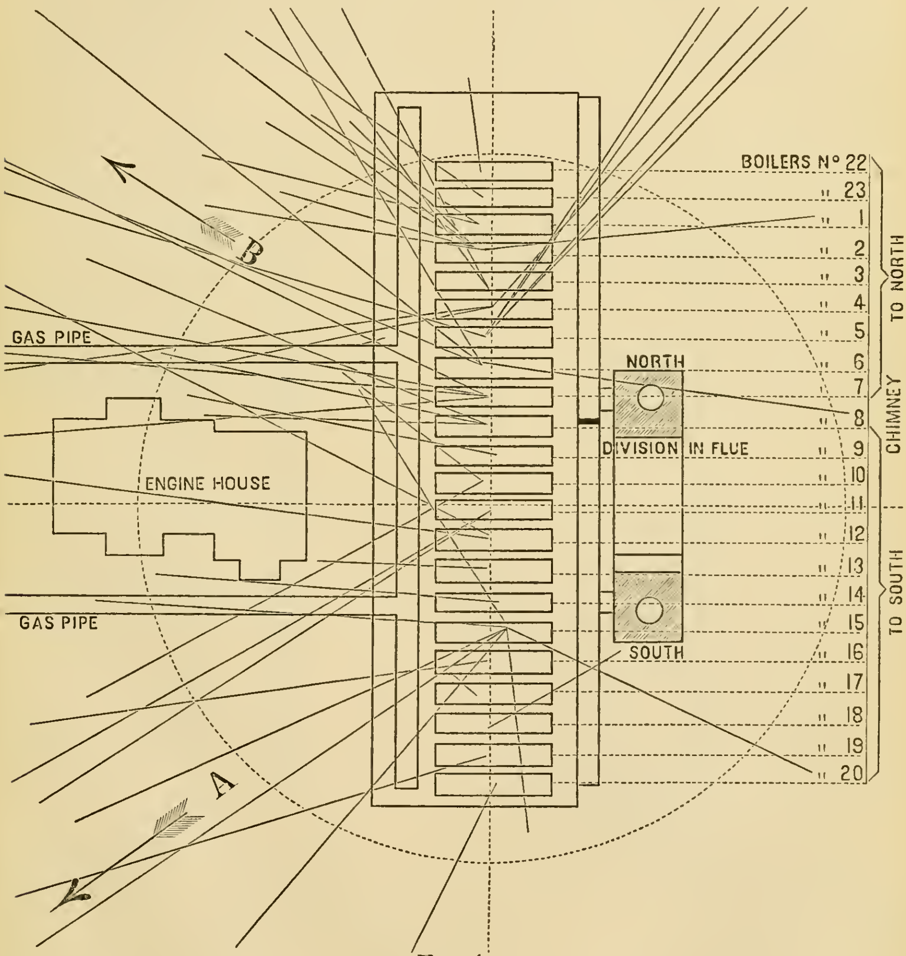

Fig. 1.

at Friedenshütte, in Upper Silesia, on the 25th day of July, 1887, of which a short notice appeared in our April issue. The Prussian government was also represented by officials from several departments.

Two papers were read upon the subject, one of which was compiled by the engineers of several Rhenish boiler inspection companies, and the other by engineers of companies working in the north and east of Prussia, which differed only in some matters of minor detail. The assembly, therefore, appointed a committee of six chief engineers to compare the two reports and draw up a new one embodying the essential points of the two, to be sent to government officials, the various industrial or technical journals, and reputable daily newspapers. This committee consisted of the following named engineers: Weinlig, of Magdeburg; Eckermann, of Hamburg; Böcking, of Düsseldorf; Vogt, of Barmen; Münter, of Halle; and Emundts, of Gladbach. The following is a synopsis of their report, for which we are indebted to Herr Minssen, of Breslau, editor of the *Journal of the German Boiler Inspection Societies.*

The terrible accident at Friedenshütte stands without a parallel in the history of boiler explosions. Neither German, American, nor English statistics show anything approaching in magnitude and destructiveness the huge catastrophe in Upper Silesia. A consideration of all the facts in the case leads inevitably to the conclusion that the explosion was not due to the causes which ordinarily bring about boiler explosions. Before entering into a discussion of the explosion, we must say that there was no fault to be found with the inspection or management of the boilers. We make this statement here in order that we may not be misunderstood when we afterwards speak of defects of construction and in the general arrangement, for the explosion was partly due to this and partly to defects or conditions arising suddenly and not visible after the explosion. The investigation of a single boiler explosion often involves much trouble in the search for details, and in this case is rendered much more difficult by the fact that the fragments of the different boilers could not be identified. Portions of some of the boilers could not be found at all. All the details of the disaster will certainly never be known; it is without precedent, and all that can be done is to give a reasonable explanation that accords with what facts are known.

The boiler-house at Friedenshütte contained twenty-two steam boilers, which were arranged in one continuous battery, side by side. They were all precisely alike. Each consisted of an upper cylinder, 1,570 millimetres (61.8 inches) diameter, and 12,550 mm. (41 ft. 2 ins.) long, and two lower cylinders 785 mm. (30.9 ins.) diameter, and 11,765 mm. (38 ft. 7.2 ins.) long. These lower cylinders were connected with each other by one neck, about 20 inches in diameter, near the front end, and each was connected to the upper cylinder by two similar necks a few feet from the ends.

The plates of the upper shells were 13 mm. ($\frac{1}{2}$ in.), those of the lower shells 8 mm. ($\frac{5}{16}$ in.), and those of the necks 11 mm. ($\frac{7}{16}$ in.) thick.

The upper cylinders were supported in the usual manner by wrought-iron brackets resting upon the side walls of the brick-work; the lower ones rested, one upon three, and the other upon two iron chairs.

The pressure allowed was 75 lbs. per square inch (5 atmos.). With the above thicknesses of plates, this was not excessive.

The boilers were all connected to one main steam-pipe passing over them by copper pipes, which were furnished with self-acting steam valves of 156 mm. ($6\frac{1}{8}$ ins.) diameter, and two safety-valves of 85 mm. ($3\frac{5}{16}$) diameter, as shown in Fig. 3.

The feed apparatus was the same for all boilers, there being two pipes with check-valves in front of each boiler, in the ordinary manner.

The flues were arranged as they usually are with boilers of this type. At the rear end of the battery a large flue received the gases from all the boilers and carried them to the chimneys, of which there were two. Near the middle of this flue was a division

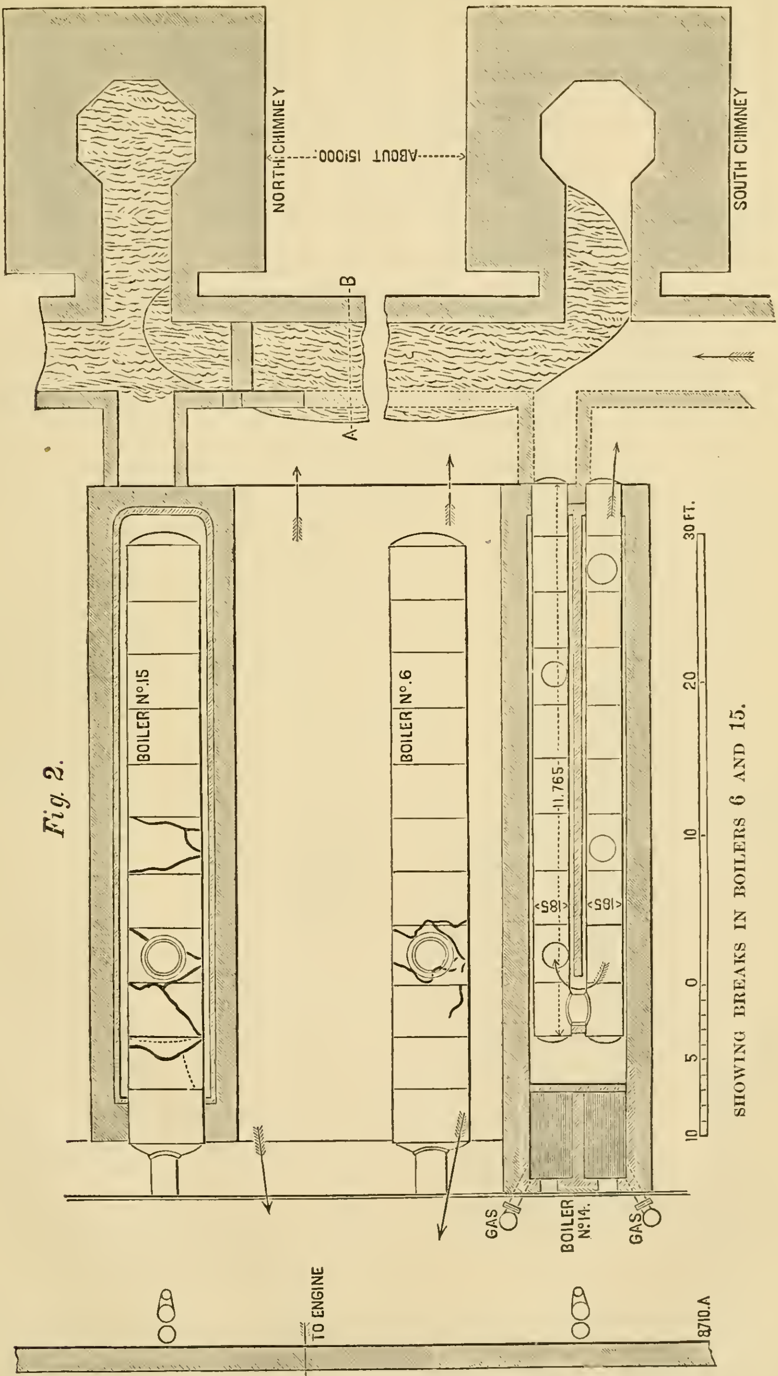

Fig. 2.

SHOWING BREAKS IN BOILERS 6 AND 15.

wall, causing boilers Nos. 22, 23, and 1 to 7 inclusive, to discharge into the northern stack, and 8 to 20 into the southern one. (See Fig. 1.)

The boilers were all fired by high furnace gases, distributed from an iron pipe to all in the same manner, by smaller vertical pipes to each boiler. Besides this, there was a double grate, each 1,885 mm. (6′ 2″) long, and 940 mm. (3′ 1″) wide beneath the front end of upper cylinder. The furnace gases were introduced above this grate, on which was kept continuously just sufficient fire to ignite the gases as they entered. The amount of coal-dust burned for this purpose did not exceed from 2 to 3 lbs. per square foot of grate surface per hour, so that two men and a boy were sufficient to do the firing and attend to the water in all the boilers.

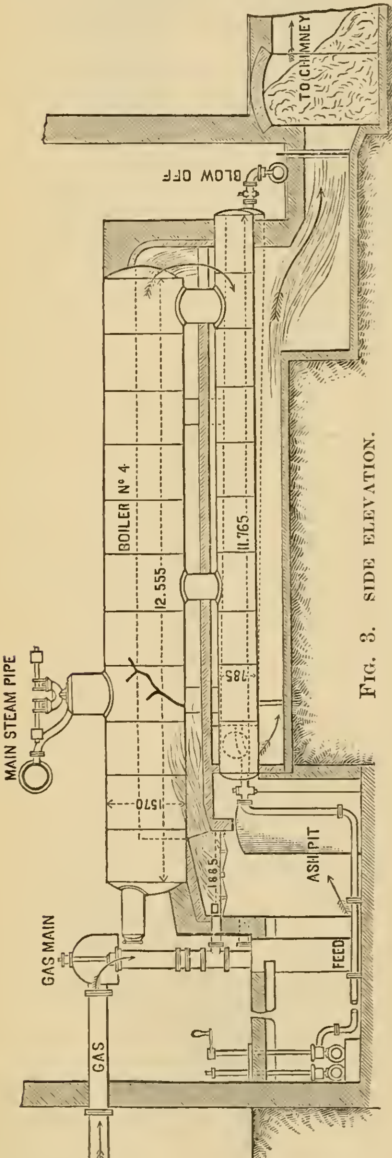

FIG. 3. SIDE ELEVATION.

Steam was required only for the blowing engines, and some other minor purposes, so that eighteen boilers were always sufficient to do the work; four boilers were therefore always out of use for cleaning and repairs. Shortly before the explosion, Nos. 1, 3, 16, and 20 were blown off and were empty.

The feed-water was, as is apt to be the case in coal districts, bad for boiler use. It made a bad scale, which became detached, and, falling to the bottom of the boilers, formed a deposit which caused some pitting of the shell-plates. The analysis of the water gave the following result:

Silicic Acid,	-	.0300 grammes.
Iron Oxide,	-	.0160 "
Lime, -	-	.2624 "
Manganese Oxide,		.0540 "
Sulphuric Acid,	-	.3698 "
Chlorine,	-	.0139 "
Organic matter,	-	.1200 "

The feed apparatus was of sufficient capacity, and in good order.

Twenty of the boilers were built in 1872. The plates were of iron. It is well known that iron plates made from 1871 to 1873 lack the elasticity and ductility essential in boiler-plates. They were very brittle, and tests made on fragments of the exploded boilers showed a quality much below the usual standards, although it is impossible to ascertain how much the plates had deteriorated by their fifteen years' use day and night.

For fifteen years, day and night, the boilers had run without interruption, until, at half past 12 o'clock, on the night of July 25, 1887, the twenty-two boilers, including the four empty ones, exploded without any warning whatever. The boiler-house was completely demolished, and several small houses in the vicinity, occupied by the workmen, were set on fire by red-hot bricks, which were scattered over their roofs.

The three firemen were instantly killed, nine more workmen were so badly injured that they died three days afterward, and thirty other men and women were more or less severely injured, but recovered.

The heap of ruins was so vast and chaotic that the discovery of every detail of the explosion was impossible, although the investigating engineers examined every piece of iron which was found during the clearing away of the debris, which work required several weeks to accomplish.

Low-water at the same time in eighteen boilers cannot be considered possible. It is not at all probable that the pumps did not draw, or that five pumps, of which three were continually working, would all fail at once, nor could it occur in so many boilers all at once by leaking seams or unusually great evaporation without being discovered.

A soft blue annealing color, which showed itself upon some plates of boilers 6, 7, and 12, was found, but only upon single plates of these boilers, and in no instance extended over the whole surface of the plates. To find it at all it was necessary to scrape off the oxide of zinc with which the plates were covered; the inner surface of the plates and the fractures through them did not exhibit the blue color at all. All things considered, low water as a possible cause of the explosion cannot be considered.

An excessive steam pressure could only arise when the engines were stopped and the firing of the boilers was continued, with all thirty-six of the safety-valves stuck fast to their seats. And in this case, with the blowing engines stopped, the flow of gas would have ceased, and the pressure would have to be raised by firing with coal alone; and, as we have seen, the amount of coal used was so very small, a dangerous pressure could not have been reached for many hours. There can be no plausible explanation of a dangerously high steam pressure.

There is still to be considered the question whether the catastrophe would not have been brought about if, by chance, one or two of the boilers had exploded from some of the ordinary causes.

There is no doubt that, by the explosion of one or two of the boilers, a violent shock and a destruction of the large main steam-pipe would have occurred, and we must suppose there could occur a sudden discharge of pressure from the other boilers, in consequence, and their explosion might follow as a result. But this is not probable. Each boiler was connected to the main steam-pipe by a pipe six inches in diameter, through which the steam would have to escape; and experience shows that the sudden opening of a pipe of this diameter in a boiler having the amount of steam and water room of those under consideration is not sufficient to produce any serious disturbance. Besides, it must be considered that the upper cylinders flew in a direction just opposite to that which they ought to have taken had the explosion occurred in this manner.

Official statistics of boiler explosions in Germany show, of fifty-seven explosions of boilers of the same type of construction as those at Friedenshütte, eighteen boilers exploded in batteries, and in only one case did the explosion of one boiler cause the explosion of a neighboring one, the number of boilers in the batteries ranging from two to ten.

All things being considered, we must believe that the accident was caused by the use of the furnace gases for heating the boilers. An explosion of these gases, either alone or mixed with gases from the coal used, is the only thing that could produce the effect shown by the direction of flight of the boilers. We should not think the effect of the exploding gases would be so serious were we not convinced that the construction of the boilers was favorable to it and the materials of bad quality.

The furnace gases burn all along the flues, so that there are no really well defined furnace plates. This gives rise to great expansion and contraction in different parts of the boiler, which is manifested by cracks at girth seams, etc. The construction of such boilers is also inherently defective, and they are fortunately fast going out of use.

The fan-like form of the direction in which the fragments of the upper cylinders were thrown, the manner in which the flues were destroyed, the front side of the main flue between the chimneys being squeezed against the back wall, and the top blown off all show that the active agent was a force acting from a center between the two chimneys. This could be nothing but an explosion of the furnace gases mixed with gases from the coal.

The composition of the gases from the Friedenshütte furnace is estimated as follows:

Nitrogen,	63	per cent.	by val.
Carbonic Oxide,	34.3	"	"
Carbonic Acid,	.6	"	"
Hydrogen,	1.4	"	"

on the authority of Bunsen, Ebelman, Schurer, etc.

Jung of Burbacher-Hüette gives their composition as follows:

Nitrogen,	60	per cent.
Carbonic Oxide,	24	"
Carbonic Acid,	12	"
Hydro-carbons,	4	"

and says: "The greater the amount of carbonic oxide, the greater the value of the gases for heating purposes."

Lürmann, a well-known furnace engineer, says furnace gases are "difficultly burning" and warns against trying to burn them and coal together.

The furnaces at Friedenshütte blew grey Bessemer iron. The gases are very rich in carbonic oxide, aud poor in carbonic acid.

By stoppages, for instance, at drawing the furnace, by sudden shutting down of the steam engines, or by simultaneous opening of the furnace lids, the flow of gas under the boilers might entirely cease and the flames be extinguished. When the flow again begins, unburnt gases enter the flues, air enters through the grates, fire-doors, cracks in the brick-work, etc., and the explosive mixture is formed, and only waits ignition, which occurs sooner or later.

During the hour from 12 to 1 at night there was a pause for taking supper, as for dinner at noonday. Very likely, at this time an extra thick layer of coal-dust was put upon the grates, or the flames were extinguished after the coal was burnt out. After mixing of both sorts of gases, from the furnaces and from the coal, it would be quite immaterial where the ignition of the mixture began, or whether several explosions occurred at once, or only a single one in several flues.

In either case, if a gas explosion occurred, the effect upon the boilers would be the same. The thrust from underneath the upper cylinders would first break the middle of the boiler and, simultaneously, the rear connecting leg, thus separating the upper from the lower cylinders, the upper boiler rising at its rear end and turning on the forward connecting leg, would be projected forward, upside down. This was exactly what occurred in this case.

It is not our purpose to criticize the use of furnace gases as fuel for boilers, nor to condemn the above-described arrangement, for it is only in very rare cases that there would be a coincidence of all the dangerous conditions, as at Friedenshütte. Other and better constructions than these, which do not allow of the extinguishment of the gases, are well known and appreciated in German iron districts.

In short, we may sum up the results of our investigations in the following words:

By an unfortunate coincidence, an explosive mixture of gas and air formed in the boiler flues, and suddenly ignited. The effect of this gas explosion was a local rupture of some parts of the boilers, which was easily effected in consequence of the great length and inferior construction of the boilers, and the bad quality of the materials. The explosion of the gas worked the lifting and breaking of the boiler-shells, which resulted in the tremendous explosion and devastation of the whole boiler-house.

Boiler Explosions.

April, 1888.

Steamer (74).—The boiler of the steamer *Bob Irving* exploded on the Skagit River, W. T., April 1st. When parties who were within hearing distance at the time went to the *Irving's* assistance, it was found that the latter was wrecked, and by the explosion the master and owner, Captain Olney, and the fireman had been killed. The engineer, a deck-hand, and a Chinese cook were badly injured. The steamer was loaded with hay and oats, which were scattered in every direction. The boiler was hurled completely out of the boat and lodged on the bank of the river. The head of the captain was severed from the body. No traces have been found of the remains of the fireman. There is some doubt as to the cause of the explosion, but it is believed that the water in the boiler was allowed to get too low. The report of the explosion was heard for some miles in the surrounding country.

Iron Works (75).—By the explosion of a boiler at an iron works in Richmond, Va., April 2d, the man in attendance was killed.

Locomotive (76).—A freight engine exploded its boiler on the Erie railroad at Craigville, N. Y., April 6th. Conductor John Clark, Engineer John Bodine, and Fireman Boyce were killed. The explosion hurled the boiler several hundred feet over a stream and into an adjoining field. The fire-box was thrown far into the air. A heavy iron rod was thrown a quarter of a mile, and other parts of the machine were scattered in all directions. The report of the explosion was heard for miles around, and the windows of houses were broken. Only the heavy driving-wheels were left on the track. The engineer and fireman were thrown on either side of the track, and when assistance came they were dead. Conductor Clark was yet alive, but his skull was crushed and he had internal injuries. He was taken to a house near by, where he died. Engineer Bodine was fifty years old, married, and lived at Middletown, N. Y. Clark was thirty-five years old, and lived at Port Jervis. Boyce had only been on the road a short time. It was thought that his home was in New York.

Knitting-Mill (77).—One of the presses in the New Britain Knitting Factory, New Britain, Conn., exploded April 7th, creating a panic and nearly scalding to death the operator, Tremont Hall. The press was blown to pieces, and many employees had narrow escapes. The cause of the accident is said to be due to a defective steam-trap.

Violin Factory (78).—By the explosion of a boiler in the violin factory of Julius Kraft, on Bay Avenue, Brooklyn, N. Y., April 9th, two men were severely injured. The boiler was a small second-hand affair, which Kraft had just purchased of John Mein, a machinist, and Mein and a man who was employed by him had set up the boiler and a small engine, and were just testing it when it went up. Mein and his helper were the injured parties, and it is to be hoped that every man who is engaged in the business of selling such traps will meet with a similar experience.

LOCOMOTIVE (79).— There was an accident on the Atlantic & Pacific Railroad, at Caruzo, Arizona Ter., April 8th. The flues blew out of an engine, injuring four men. The fireman and brakeman are not expected to live.

SAW-MILL (80).—At Baldwin, Ill., a saw-mill boiler exploded April 10th. A young man named Isaac Holden was engineer, and had just started the engine when the accident took place. Three other men were at work at the saw-mill,— John Henry, Henry Fink, proprietor, and James R. Mitchell. Mitchell, who occupies the position of second sawyer, was thrown across the log that was being sawed into lumber, and had one leg sawed off and several other bad bruises that caused immediate death. Holden was blown about fifty feet from where he was standing against a brace in the mill, breaking the brace and nearly severing his head from his body. He was dead before any assistance could reach him. Fink, the proprietor and also head sawyer, received several bad cuts on the head and other serious injuries, which may prove fatal. John Henry was at work removing the sawdust in the pit, received a cut in his head, but was able to give the particulars. The boiler and engine were blown about one hundred yards from the mill.

SAW-MILL (81).— April 12th, at Pelapatchee, Miss., a saw-mill boiler exploded, killing three and injuring one.

SAW-MILL (82).— At Coalville, Ohio, April 12th, an old boiler in a saw-mill exploded, killing two men and badly injuring three others.

COLLIERY (83).— One of a nest of eleven boilers at Centralia Colliery, Centralia, Pa., exploded April 15th, with fearful results. The fireman noticed that one of the boilers was leaking and went about examining it, while the engineer started for the engine-room to turn off the steam. He had no sooner reached it than the explosion occurred. Neither the fireman nor engineer were injured, but Michael Dixson, James Flynn, and John Purcell, who were standing on the Lehigh Valley Railroad, opposite the colliery, were struck with the flying pieces of boiler and seriously injured. The boiler-house took fire, but was extinguished by the people of the neighborhood. The boiler-house was completely wrecked, and the colliery will be idle for two weeks in consequence. Loss will reach $2,500.

SAW-MILL (84).— April 16th, at St. Charles, Mo., a saw-mill boiler exploded. Two were killed, and two badly scalded.

HEATING BOILER (85.)— April 18th, at Union City, Tenn., a boiler in the bath-room of a barber shop exploded and demolished the building, and badly scalded two persons.

RESTAURANT (86).— An explosion occurred in the Citizens' restaurant, on Fulton street, near Willoughby, Brooklyn, N. Y., April 19th. The restaurant was owned by Charles Raynor, and was located in the Brooklyn *Citizen* building. It was caused by the bursting of a hot-water tank. The two plate glass windows of the restaurant were blown out and the place considerably wrecked. Raynor was severely cut on the head and leg by a piece of iron. George Edwards was cut on the arm, and Ida Flynn was cut about the head. Raynor's condition is considered serious.

STEAM TUG (87).—Between two and three o'clock, P. M., April 21st, the large tug-boat *Magic* was blown to pieces at the head of Newtown Creek. The boiler that exploded scattered in every direction, a large portion traveling a distance of three hundred feet. The pieces of iron and wood ascended a distance of two hundred feet. A dozen people who do business at the head of Grand Street, which is near the scene of the disaster, say the sight of the flying debris went beyond anything they had ever seen. Two men were blown to atoms, and another was frightfully injured. Thus far it has not been learned whether, or not, any of the people in the neighborhood were injured. The boat was one of the largest that has been at work on the creek. It was owned by one of the firms doing business there and only plied from the mouth of the creek at the river to the head of the creek, about where the explosion occurred. What led to the explosion and the other circumstances of the disaster could not be learned. It is feared that more than two men were killed. Of the latter nothing has been found excepting their hats and small portions of their clothing. The third man is terribly mutilated. The explosion is regarded as the worst that has occurred in the vicinity of Brooklyn in years. The engineer, Samuel Barber, and the cook, William Symington, were the men killed. The captain of the boat was not on board. He left a few minutes before the explosion. The firm of Russell Brothers owned the tug. When the disaster occurred she was moored at Burr's dock.

Steamer (88).— The steam ferry boat *Belle*, of Ashland, Ky., exploded her boilers April 20th. The boat is a total wreck. Capt. J. L. Kouns had two ribs broken and was severely bruised and burned about the head. Abram Moore will die. He had an eye blown out and his head cut. Two or three others were seriously hurt. It was a clear case of dry boiler.

Cotton Mill (89).— By the breaking apart of an eighteen-inch steam main at the mill of Messrs. B. B. & R. Knight, Natick, R. I., April 21st, George H. Downing, chief inspector of piping, was instantly killed, and John Rice, a watchman, who was sitting one hundred feet away, was bad'y scalded. The inside of the building where the break occurred was badly wrecked. The cause of the break is not clear, as only eighty pounds pressure was on, and the pipe had been tested to 400 pounds pressure.

Paper-Mill (90).— The boiler of the Russell Paper Company, Lawrence, Mass., used to boil rags, exploded April 28th. Michael Melvin and Robert Evans, who were in the room at the time, were both blown through the walls, which were partially demolished. They were carried to the hospital. The former is very badly scalded and probably will die. Evans's injuries are not serious. The report of the explosion was heard all over the city. No cause for the accident is known.

Tile Factory (91).— The boiler of the tile factory, owned by William Caldwell, situated eighteen miles north of Shelbyville, Ind., blew up just as the machinery was started, April 30th, instantly killing the owner, William Caldwell, and Norman Conde, and fatally injuring Joseph Laken. Five others, Joseph Wolf, Allen Laken, Jordan Calwes, Lou Rea and his son, were badly wounded, and two of them were expected to die. A large portion of the boiler was blown several hundred feet, and the brick-work in which it was set was sent flying in all directions, destroying the building and doing great damage. The mill had been idle for almost a year, and the boiler was filled for the first time on Saturday night, and allowed to stand until the morning of the explosion, when a fire was built under it. Unknown to the engineer, the water had almost all leaked out of the boiler, and the little left was converted into steam so quickly that the boiler could not stand the pressure.

An apparatus for burning the gas from the distillation of petroleum is being tried. A tank holding 162 gallons of petroleum is placed on the tender, and the petroleum runs by gravity into the retort, which is also placed on the tender, and the gas is fed into the fire-box by a small steam injector. It is said that steam is easily raised and maintained.

The Locomotive.

HARTFORD, JUNE, 1888.

J. M. ALLEN, *Editor.* H. F. SMITH, *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.*
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OUR leading article this month will be found of interest as a description of the greatest explosion of steam boilers which the world has ever seen. It is to be hoped that it will never see another one like it. The report from which our article is extracted contains a very full and complete description of the boilers, their settings and attachments, and a minute and detailed discussion of all the causes which could possibly lead to the accident, besides much valuable matter relating to gas-fired boilers and kindred subjects, which we regret that we have not space to reproduce in full. We believe, however, that we have touched upon the most important points, and believe the article will be found of sufficient value to repay a careful perusal. It emphasizes the fact that gas-fired boilers at iron works, as we have frequently pointed out, are subjected to very severe conditions, and that too much care cannot be exercised in their design, construction and management.

THE explosion which probably caused the greatest loss of life on record occurred on the Mississippi River near Memphis, Tenn., on the 26th of April, 1865. The steamer *Sultana* was on her way up the river with about 2,200 people on board, mostly Union soldiers just liberated from southern prisons. When near Memphis her boiler exploded, destroying the boat, and 1,700 lives were lost. Many were instantly killed and the others were drowned, being too weak from their experience in the prisons of the South to do anything to save themselves.

THE latest idea in boiler construction is to leave several bad leaks in the boiler to allow for expansion. Expansion of what is not stated, but some one who is described as a competent engineer says it is so, and that boilermakers prefer to have new work show leaks for the above reason. Now this may be so, but if it is why is it that seams are caulked destructively, painted sometimes, puttied, and even have driven into them wooden shims to prevent leaks when getting ready for the hydrostatic test? And why is it that in those shops where they have the reputation of doing the best work no leaks occur, no paint is allowed on the boiler until after it has been tested, and in many cases 150 pounds pressure does not cause *one drop* of water to come through seams?

A CORRESPONDENT of *Power* gives an amusing account of a saw-mill boiler explosion which occurred last February out in Michigan. It seems that about three weeks before the explosion there was a fire on the premises which damaged the steam gauge. It was taken to a machine shop, repaired and sent back with the statement that it was "as good as new". Of course it was. Somehow or other, though, it would stick, and no one could tell how much pressure was on it without "whacking" it with a stick or anything else that was handy. On the morning of the explosion the proprietor of the mill started a fire under the boiler, got up 40 pounds pressure, filled up with water, and went to breakfast. When he returned he found the fireman "whacking the gauge as usual," which indicated 60 pounds. They began the day's work as usual, but on giving the engine steam it "fairly jumped". After sawing one log the proprietor concluded that there was more pressure on the boiler than he had ever had before. He then told the men to be getting another log ready while he "whacked" the gauge to see if it wouldn't rise higher. He had just begun the operation of "whacking" when the boiler let go. Both heads were "whacked" out clean and blown about 30 rods. The flues were broken up into pieces about 2 feet long and "whacked" together flat. The fireman was instantly killed, and the proprietor was badly hurt. Altogether it seemed to be quite a good day for "whacking".

We know now why boilers explode. Peter has told us all about it. There are two kinds of steam in a boiler when it is at work, viz., engine-driving steam, which is one-third water, and explosive steam. Explosive steam may be of a variety of colors, blue, red, mottled, and in fact anything else almost, it all depends upon the color of the end of one's nose and how he looks at it. It is also liable to get dry and "grippy", whatever that is. As long as you can keep the two kinds of steam well mixed there is no danger of an explosion, no chance for the red, white, and blue explosive steam to get "grippy", but just let them get separated, let the explosive steam get into a layer by itself down next to the water, where hot spray can "spatter" up into it and off she goes! Just exactly 2000 lbs. per square inch will be generated under these circumstances every time and don't you forget it for Peter says so and he run a boiler this way two years and it didn't explode either and he run it all the time with low water and you can't explode a boiler unless it has low water they only burst when they have enough water in them and he has examined 7484 hundred cases and only one burst and that had on 170 lbs. and you needn't blow up then if you'll keep blowing off and a boiler will explode just as quick with 10 lbs. as it will with 350 pounds and every boiler explosion is just the same way; — at least this is what Peter says.

Early Railroading in New England.

By Samuel Nott, C. E.

Further as to early railroad matters in New England: The Boston & Worcester Railroad Company in 1834 experimented with the *Black Hawk*, a locomotive built in Philadelphia, Pa., to use anthracite coal for fuel. One of the experiments left the *Black Hawk* helpless on the track a few miles out from Boston, and the *Meteor*, referred to in the January and April, 1888, Locomotive, came to the rescue, and hauled the disabled *Black Hawk* to Boston in fine style. That locomotive soon abandoned the field to wood-burning locomotives, and for some fifteen years no progress was made in New England in the use of anthracite or bituminous coal for locomotive fuel. About 1850, bituminous coal began to be so used, and for nearly thirty years has been the main fuel in Southern New England, at least, and anthracite coal has, as is well known, long been the main fuel in large regions, in and near which it abounds.

PASSENGER CARS.

Supplementing the notes of January, 1888, on the locomotive *Meteor* (1834), the following regarding passenger cars and their development in New England, from the coach form, then shown, may be of interest: In August, 1838, when the Eastern Railroad was opened from East Boston to Salem, thirteen miles, it was equipped with cars of four wheels, seating twenty-four passengers, twelve each side of a midway passage. The wheels were boxed up into the car, damaging several seats. Street car No. 50 in Hartford is about a fair sample of many of those Eastern Railroad cars as to size and weight, excepting the ventilating top. Those cars of 1838 were greatly praised and considered very luxurious. In January, 1843, when the Portland, Saco & Portsmouth Railroad was opened from Portsmouth, N. H., to Portland, Me., fifty miles, as an extension of the Eastern Railroad, it was equipped with cars seating forty-eight passengers, and run on two trucks of four wheels each. These were considered perfection. As to weight and strength, they were as paper boxes compared with the best passenger cars of the present day.

For twenty-five years down from 1840, as the writer remembers, though the cars were supplied with stoves of the simplest kind, and burning wood mostly, there were no fires caused by them when accidents happened to the cars. In these later years such accidents have usually led to fires, which have been very destructive to life, although the stoves and other heating arrangements are better, and better secured, seemingly, than before. Why this difference? The only explanation occurring to the writer is that the earlier cars were built of woods seasoned by the natural process, and the later cars of woods seasoned by artificial processes, and thereby become as tinder, compared with the other woods. The great increase in the quantity of oils, paints, and varnish used per square foot of surface work in passenger cars in these later years, as compared with the earlier work, has also seemed to be a reason for the great increase of danger from car stoves and other car-heaters.

A Quick Stereotyping Process.

A new stereotyping process is described as "almost as quick as lightning" by the *Paper World*. As a matter of every-day labor the "starter", or the number of plates required to enable the pressmen to begin work on the presses, is completed, ready for the presses, in seven and one-half minutes, and thereafter two plates a minute are turned out.

The means by which this extraordinary feat is accomplished are interesting as showing the wonderful improvements in one of the mechanical arts within the last year. Stereotyping is one of the newest of the important arts of the world. In 1850 Kronheim & Co., of Paris, invented the papier maché process, which is the process of pressing a wet, thick, soft sheet of paper into the face of a form of tpye so as to form a paper matrix of the type. Then this matrix is put into a mould, and melted type metal is poured in, which, when cooled, forms a plate ready for the press.

Until within a few years this paper matrix was built up by pasting several sheets of paper of different qualities together, the inner sheets being somewhat like blotting paper, and the face that was to go against the type very tough and of fine quality. Now a paper is made especially for the purpose, and sold to the publishers in sheets of the size of the pages of the newspaper.

The first to try to introduce the stereotyping process to newspaper publishers was a man named Duncan, who came over from London in 1856, hoping to find America more appreciative than British publishers. He failed because the circulation of American papers did not then demand such an innovation, the Hoes having just turned out their first lightning press. It used type, and there was no real need of plates.

A year later, however, the circulation of the London *Times* had advanced so far that the publisher was obliged to set the forms in duplicate, using two of Hoe's mammoth presses. The great cost of a double force of type-setters made the manager ready to listen to an innovator. At that time James Thompson was foreman of the London Newspaper Stereotyping Company, a concern engaged in selling column plates of news to country newspapers on what is now called the patent plan. The *Times* investigated Mr. Thompson's methods, and adopted them, first for the advertisements standing over from day to day, then for whole pages of advertisements, and, finally, for the entire paper. It was considered a triumph of human ingenuity when the work had been so far perfected that two plates were turned out complete in forty-five minutes. The paper did not get to press so early by that forty-five minutes, but the publishers had saved the cost of setting the type in duplicate. The adoption of the system by the other papers of large circulation followed as a matter of course, for even if they did not have to set their type in duplicate they saved enough in the wear of type to justify the expense, not to mention other advantages of plates, such as the ease with which extra copies can be printed as wanted.

In the early days a matrix which would stand the casting of two perfect plates was considered very good, and one enterprising publisher of New York offered a substantial reward for any one who would produce a matrix that would yield six perfect plates. Now, by a secret chemical process developed by Mr. Thompson, a matrix is made that will turn out sixty plates if needed.

But the most important improvements relate to those parts of the work which consume time between the moment of receiving the type form and the handing of the completed plate to the elevator man to be carried to the press-room. Formerly with a good many motions, consuming much time, the paper was beaten into the interstices between the type, with brushes; but now, by the new process, when the form is shoved on to the bed of the moulding press the type is oiled as before, the prepared paper is laid on, a blanket is laid over all, and the form and bed are rolled between two heavy iron rollers that do in thirty seconds the work which took two men with brushes six or seven minutes to perform.

From this press the form with the matrix on goes to a drying press as before, but, what with steam below the bed and gas jets in the platen, it remains in this press only three minutes.

The matrix is now taken off. It is steaming hot, but stereotypers are the modern salamanders, and do not mind a little matter of handling things heated up to 212 degrees Fahrenheit. From this press the matrix goes to a scorching table, which is one of the important improvements made by Mr. Thompson. It is simply a flat iron table with gas jets beneath which heat the table to a scorching temperature. The matrix is laid back down on this table and covered with a thick asbestos cloth blanket. It remains there while a man may count thirty, and then it comes out done to a turn. Every particle of moisture which remained in it after the drying in the steam-heated process is driven off, and it is simply crispy dry as well as scorching hot. The stereotyper grabs it from the table, and goes on the run to the moulding box, where the cast is to be made.

The casting box consists of two curved iron plates, with shoulders on that shut together in such a way as to hold the matrix against one of the plates and leave space between it and the other plate, so that when the type metal is poured in a plate of the right thickness is produced. The box is curved because the plates must be curved to fit the cylinders of the press.

It is when casting the plates that the advantages of Mr. Thompson's scorching process are seen. Take as much care as he would in the old way of drying without scorching, the matrix came to the casting box moist, and the first cast was chilled by the moisture and spoiled. As a matter of fact, two casts were generally required to heat up and dry out the matrix. Now if the man who brought the scorched matrix to the box should stop to blow his fingers to cool them, two others might shut the matrix in the box, pour in the metal, and turn out a completed plate while he was giving his fingers three good puffs.

The solidifying of the metal as well as reducing the temperature to a degree where the plate may be handled has always been done by means of water, formerly by pouring water with a dipper over the convex side of the casting box, but now Mr. Thompson has placed several perforated gas-pipes in the concave side of the casting box, and has connected them by means of a hose with the waters of Croton lake. A valve is opened and a flood pours through the perforated pipe, cooling all parts of the box at once, and in a fraction of the time required by the dipper process.

The metal used in making stereotype plates is composed of tin, lead, and antimony. If kept at a proper temperature it flows like water, and is perfect for its purpose. But in the melting pots of the ordinary stereotyping rooms the metal is not always kept at just the right temperature. This is due to the fact that the pot, set in a brick furnace, has the heat applied to the bottom of the pot only. But the new melting pot is unquestionably the best in the country — probably it has no equal in the world. The fire is below the pot, as in other furnaces, but the heated products of combustion, instead of passing directly away to a chimney, must first wind completely around the pot in a spiral tube until they reach the very brim of the pot, when they pass away and up a stovepipe that is 106 feet high, to insure a good draught. Thus the metal is heated at the bottom and on all sides, and is just right when wanted.

Undesirable Immigration Must be Stopped.

The matter of the restriction of immigration to this country has already received some attention in Congress, and the indications are that the session will not end without the adoption of legislation in that behalf. This movement is in direct response to a strong popular demand. The American people require that the unlimited freedom of admission to this country, hitherto accorded to Europeans, shall hereafter be denied. They have acquired the conviction that the time has come to reform, in the interests of a nation of sixty millions of people, a system which was adopted by, because it was only fitted for, a nation of three millions of people. The facts which have produced this conviction are, in our opinion, conclusive in favor of reform. That foreign governments, and particularly the British government, have made a practice, for many years, of shipping paupers and criminals hither, appears to be beyond question. The anarchist and socialist element in our population is almost wholly of European origin. It is asserted, and it is probably true, that foreign-born workingmen are the instigators of the larger number of the labor disturbances that occur. It is certain that quite half of the convicts in our prisons are of foreign birth, and of the other half, a considerable proportion are the children of foreigners. The population of the almshouses all over the country is chiefly composed of Europeans. Ninety-five per cent. of the rum-holes in the country are kept by men who have come here from abroad to engage in a traffic which, as the one great producer of crime, is the greatest enemy of social order and the greatest squanderer of the substance of the people. Many of the decent, orderly, and reputable of the immigrants have formed themselves into isolated communities, particularly in the Northwest, where they teach their native language in the public schools, print newspapers in their own tongue, and live as much apart from American influences as if they were still in Europe. In our large cities and towns other foreigners who are respectable people, and who are in most particulars desirable members of the community, employ their influence and their votes to make war upon the law and the custom which require the observance of Sunday as a sacred day of rest; and they are making such headway as actually to menace an institution which Americans, as a rule, regard as of the highest value for economical as well as religious reasons. More than this: instead of losing their identity in the whole mass of the population and becoming simply Americans, many of these people show a marked propensity for clannishness, and this is carried so far into politics that American citizens by birth are continually threatened by the misuse, under the sway of unscrupulous politicians, of the "Irish vote," and the "German vote," or some other kind of a vote that has no right to any power at all unless it is, first, last, and all the time, simply an American vote.

The American people, we believe, are resolutely bent upon trying to bring this kind of a thing to a conclusion. Three measures of reform have already been presented to Congress. One proposes effective means for the exclusion of convicts, paupers, idiots, and insane persons. Another requires American consuls upon application to inquire about and certify to the moral character and ability to earn support of intending immigrants, and levies a duty of $2 a head upon foreigners not having a certificate. A third requires ten years' residence before foreigners can declare their intention to become citizens of the United States, except in the case of those arriving before the age of twenty-one years, when a residence of only six years can be required. We express the opinion that none of these schemes is sufficiently comprehensive or far-reaching. It is doubtful if ten years be a sufficient space of time to satisfy the wishes of the people who want to have the present five-year period in the naturalization laws extended. It is a good suggestion that immigrants shall be supplied with a certificate from the American consul at the port from which they come; but a two-dollar penalty for neglect to secure such a certificate is simply absurd. The person who comes here without such certificate should be sent back again at the expense of the steamship company. In fact, the immigrants should be refused admission unless he can produce some kind of clear proof that he is neither a criminal nor pauper, and that he intends to engage in an honest vocation at once.

This country wants all the foreigners it can get who come here for the purpose of engaging in useful industry and of becoming American citizens in fact, as well as in name. Every worker who steps ashore and goes to work, is a producer of wealth for the country and for himself, and he ought to be welcomed. There are millions of such people among us, and they form a very valuable part of the population. Such a man, however, owes much to the country which offers him so many advantages. He should help to sustain existing laws and institutions, instead of antagonizing them. He should learn the English language, and should bring up his children as Americans, not as Germans or as Frenchmen. He should not be permitted to vote, no matter how long he has lived here, until he can read, write, and speak English. There should be a positive prohibition of the use of any public funds for the support of schools in which another language than the English is used for purposes of ordinary instruction. No public lands should be suffered to be used for establishing a community which proposes to exclude the common use of the English tongue. The purpose of our laws permitting immigrants to come here to enjoy the advantages of our institutions is to make good American citizens of them ; and anything which interposes an obstacle to such a result should be swept away, if that be possible. We want such citizens made of such material. We want all the effective workers that are willing to come here to be assimilated with our people; but we do not want the scum, and the filth, and the vagabondage of Europe poured in upon us, and the time has come to declare that we will not have them.— *The Textile Record.*

Exploding torpedoes is not an unusual way of expressing good wishes, but it may have somewhat unexpected results, as was exhibited recently when that method was adopted on an English railroad on the occasion of the marriage of a lady and gentleman who were starting by train on their honeymoon. The fog-signals frightened two horses, which knocked down, ran over, and killed a man. The jury at the inquest added a recommendation to their verdict "That the Great Western Railway Company should be informed that fog-signals ought not to be used for wedding purposes."

Incorporated 1866.

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The Locomotive.

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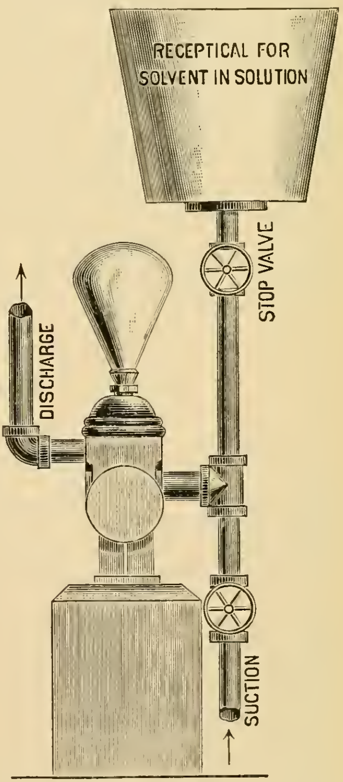
Pumping Solvents into Boilers.

The use of something to remove scale or to prevent its formation in steam boilers is so commonly necessary, that some sort of apparatus for introducing it into a boiler every day in the form of a solution, and without interfering in the least with the operation of the boiler, will be found a most desirable, convenient, and economical thing.

In most steam plants if the use of a solvent is found to be necessary, there is no way to get it into the boilers without shutting them down, cooling off, and introducing it through the man-hole or hand-hole. If this is done only when the boilers are opened up for cleaning of course no extra expense is involved, but as a rule the stoppages for this purpose are so far apart that the use of the solvent amounts to very little, as in the natural course of running it will be entirely blown out and lost long before the next charge can be introduced. If a stop is made as often as the solvent should be introduced for the special purpose of putting it in, great and unnecessary expense is involved. The loss entailed by one such stoppage would more than pay for a proper apparatus for introducing it daily or oftener if desired, and in the form of a solution. And it is plain that small quantities in solution introduced at short intervals will be much more effective than a large quantity at longer intervals, and when water is very bad a much greater quantity of the solvent can be used in a given time than can be where large quantities are put in at longer intervals. For illustration, with some waters a charge of 30 pounds of soda ash once a month might cause serious trouble for a while after it was put in, but one pound a day could not possibly injuriously affect the working of the boiler.



Our illustration in this issue shows a very simple and convenient method of attaining the desired result, and the apparatus can be attached to any pump or injector at a very slight expense. We have shown it attached to an ordinary steam pump. An explanation of the cut is hardly necessary; the practical engineer will understand it at a glance. To the upper end of the suction pipe another pipe is connected by means of the T, and extended to any convenient height. This pipe is provided with a stop valve, and carries on its upper end a receptacle (in making the cut our artist was a trifle lame in his spelling of the word "receptacle," but this will not interfere with the efficient working of the actual apparatus) for the solution which it is desired to put into the boiler. This may be an iron or a wooden vessel as may be preferred, and of any required size. This vessel is filled with the solution while everything is running as usual. If the pump is drawing its supply, the only thing necessary to do is to open the valve connecting with the vessel above and its contents will be put into the boiler with a very few strokes of the pump, when the valve may be again closed until it is wanted for use again. If, on the contrary, the pump is drawing its supply from some source which exerts pressure, more or less, as is frequently the case, the stop valve in suction pipe should be closed while the connection to the open vessel of solvent is open, or it would be driven out of the top of the vessel. But in either case a few moments suffice to complete the operation without any interruption to the operation of pump or boilers.

Another advantage which in many places would incidentally accrue from the attachment of this apparatus as shown is this: It can be made to serve as an air chamber to the suction pipe of the pump. Under some circumstances an air chamber here is a necessity, and in no case is it a disadvantage. With the stop valve in the pipe connecting with the solution placed well up, quite a large air chamber will be formed above the top of the suction pipe, which will make as good an air chamber as the maker of the pump could furnish. In making the attachment, if its utilization for this purpose is desired, a portion of the pipe should be made larger in its middle portion than would be necessary for the purpose of introducing the solvent merely, reducing at the lower end where it connects with suction pipe, and near the upper end, to obviate the necessity of using a large stop valve. If the air chamber is not desired, the stop valve in the upper pipe should be put down as close to the suction pipe as it can conveniently be connected.

The same attachment can be made to the suction of a power pump, or to an injector. Owing to difference in the circumstances which would be found in different places, the details of the connection might vary somewhat, but the principle would remain the same, and any ordinarily intelligent engineer should be able to get it up without difficulty and at an expense of a very few dollars.

Inspector's Reports.

April and May, 1888.

During the month of April, 1888, our inspectors made a total of 4,216 inspection trips, examined 8,255 boilers, 3,706 both externally and internally, and tested 521 by hydrostatic pressure ; 6,543 defects were reported, of which number 545 were considered dangerous, and led to the condemnation of 30 boilers. Our usual summary of defects is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	500	21
Cases of incrustation and scale,	769	24
Cases of internal grooving,	55	4
Cases of internal corrosion,	304	26
Cases of external corrosion,	466	25
Broken and loose and defective braces and stays,	130	18
Settings defective,	243	18
Furnaces out of shape,	231	14
Fractured plates,	215	55
Burned plates,	123	13
Blistered plates,	313	18
Cases of defective riveting,	1,129	75
Defective heads,	48	18
Serious leakage around tube ends,	1,059	77

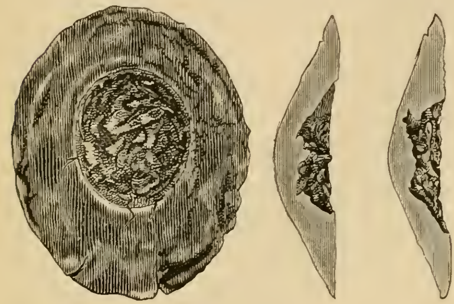
Nature of Defects.	Whole Number.	Dangerous.
Serious leakage at seams,	285	15
Defective water-gauges,	133	17
Defective blow-offs,	71	20
Cases of deficiency of water,	9	4
Safety-valves overloaded,	31	13
Safety-valves defective in construction,	56	25
Pressure-gauges defective,	263	32
Boilers without pressure-gauges,	11	9
Unclassified defects,	99	4
Total,	6,543	545

In the month of May, 1888, our inspectors made 3,983 inspection trips, visited 7,951 boilers, inspected 2,754 both internally and externally, and subjected 519 to hydrostatic pressure. The whole number of defects reported reached 6,237, of which 781 were considered dangerous; 36 boilers were regarded unsafe for further use. The defects in detail were as follows:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	507	45
Cases of incrustation and scale,	726	77
Cases of internal grooving,	59	14
Cases of internal corrosion,	442	85
Cases of external corrosion,	440	21
Broken and loose braces and stays,	105	12
Settings defective,	247	16
Furnaces out of shape,	276	8
Fractured plates,	119	33
Burned plates,	103	15
Blistered plates,	255	17
Cases of defective riveting,	356	119
Defective heads,	718	12
Serious leakage around tube ends,	911	210
Serious leakage at seams,	278	19
Defective water-gauges,	114	17
Defective blow-offs,	45	7
Cases of deficiency of water,	3	1
Safety-valves overloaded,	50	7
Safety-valves defective in construction,	52	12
Pressure-gauges defective,	388	31
Boilers without pressure-gauges,	12	2
Unclassified defects,	31	1
Total,	6,237	781

Among the unclassified defects in our monthly summary of the work of the inspectors, some strange things are included. In many cases the defect is of such a nature that a single line would fail to describe it, — such, for instance, as one recently found by one of our inspectors, where seven boilers, in one boiler-room, were set so as to point toward all four of the cardinal points of the compass; were connected to one flue, which had to make several right-angled turns to take in all the boilers and reach the chimney; and to make all things complete, one of the boilers had no safety-valve. The boilers themselves, in this case, were all right, and the proprietor thought he had a first-class lay-out, but to us it would seem that the engineer who planned it must have had a very small "bump" of geometry on his head. Of course, in such a case as this, the boilers could not properly be called defective; at the same time, there were more defects to the square foot in that boiler-room, taken as a whole, than are usually to be found in second-hand boilers.

WE give herewith the cuts of thin rivet-heads promised in our May issue. They are shown of actual size and form. Besides being so thin, which would have made them very weak if all other conditions had been right, it would appear either that they were made of a very poor quality of iron, or were most unmercifully hammered after they got cold, for our inspector knocked them off with blows of a light hammer which failed to make any indentation, — at least this was the case with the specimens illustrated here.



Boiler Explosions.

MAY, 1888.

SAW-MILL (92).—There was a boiler explosion at the mill of the Superior Lumber Company, Ashland, Wis., May 8th. The flue of the boiler blew out, blowing a brick wall outward, and striking a man named Kennedy on the back of the head, but not killing him. The engineer was badly scalded. Damage $1,000. The explosion was heard several blocks away.

SAW-MILL (93).—The boiler exploded May 8th at Hodge's sash and blind shop on South Elm Street, Manchester, N. H. Frank F. Thompson, engineer and fireman, kindled the fire under the boiler, which was of 100 horse-power. The safety-valve was supposed to blow off at 90 pounds, and but 40 pounds showed on the steam-gauge when Thompson left the room to fill the oil-cans. A moment later the explosion came. William H. Tyler and Harvey D. Emery, employees, were hurled 150 feet and killed, their bodies being terribly mangled. The boiler-house, engine-house, and dry-house, all of brick, were completely demolished. Thompson, the engineer, was found beneath the ruins of the engine-house, but was not fatally injured. The main shop was riddled with brick and sections of iron, and the chimney torn down. One section of the boiler, weighing two tons, was thrown 300 feet, carrying away the corners of two dwelling-houses on Auburn Street, badly injuring Mrs. James Mahoney and tearing away the whole front of her room. Two other sections were blown 500 feet, but did no special damage. Irving R. Hadley was struck by a flying brick, but was not fatally hurt. The damage to the shop was from $8,000 to $10,000.

PACKING-HOUSE (94).—A boiler in the packing-house of Hart & Brother, Wilmington, Del., exploded May 10th, fatally wounding John Whelan and Philip McBride, two employees, and painfully injuring two others. The force of the explosion sent the boiler and the front of the office into the street, wrecking a part of the building. The loss to the firm was about $5,000.

LOCOMOTIVE (95).—A large mogul freight locomotive, comparatively new, which was drawing a freight train, exploded near Rawling's Station, Maryland, May 13th, while under way. J. J. Woodruff, engineer, and H. D. Kitzmiller, fireman, were instantly killed. Engineer Woodruff's body was blown to atoms, and sixty of the fragments were gathered by the undertaker for burial. The fireman's body was terribly scalded. Fragments of the locomotive were found 500 yards away. It was one of the severest explosions ever experienced.

Saw-Mill (96).—The boiler in the Caro Wooden Works, Caro, Mich., exploded May 14th, killing Henry Howland and severely injuring Joseph Randall, Frank Riddle, Albert Riddle, and T. W. Wisner. The explosion was caused by low water in the boiler, which was old and patched.

Saw-Mill (97).—The boiler of Frank Smith's steam saw-mill, near Onancock, Va., exploded May 15th, killing Edward Holt, the engineer, outright, and fatally wounding Tobe Savage, the colored fireman, and a colored teamster. The explosion was caused by the fireman allowing the water in the boiler to become nearly exhausted. Holt was struck full in the mouth by a bolt from the boiler, which knocked out all his teeth and passed out at the top of his head. He was about thirty-four years old, and left a widow and four small children.

Agricultural Engine (98).—The boiler of a portable engine, which was being used in shelling corn, exploded about 11 o'clock May 17th, on the farm occupied by Benjamin Pleasanton, about three miles below Port Penn, Del., killing two men and injuring two others. The killed were Benjamin Pleasanton, the tenant of the farm, and Walter Burton, a farm hand employed by Pleasanton. Wilson Green, colored, is seriously injured, but will probably recover. Samuel Lofland, another farm hand, was slightly injured. The force of the explosion was terrific. It is supposed to have resulted from low water in the boiler and the bad condition of the boiler and injector. The engine and boiler belonged to Pleasanton, but had not been in use for two or three years, and had become rusty, but despite this fact the boiler was put in service without being overhauled. The exact cause of the explosion is not definitely known, but it is thought that although the indicator showed sufficient water, the boiler itself was almost depleted of water, and that the injector did not work properly, and connections between the boiler and indicator were rusted and out of order.

Saw-Mill (99).—By the explosion of the boiler of a saw-mill at St. Francis, Mo., May 22d, two workmen were fatally injured.

Saw-Mill (100).—The boiler in Hodgman's saw-mill at Portage, a station on the T., C. & S., three miles south of Bowling Green, O., exploded May 23d. Clem England, aged 17, and Chas. Hodgman, aged 12, were instantly killed. William Hodgman, the owner, was seriously and perhaps fatally hurt, and another man was slightly injured. England was running the engine, and no particulars of the cause of the explosion could be definitely learned. It is supposed, however, that the water in the boiler got low while the men were at dinner, and the sudden influx of cold water caused the explosion.

Car-Heater (101).—The reservoir of a car-heater exploded, May 24th, in a Richmond & Danville car which was standing at the station at Atlanta, Ga., slightly injuring three passengers.

Saw-Mill (102).—Two boilers exploded in a saw-mill at Harrison, Ga., May 25th. Two men were killed and five others badly injured.

Saw-Mill (103).—The boiler of a saw-mill near Wartburg, Tenn., exploded May 29th, killing one man and injuring another.

Locomotive (104).—A railroad wreck occurred three miles from Louisville, Ky., May 29th, on the Louisville & Nashville Railroad, in which engineer W. M. Quinn was killed, and fireman Richardson and brakeman George Farley were fatally injured. The engine-boiler exploded. Twenty-one freight-cars were demolished.

STEAMBOAT (105).—The steamer *Inverness* collapsed her flues twelve miles below Quincy, Ill., May 30th, an accident which resulted in the death of five men. These men, with half a dozen others, were precipitated into the river. The killed were: Joseph Halpin, the fireman; George Crait, runner for the captain; John Green, deck-hand; Charles Conroy, deck-hand; William Tierney, deck-hand. None of the bodies of the killed were recovered. The others who were precipitated into the water swam ashore or were rescued by boats from the *Mountain Belle*, which was near the *Inverness* at the time. The damaged boat belonged to McDonald Bros., of LaCrosse, where all the victims lived.

STEAMBOAT (106).—The steamboat *Fulton*, on her way from the old basin around to the river, at New Orleans, La., exploded her boiler May 31st, near the latter point, tearing the boat to pieces and instantly killing the pilot, Ed. Perkins, who was at the wheel, and fatally wounding the captain, W. H. Riddell. Two of the colored deck-hands — Jake Landay and A. Watson — were fearfully scalded by the steam and were fatally hurt. The engineer on duty at the time could give no reason for the explosion, and no one knew how it happened.

SOME interesting experiments made late last winter on a railroad in Massachusetts to determine the amount of steam required to warm passenger cars in actual service are worth recording here. The cars experimented upon consisted of a combination baggage and second-class car, a smoking car, and two ordinary passenger coaches. The steam was taken from the locomotive which carried a pressure of 170 lbs.

With the external temperature at 27°, and the cars standing, the time required to bring them to a temperature of 67½° F. was one hour and twenty-six minutes, and the amount of steam used was 386 lbs.

The two next experiments were made while the train was on its regular trips, occupying one hour and twenty-five minutes each. The external temperature was 27° F., the steam used being at the rate of 334 lbs. per hour on one trip, and 307 per hour on the other, the cars being uncomfortably warm on the first trip, and about right on the second.

The two last experiments were made with five cars heated, external temperature 30° on the first trip, and 19° on the second. On the first trip the steam consumed was 326 lbs. per hour, but the train was not sufficiently warmed. On the second trip 380 lbs. per hour, but the cars were still uncomfortably cold. Before the end of the trip the temperature had fallen to 57° in the rear one.

ACCORDING to *La Metallurgie* an alloy useful when metals are to be soldered togetner at a low temperature can be made as follows: Copper in a fine state of division is obtained by precipitation with zinc from a solution of sulphate of copper. From twenty to thirty parts of this, according to the hardness required, are mixed in a cast-iron or porcelain mortar with concentrated sulphuric acid, to which is finally added seventy parts of mercury, and the whole triturated with the pestle. The amalgam thus formed is thoroughly washed with water to remove the sulphuric acid, after which it is left untouched for from ten to twelve hours, at the end of which it is hard enough to scratch lead. To use the alloy for soldering it is warmed till it has about the consistency of wax, and in this state it is applied to the joint, to which it adheres very firmly on cooling.— *Exchange.*

The Locomotive.

HARTFORD, JULY, 1888.

J. M. ALLEN, *Editor.* H. F. SMITH, *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.

ONE of the greatest mistakes that can be made in designing boilers, and the one that is most frequently made of any, consists in putting in a grate too large for the heating surface of the boiler, so that with a proper rate of combustion of the fuel an undue proportion of the heat developed passes off through the chimney, the heating surface of the boiler being insufficient to permit its transmission to the water. This mistake has been so long and so universally made, and boiler-owners have so often had to run slow fires under their boilers to save themselves from bankruptcy, that it has given rise to the saying, "Slow combustion is necessary for economy." This saying is considered an axiom, and is regarded with great veneration by many, when the fact is, if the truth must be told, it has been brought about by the wastefulness entailed by boiler plants proportioned badly by ignorant boiler-makers and ignorant engineers, who ought to know better, but don't.

Let us consider the matter briefly: Suppose we are running a boiler at a pressure of 80 lbs. per square inch. The temperature of the steam and water inside will be about 325 degrees F. The temperature of the fire in the furnace will under ordinary conditions be about 2,500 degrees F. Now, it should be clear to the dullest comprehension that we can transmit to the water in the boiler only that heat due to the difference between the temperature in the furnace and that in the boiler. In the case of the above figures about seven-eighths of the total heat of combustion is all that could by any possibility be utilized, and this would require that radiation of heat from every source should be absolutely prevented, and that the gases should leave the boiler at the exact temperature of the steam inside, or 325 degrees.

To express the matter plainly, we may say that the utilization of the effect of a *fall* of temperature of 2,175 degrees is all that is possible.

Now suppose, as one will actually find to be the case in many cases if he investigates carefully, that the gases leave the flues of another steam-boiler at a temperature between 500 and 600 degrees. The latter temperature will be found quite common, as it is considered to give "good draft." This is quite true, especially as far as the "draft" on the owner's pocket-book is concerned, for he cannot possibly utilize under these conditions more than $2,500 - 500 = 2,000$ degrees of that inevitable difference of temperature to which he is confined, or four-fifths of the total, instead of the seven-eighths, as shown above, where the boiler was running just right, and any attempt to reduce the temperature of the escaping gases by means of slower "combustion," as he would probably be advised to do by nine out of ten men, would simply reduce the temperature of the fire in his furnace, and the economical result would be about the same. His grate is too large to burn coal to the best possible advantage, and his best remedy is to reduce its size and keep his fire as hot as he can.

This is not speculation, as some may be inclined to think. Direct experiments have been made to settle the question. The grate under a certain boiler was tried at different sizes with the following result:

With grate six feet long ratio of grate to heating surface was 1 to 24.4
With grate four feet long ratio of grate to heating surface was 36.6

The use of the smaller grate gave, with different fuels and all the various methods of firing, an average economy nine per cent. above the larger one, and when compared by burning the same amount of coal per hour on each, twelve per cent. greater rapidity of evaporation and economy were obtained with the smaller grate.

Explosion of the Boilers of the Steamer "Julia."

The explosion of the boilers of the ferry steamer *Julia*, owned by the Southern Pacific Railroad Co., on the morning of February 28th last, at 6.10 A. M., when just starting on her regular trip from South Vallejo to Vallejo Junction, Cal., by which thirty-four persons were killed and twenty-two others more or less severely injured, calls for more than a passing notice.

The *Julia* was a side-wheeler, 170 feet long, 32 feet beam, 8 feet 8 inches deep; gross tonnage, 503.2; net tonnage, 407.31. Her engines were of 200 horse-power.

The boilers were of the locomotive type, shells 54 inches diameter, increasing by a tapering course to 60 inches at the fire-boxes. The fire-boxes were $\frac{46}{100}$, the tapering courses $\frac{3}{8}$, and the barrels $\frac{5}{16}$ of an inch thick of iron, which it is claimed was branded 60,000 lbs. tensile strength. The tube sheets were $\frac{3}{8}$ of an inch thick, and each boiler contained 93 tubes, 3 inches in diameter and 12 feet long.

Of the fifty-seven persons known to have been aboard at the time of the accident but three escaped uninjured, and had the explosion occurred on the next trip there is no doubt that two hundred persons would have been killed, as at that time the boat would have connected with the train which brings the passengers from Napa Valley.

The *Julia* was an old vessel, having been built in 1864 for the Stockton and San Francisco route. The boilers which burst were made by the railroad company at their shops in Sacramento in 1876, and had undergone repairs from time to time since. Two years ago they were thoroughly overhauled and repaired, we are informed, by the direct order of Senator Stanford, and under the supervision of William Makinzie, now master mechanic of the shops at Sacramento, and were tested and pronounced in good order at that time. The last official inspection by the United States local inspector was in June, 1887, at which time, also, they were pronounced to be in good condition.

The explosion occurred, as stated above, as the boat was about to start on her regular trip a few minutes past six o'clock in the morning. Its force was terrible. The boat was shattered from end to end, the fire-box of the starboard boiler being blown clear through the side of the boat into the stream.

The fuel used was crude petroleum, of which about 2000 gallons were stored on board. This was scattered by the force of the explosion over the boat and the wharf, which instantly caught fire. The wreck of the boat was burned to the water's edge. The south end of the wharf and the depot office caught fire and were burned, along with four new passenger cars which were standing on the track under a shed. In fact, the fire was extinguished only after it had burned the buildings and nearly all of the wharf.

The fireman was instantly killed, but the captain and both engineers escaped with painful but not serious injuries.

The boilers were allowed to carry a pressure of 110 pounds of steam, and at the time of the explosion the steam gauges showed 105 pounds, as testified to by several persons who were looking into the engine-room when the explosion occurred.

The plates were not tested at the time the boilers were made, as at that time the local board of United States inspectors had no testing machine. They were branded 60,000 T. S. After the explosion the coroner had sixteen pieces tested, which were cut from various parts of the shell. Eight of these pieces were made and tested in accordance with the rules of the United States supervising inspectors. The tensile strength ranged from 48,200 to 63,560 pounds per square inch, the average being 55,348 pounds. The remaining eight were made and tested in accordance with the rules of the Naval Construction Department, and ranged from 44,567 to 54,847 pounds tensile strength, the average being 49,892 pounds per square inch. We were unable to obtain any official record of the ductility, but it was stated to average about 12½ per cent.

The coroner summoned experts from various parts of the State to endeavor to ascertain the cause of the explosion. Each one had a different theory, some contending that the tubes first gave way, causing a rupture of the shell. Others contended that the initial rupture took place in the shell of the starboard boiler, on the starboard side, and about twenty inches from the bottom on the tapering course. This theory appears to be borne out by the fact that after the sheets let go they flew against the barrel of the port boiler and bent in the opposite direction to which they were rolled when the boiler was made. The shock caused the port boiler to let go at the small end of the taper-course.

If the tubes had let go first, we are led to believe that the pressure, supposed to have been 105 pounds per square inch at the time, would have forced the tube-sheet back into the fire-box, while as a matter of fact the reverse is the case, as the sheets of both boilers were found deflected *toward* the pressure, that of the starboard boiler being deflected 5 inches, and that of the port boiler 4½ inches in this direction. There were no indications of low water at the time of the explosion.

The coroner's jury, after a month's investigation, rendered a verdict, in which they expressed the opinion that the boilers were not strong enough to carry 110 lbs. pressure; that boilers intended to burn liquid fuel should be constructed differently from those of the *Julia;* that the United States inspector was careless and negligent in the discharge of his duties; and that the use of petroleum should be prohibited by law on all steam passenger or ferry boats, — at the same time they were not prepared to say that it was the cause of this explosion. That did not appear in their finding.

Later the accident was thoroughly investigated officially by H. S. Lubbock, United States supervising inspector for the district in which it occurred. His decision was to the effect that the primary cause of the explosion was an explosion of gases which had accumulated in the fire-box of the port boiler, causing the sides of the fire-box to bulge outward and raising the fire-box end, thereby throwing the weight ahead, which brought such a strain on the throat sheet that it let go, the explosion of the starboard boiler resulting from the shock received from the explosion of the port boiler. This seems to be the most rational explanation of the disaster.

The loss to the Southern Pacific Railroad Co. by the accident amounted in round numbers to $250,000.

"I REMEMBER," says a bridge constructor, "when working at the big bridge across the Niagara, when the two cantilever arms had approached within fifty feet of each other, a keen rivalry as to who should be the first to cross sprang up among the men. A plank fifty-five feet long connected the two arms, leaving about two and a half feet of support at each end. Strict orders were issued that no one should attempt to cross the plank upon penalty of instant dismissal.

"At the noon hour I suddenly heard a great shout from the men, who were all starting up. Raising my eyes, I saw a man step on the end of that plank, stop a minute, and look down into the whirlpool below. I knew he was going to cross and I shouted to him, but he was too high up to hear. Deliberately he walked out until he reached the middle of the plank. It sagged far down with his weight until I could see light between the two short supporting ends and the cantilevers on which they rested. He saw the end in front of him do this, hesitated, and looked back to see how the other end was. I thought he was going to turn. He stopped, grasped both edges of the plank with his hands, and, throwing his feet up, stood on his head, kicking his legs in the air, cracking his heels together, and yelling to the terrified on-lookers.

"This he did for about a minute — it seemed to me like forty. Then he let his feet down, stood up, waved his hat, and trotted along the plank to the other side, slid down one of the braces head first, hand over hand, and regained the ground. We discharged him, of course, but what did he care? He got all the glory, his fellows envied him, and he could command work anywhere."

Slipping at High Speed.

Some ten years ago M. Rabeuf, an engineer on the Northern Railroad of France, noticed the slipping of locomotive drivers when running (and using steam) down grade, even without any train load to haul. He made several observations, and concluded that this slipping increased in some ratio to the speed, and that it was much greater at the same speed in descending than in ascending grades. He found, by measuring the distance run, and noting the number of revolutions made by the drivers in that distance, that the circumference of a driver multiplied by the number of revolutions gave a product from 13 to 25 per cent. greater than the distance. That is, fuel was wasted and tires and rails worn out by useless revolutions of the drivers. Several explanations of the phenomenon observed by M. Rabeuf were offered at the time, and within a year M. Durand-Gréville has published in the *Review Scientifique* the remarkable theory that in going down grade the wheels tend to get away from the rail by the amount of the vertical component of the motion of the locomotive, and in going up grade they tend to approach the rails by the same component. Hence, he reasons, there is less adhesion in going down grade and increased adhesion in going up. M. A. Stévart takes, in a recent issue of *L'Industrie Moderne*, space equivalent to about a page and a half of the *Railroad Gazette* to state the theory of M. Rabeuf and the more or less ingenious explanations of it, and to show that these explanations are mechanical illusions. This he does very prettily, but one is surprised to find that after all the ingenuity and erudition which he has expended on the subject he accounts for the phenomenon by the simple and conclusive statement that it does not exist. In other words, "the boy lied" from the start. M. Stévart says that he made numerous runs between Liège and Verviers, registering the revolutions of the drivers, and found "no appreciable difference between the measured distance and the development of the circumference of the drivers multiplied by the number of revolutions." The distance between these stations is about fourteen miles and the difference of altitude about 400 feet. Moreover, M. Stévart made various long runs at high speeds with coupling rods removed, and found no appreciable change in the relative positions of the crank pins. He quotes various authorities, who sustain his position, that this particular kind of slipping does not occur. It seems probable that M. Rabeuf's figures were the result of the singular conditions under which he made his experiments, putting the reverse lever in full gear when running down grade.

The statement that engines slip continually while running at full speed is often made, but almost invariably by persons of no practical experience, who appear to be unaware that any slip of the drivers can be instantly detected by an engine runner. Any one who has run a fast train knows that on entering a damp tunnel slipping occasionally occurs, but the vibration imparted to the engine is so peculiar that no one who has once felt it is likely to fail to recognize it again. Messrs. Abbey and Baldwin, when making some observations on the running of a Jersey Central express passenger engine on the Bound Brook route, found that the slip at high speed was practically *nil*. The wheels, as calculated from their diameter, should give 298.98 revolutions per mile. A counter showed that 298.62 revolutions per mile had been actually made, the difference being negative and only $\frac{1}{3}$ of a revolution per mile, or within the limits of errors of observation. As these engines are run very hard and made to do their utmost, it might reasonably be expected that they would show slip, if any existed at high speed. It is therefore reasonable to suppose that any continuous slipping at high speed is non-existent. The continuous slipping theory is supported by so very little evidence, either practical or theoretical, that it must take its place among the numerous other pseudo-scientific delusions.—*Railroad Gazette.*

Half a Century Ago.

Just one-half a century ago, in 1838 — when the *Journal* was six years old — a census of all the steam-engines of every description in the United States was taken. This work was done in pursuance of a resolution of Congress, the object apparently being to secure information upon which could be based a law for the regulation of the use of steam; and it was, in fact, shortly after that time that the first general law in relation to steamboats was passed. The census was taken by the collectors of customs in the different districts, and appears from the report which was submitted to Congress, a copy of which is now in our possession, to have been pretty carefully done. It is curious to look over the figures now, and to contrast them with some of those for the present year.

In his preliminary statement the Secretary of the Treasury says that full reports have been received from all the States except Mississippi and Tennessee, in which two or three districts were missing; and that they were somewhat imperfect from the States of Illinois and Arkansas and the territories of Wisconsin and Iowa. An estimate is made, which is probably a pretty close one, for the missing districts, in several of which it is considered that the absence of returns was due to the fact that there was nothing to return; that is, that there were no steam-engines there.

The summary, including estimates, informs us that there were then in the United States 800 steamboats, 350 locomotives, and 1,860 stationary steam-engines, but these were very unevenly distributed. The largest number of the stationary engines in any one State was in Pennsylvania, where 383 were found, some of them in factories, but a considerable number employed as hoisting and pumping engines in the coal mines, which were already beginning to be an important industry. Curiously enough, Louisiana stood second among the States in her stationary engines, having not less than 274, or about one-sixth of the whole number in the United States. At first sight it appears strange that a State which has never been noted for its manufactories should have had, at that early day, so many engines, but this may be explained by two causes: one, that a large number of small engines were employed on the numerous sugar plantations of the State for crushing cane and similar purposes, and another being that in so level a region there is almost an entire absence of falls which can be utilized for water-power. Thus in Massachusetts, which was considered at that time the leading manufacturing State, there were only found 165 stationary engines; but this is not surprising when we remember that a large proportion of the mills were run by water-power. New York was fourth on the list, having 87, while Ohio already had no less than 83.

The number of steamboats in service, as already stated, was 800. Nearly all of these were employed in river and inland navigation, very few being sea-going vessels or, at least, employed on ocean routes. Not one of the number had crossed the Atlantic, but in New York five were registered as plying between that port and Wilmington, Charleston, Texas, New Orleans, and Natchez; the last, by the way, would be considered rather an unusual route for a steamer nowadays. In Philadelphia there were four steam vessels which ran between that place, Wilmington, and Charleston; in Baltimore two were owned, forming a line to Charleston and Savannah; two coasting steamers were owned at Wilmington, N. C., and two at Charleston.

The Secretary expressed considerable surprise at this, in consideration of the fact that the first steamship — the *Savannah* — which ever crossed the Atlantic had been built in New York nineteen years before, and that the voyage had been successfully made by other steam vessels since that time. The *Sirius*, in fact, had opened the first steamship line between New York and Liverpool, and was soon to be followed by the *Great Western.*

The United States Government at that date owned one sea-going war steamer, the *Fulton;* it also owned 13 steamboats employed in the service of the various departments.

In the number of steamboats New York led all the States, having 140 reported; the larger number of these were returned from New York City, and were employed on the Hudson River, Long Island Sound, and the adjacent waters, though already a considerable number of lake steamers were registered at Buffalo. Pennsylvania came second with 134 steamers, a few being owned in Philadelphia and two or three at Erie, but the majority belonged in the Pittsburgh district and being employed on the Ohio and Mississippi and their tributaries. Ohio was the third State in the number of steamers, owning 79, and 41 belonged in Kentucky, no other State possessing an equal number.

The largest steamboats then owned in the United States, which are mentioned in the report, are the *Natchez*, of 860 tons measurement and 300 horse-power, which was employed on the route from New York to Natchez, mentioned above; the *Illinois* of 755 tons and the *Madison* of 700 on Lake Erie; the *Massachusetts* of 626 tons plying on Long Island Sound. These are small vessels compared to the great lake and river steamers of the present day.

Then, as now, the chief source of accidents on steamboats seems to have been either the defective construction of boilers or the tendency to work them too hard. The accidents mentioned in the reports are nearly all from boiler explosions, and the legislation proposed or at least recommended by the Secretary related almost entirely to the care of the boilers, the regulation of the material to be used and the pressure to be employed, with provision for frequent inspection.

The most interesting part of the report to us, however, is that which enumerates the number of locomotives, of which there were 350 reported. More than one-quarter of these were in Pennsylvania, and were used on the short coal roads in the eastern part of that State, although a considerable number were on the road from Philadelphia to Columbia and on the Reading road. The Portage Railroad crossing the Alleghanies was operated by stationary engines hauling the cars up inclined planes. Massachusetts came second with 37 locomotives; Virginia, third, with 34; New Jersey, fourth, with 32 — most of them on the Camden & Amboy; Maryland, fifth, with 31, nearly all Baltimore & Ohio engines; New York, sixth, with only 28, and South Carolina, seventh, with 27. No other State had then more than 10 locomotives owned within its limits. The engines in New York were on the Long Island and Harlem roads — then the only lines running out of New York City — and on the Mohawk & Hudson and the other short lines running westward from Albany, which now form part of the New York Central.

These 350 engines were employed on 1,500 miles of road, and form a very striking contrast to the 29,500, the estimated number in the United States at the beginning of the present year.

It might be curious to note, however, that the number of locomotives has really increased very little faster than the mileage of railroads. In 1838 the average number was one to $4\frac{1}{4}$ miles of railroad, while in 1888 it is only a very small fraction over one to $4\frac{1}{2}$ miles. This, however, does not make any allowance for the increased power of the average locomotive of to-day over that of the engines employed 50 years ago.

In relation to locomotives, this old report is not as full as might be desired; this is, perhaps, to be expected, as the information called for related chiefly to steamboats, and the regulation of interstate commerce other than that by water was not then the pressing question which in these later years the development of railroads has made it.

Very little information is given as to the size of the locomotives, although in some cases their horse-power is enumerated, which is, however, rather an indefinite guide. The largest given were rated at from 20 to 25 H. P., although a few on the Boston & Providence and the Boston & Worcester ran as high as 30. The New York railroads did not require so much power apparently, for the heaviest locomotive given on any of them was rated at 20 H. P.

Some of the locomotives were built in England, but the majority at that time were of American manufacture. The firms of Baldwin and Norris, in Philadelphia, had already begun to make a name; the Locks & Canals Company in Lowell was engaged also in the building of locomotives, and a number of other makers appear in the list given — as Garret & Eastwick, Philadelphia, the New Castle Company, Bolton & Company, and one or two firms in Boston which have either ceased to exist or have gone out of the locomotive business.

Some attempt appears to have been made to collect statistics in relation to accidents on railroads, but it was so slight and the results were so imperfect as to be hardly worth recalling. Two accidents, it is stated in the report, had occurred up to that date from the explosion of locomotive boilers, and other accidents are referred to incidentally, but not described.

Although no direct statement to that effect is made in the report, it is very evident from its general tone, and from many indirect references made in it, that while much interest was felt in railroads, they were regarded then as entirely subordinate and inferior in importance to steamboats and river navigation. The steamboat was the great vehicle of commerce wherever it could be used, and the railroad, like the highway road, was useful chiefly as an auxiliary or feeder to the water lines. No one then anticipated to what an extent the railroads would take business away from the steamboats, and the prophet who then predicted the construction and successful working of railroads parallel to such highways as the Hudson or the Mississippi would have had very little credit in his own country — or elsewhere.— *The Railroad and Engineering Journal.*

Another Remarkable Locomotive.

A most remarkable locomotive, says the *Railroad Gazette*, the invention of a New York gentlemen who is too modest to allow his name to be mentioned, will soon burst upon an astonished world. Among other remarkable features too numerous to particularize, the boiler will evaporate 18 pounds of water per pound of coal. The inventor's assurances on this point are emphatic, and his explanation is lucid and leaves the reader in a completely evaporated, not to say dry condition, for after the fuel has indulged in the 18 pounds performance, it has sufficient surplus energy or waste heat left to do further wonders, for, "before the steam passes into the cylinders it is superheated by contact with an area four times greater than the evaporating surface, and being thus dried it passes into the cylinders with six pounds of water for each pound of coal that generates it."

This is a good deal to swallow all at once (quite a long drink in fact), but more remains behind. The boiler pressure is to be 210 pounds per square inch, though the inventor states that it would be higher if the gauge of the road were wider. The boiler is also rectangular, possibly because there are milestones on the Dover road, and not because the inventor "worked two years to discover some base of computation for a round boiler, and could find none; I could not even determine the evaporating surface, much less the quantity of water which should be carried under pressure, and the volume of steam to be held in reserve."

A useful hint to young, very young locomotive designers, is embalmed in the following aptly quoted proverb from Confucius:

"The proper extent of heating surface is determined from the wheel-base and rail-centers."

It cannot be too strongly urged upon the minds of the young that to follow this teaching will insure a happy old age and will remove all blotches and spots from the complexion and pimples from the nose, while any person following any other method of proportioning heating surface will be liable to a criminal prosecution and the forfeiture of any common stock he may hold in the Wabash, Nickel Plate, or West Shore.

The new engine will weigh over 100 tons when loaded, but "the absence of bent pipes" will, of course, render her easy on the track and bridges. A ton or two is neither here nor there with a locomotive that "can haul 2,250 tons on a single trip, on an ordinary track, a distance of 145 miles, say from New York to Albany, at a speed of 14 miles per hour, and at a cost of $104 less than the same tonnage has ever been transported."

That 18 pounds evaporation looks as if "Doctor" Blanchard had something to do with it.—ED. LOCOMOTIVE.

The Wonderful Girdle around the World.

One of the marvels of telegraphy was fully demonstrated one morning recently, says the San Francisco (Cal.) *Call*, when operators in the Western Union office in this city carried on an interesting conversation over hill and dale, over mountains capped with snow, through valleys of perennial green, under the Atlantic Ocean with its unexplored secret, over the vine-clad regions of Europe, and under the Mediterranean, with Cairo, the land of the Pharaohs. The time was 3 o'clock in the morning, just after a heavy night's work, "good night" having been received on the last press dispatch. *Dramatis personæ* were three operators, and the way the affair came about was as follows:

Chief—"All clear. Have you a cigar, Bob?"

Bob—"You bet; but I'll keep it."

Chief—"You will? Who are you working with, Tom?"

Tom—"Chicago. I've old Fox here. He's going to turn on the cable office, and, by the mortal Frost, I'll speak to Valencia, or bust."

"Co, Co, Co, Ch," rattled the sounds, and "I, I, I, I, Co," came in response.

"There is the cable office," said the Chicago operator. "Go for him, old fellow."

To Valencia—"Let us have London now, please—Tor Bay."

Valencia to London—"Here is San Francisco, Cal., who wants to speak with you. Tor Bay is doing the cable transactions."

London to San Francisco—"Delighted to meet you by wire. It is just striking noon by St. Paul's clock, and very foggy, as usual. How is the weather there?"

"This is wonderful," responded San Francisco. "It is half-past 4 o'clock, standard time, here, and not yet daylight. We receive many cables from London, but never had the pleasure of meeting you before. Any Americans there? It is raining slightly. There are plenty of mushrooms on the hill, and the boys will be selling violets on the street corners to-day."

London having secured a signal from Cairo, wrote: "San Francisco, Cal., is on here and sends greetings. They want to connect the wonderland of the New World with prehistoric Egypt."

Cairo—"Say to San Francisco that it is a pleasure to span half the globe to speak with them."

"The pleasure is mutual," signaled Tom from the Western Union operating-room. The Pacific speaking with the Nile, through the Atlantic, the Bay of Biscay, and the Mediterranean Sea is a wonderful feat.

Almost every one has seen tables of expectancy of life, in which the number of years which a person of a stated age will probably live is given from data collected by insurance companies. At birth the chances are that one will live to be about forty, but if one survives the perils of the first four years the chances are that he or she will live to be about fifty-four. From the ages of twenty to sixty the death rate is very uniform and the age to which one will probably live can be reduced to a very simple rule. If you are a man between twenty and sixty add one-third of your age to fifty-three years. The sum will be the age to which you will live if you are an average man. Thus, if you are now thirty-nine, you will probably live thirteen years after reaching the age of fifty-three, or until you are sixty-six. If you are a woman between twenty and sixty add one-third of your age to fifty-four years; for your sex lives, on the average, about one year longer than the other. The results reached in this way are within half a year of those of the expectancy tables. After sixty years of age one's chances of life are greater than would be given by this rule. If they were not so the limit of life would be about eighty years. — *Washington Star.*

Judge Sporter's Suspended Sorrow. — An account of the funeral of the estimable wife of Judge Sporter in a Dakota paper, winds up with the following touching incident: "Just after the funeral, Budd Newell happened to mention that he could run the fastest foot-race of anybody in the town. The Judge happened to overhear the remark, hurriedly dried his tears, and promptly shoved up $10 that he couldn't. The course was selected on Beacon street, from Fifth avenue to the brewery, and the sorrowing and grief-stricken widower, easily beat Budd by about ten yards. Elder Hartshorn acted as starter and subsequently made some pretty loud threats of licking Mayor Price, who claimed that there was foul play." — *Oil City Blizzard.*

A contemporary in a recent issue discusses the question of whether a deep or shallow furnace gives the better result economically. This is an important question, and one which has given rise to much discussion, and the distances fixed upon by different engineers show a great discrepancy, varying all the way from fifteen to thirty-six inches for the height between grate and crown sheet. A difference of height with different kinds of fuel is undoubtedly necessary to obtain the best results, but the best height will be found between the above extremes. An eminently safe rule to follow in all cases is: *Burn* your fuel as close to the heating surface as you conveniently can.

Mr. E. Blass, a German scientist, has used an incandescent lamp for actual inspection of the inside of boilers under steam. A thick glass tube was introduced through a stuffing box, a small incandescent lamp was lowered into this and lighted by means of a small battery. By this means the whole of the boiler was lighted up, and could be inspected through a glass plate inserted in the boiler. — *Electrical Engineer.*

The Locomotive.

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Pumping Solvents into Boilers.

In the July number of the LOCOMOTIVE was an illustrated article showing how to attach an apparatus to the feed pump by which solvents can be easily introduced into a boiler. While that apparatus is very complete and effective, it may sometimes be inconvenient to make the attachment, owing to the location of the pump. We show in the illustration (Fig. 1) an easy and inexpensive manner of accomplishing the same

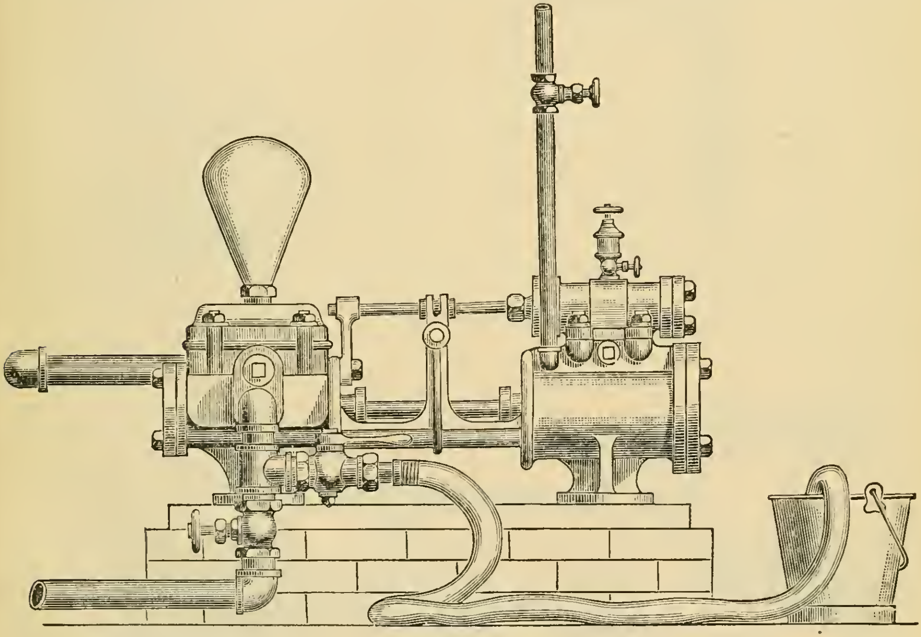

FIG. 1.

result. It consists in putting a T in the supply pipe near its connection with the pump. A stop valve is to be placed in the supply pipe a little below the T connection, and another stop valve is to be placed in the extension of the T connection. On the end of the T connection a hose is attached which runs to the pail or tub containing the solution. When the solution is to be pumped into the boiler, close the stop valve in the suction or supply pipe and open the stop valve in the extension of the T connection. The pump will then draw directly from the vessel containing the solution. When the solution has been pumped into the boiler, close the stop cock in the T extension and open the one in the suction or supply pipe, and the pump will then take water from the general supply. Fig. 2 shows a similar attachment for use in connection with an injector. The

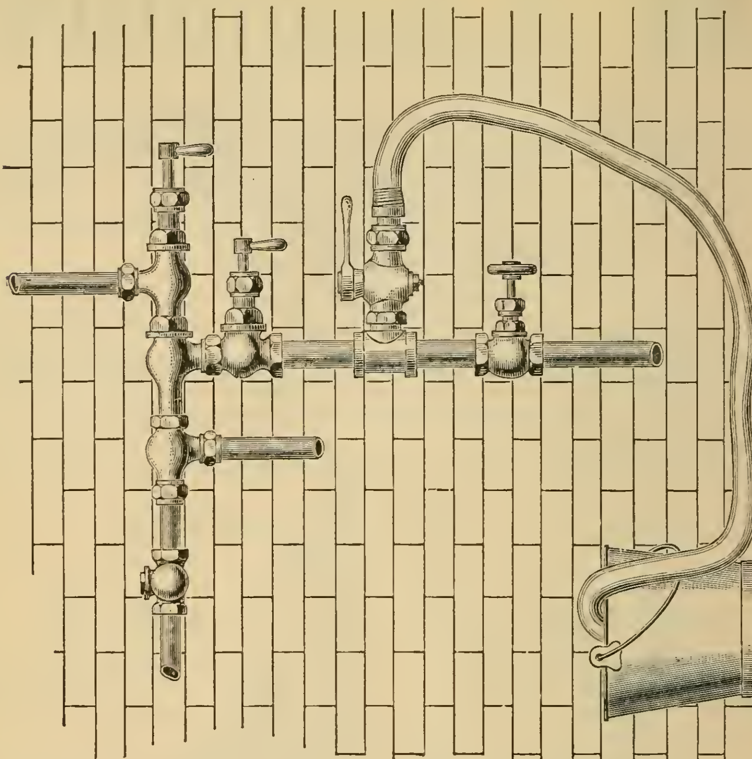

Fig. 2.

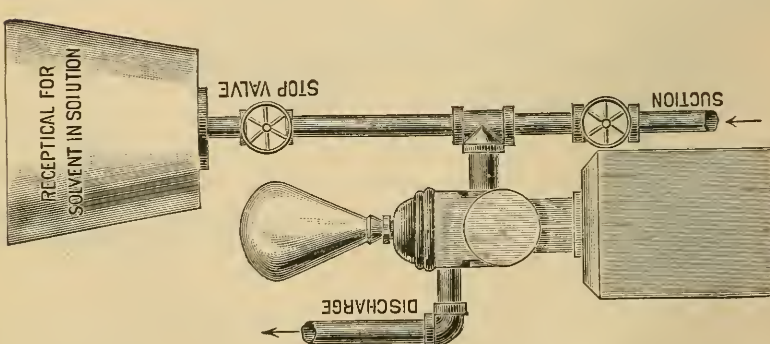

Fig. 3.

illustration is so plain that a description will hardly be necessary. In establishments where the water is of a character to render it necessary to use a solvent, one of these attachments to the pump or injector will be found very useful. In order that the three ways of making the attachment may be before the reader, we reproduce the illustration (Fig. 3), that was used and fully described in the July issue of the Locomotive.

Inspectors' Reports.

June, 1888.

In the month of June, 1888, our inspectors made 4,360 inspection trips, visited 8,363 boilers, inspected 3,551 both internally and externally, and subjected 622 to hydrostatic pressure. The whole number of defects reported reached 7,063, of which 607 were considered dangerous; 34 boilers were regarded unsafe for further use. The defects in detail were as follows:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	586	37
Cases of incrustation and scale,	800	62
Cases of internal grooving,	35	11
Cases of internal corrosion,	388	30
Cases of external corrosion,	600	32
Broken and loose braces and stays,	138	32
Settings defective,	162	14
Furnaces out of shape,	277	5
Fractured plates,	175	56
Burned plates,	148	24
Blistered plates,	320	22
Cases of defective riveting,	1,515	39
Defective heads,	45	16
Serious leakage around tube ends,	962	76
Serious leakage at seams,	331	26
Defective water-gauges,	102	24
Defective blow-offs,	54	21
Cases of deficiency of water,	9	3
Safety-valves overloaded,	21	12
Safety-valves defective in construction,	21	6
Pressure-gauges defective,	285	37
Boilers without pressure-gauges,	7	6
Unclassified defects,	82	16
Total,	7,063	607

Unclassified defects cover a large number of faults found by our inspectors which would make our list inconveniently long if they were specified in detail. Among them may be mentioned such defects as split tubes, defective connections of all kinds which affect injuriously the safety of the boiler while in operation, while the boiler itself may be without defects, and many defects of construction of a greater or lesser degree of importance.

Defective man-hole plates and frames, and re-enforcing rings, are very commonly found in new boilers. It is no uncommon thing to find cast man-hole frames cracked when the hydrostatic test is applied. Sometimes the plates are so badly warped that a tight joint is an impossible thing, and wrought iron re-enforcing rings around openings in flat surfaces are, as a rule, deficient in strength; but we will not enlarge upon the subject here. Unclassified defects, as they are found in practice, furnish subjects for discussion which can generally be made of more use when illustrated and more fully discussed.

Boiler Explosions.

JUNE, 1888.

STEAMER (107).—The steamer *Evansville*, raft boat, exploded her boilers a few miles below Winona, Minn., June 1. Jack Scanlay, second engineer, Cornelius Scanlan, fireman, and Robert Babbitt, William Armstrong, Victor Regnold, Burt Collins, and George Pickering were badly scalded. No one was killed outright.

IRON WORKS (108).—At 8.45 A. M., June 1, the boiler in the plate mill of the Eureka Iron and Steel Works, Wyandotte, Mich., exploded, wrecking the entire building, and instantly killing Terry McCoy, Patrick Finn, and George Green. A number were seriously injured. Among these were the following: Lett Curtis, Henry Pocock, E. Shaney, and Joseph Weiss. The explosion was terrific. The plate mill, 90 by 100 feet, with a roof 60 feet from the floor, was blown to fragments. A piece of the boiler weighing nearly six tons was blown across Eureka Avenue, a distance of 2,000 feet, striking Brennan's brick store and post-office, tearing a large hole in the wall. The second boiler was lifted by the explosion almost intact and carried fifty feet. Had the explosion occured half an hour later there would have been at least 100 men at work, besides many women and children who are always there at that hour with breakfasts for the men. Loss $10,000.

RENDERING BOILER (109).—A fat rendering boiler at the works of the Sacramento Wool Pulling Co., Sacramento, Cal., exploded June 2d with terrific force, completely demolishing the building in which it stood. Had the explosion occurred ten minutes earlier the loss of life would probably have been large as several men worked in the immediate vicinity and had just gone to dinner, and thus escaped.

AGRICULTURAL ENGINE (110).—A fire-box boiler on one of the ranches of Lux & Miller, California, exploded early in June, killing one man.

PORTABLE ENGINE (111).—The boiler of a portable engine in the Union Depot Company's yard, St. Paul, Minn., exploded June 6, killing Philip Fischer, John T. Duffy, and Hugh M. Nevin, besides injuring James H. Duffy, John T. Nevin, John Mohigen, John Wallace, —— McCormick, and Edward Limstead.

AGRICULTURAL ENGINE (112).—The boiler of an agricultural engine in Jerseyville, Ill., exploded June 8, badly injuring the man in charge.

STREET R. R. (113).—A boiler in the station where power is generated for the cable road, Kansas City, Mo., exploded June 8. No one was injured.

AGRICULTURAL ENGINE (114).—The boiler of an engine on the farm of Edwin Mickley, at Maple Grove, Lehigh Valley, exploded June 8, and was immediately followed by the explosion of 125 pounds of dynamite and a quantity of powder which was stored in the engine house. Mr. Mickley's barn, erected at a cost of $5,000, was completely wrecked. Window-panes a half mile distant were broken.

SAW-MILL (115).—The boiler in a mill at Bayou Sara, La., exploded June 12, killing two colored men and injuring two others.

COTTON MILL (116).—A boiler at the Wampanoag mill, Fall River, Mass., exploded June 14. Three men were seriously scalded, Eli Yarker, engineer, fatally.

WAREHOUSE (117).—By the explosion of a boiler in the warehouse of Bailey Bros. & Co., Zanesville, Ohio, June 16, three men, one a son of one of the proprietors, were killed, and two others were badly injured.

SAW-MILL (118).—The boiler in the Epp's saw mill, Mt. Forest, Ill., exploded June 21, killing Peter McIntyre and fatally scalding John Seville. The mill was badly wrecked.

Saw-Mill (119).—The boiler of the Whitefield saw-mill at Clinton, N. C., exploded June 23, badly damaging the mill.

Saw-Mill (120).—The boiler of a saw-mill at St. Elmo, Ill., exploded June 22, killing the engineer and wounding several others. The mill was completely wrecked, and fragments blown several hundred yards.

Saw-Mill (121).—The boiler of a saw-mill at Loudon City, Ill., exploded June 25. The engineer was instantly killed and another man so badly injured that he died in about two hours. Two others were badly but not fatally injured.

Coal Mine (122).—About 6 o'clock a. m., June 26, a terrible boiler explosion occurred at Rogers' coal mines, twenty miles east of Vincennes, Ind., killing outright the fireman, Wm. Burnett, and slightly scalding Engineer James Kimlo. The brick engine house walls were completely swept away. The accident will close down the mines for a time.

Saw-Mill (123).—At 5.30 a. m. on June 21, says the Harrison (Ark.,) *Times*, the boiler of Wilson & Bruton's saw-mill, about four miles north of Jasper, exploded, killing Huse James outright and so injuring Haunse Ratcliff that he died in a few hours. The accident happened, from the best we can glean, thus: On the evening previous the engineer filled the boiler and left a hot fire on closing down. During the night some over-smart young men as a joke let the water out of the boiler, which, together with the hot fire emptied it. On coming to the mill in the morning, James, being an inexperienced hand, put some pine knots into the fire before any water was pumped, thus generating a gas which exploded the boiler, tearing up the saw frame and almost destroying the mill besides blowing James to pieces. His body, arms, and head, with brains dashed out being blown, with a portion of the boiler, 100 yards through the timber up a steep hill. Ratcliff was setting the saw at the time of the explosion and a portion of the boiler struck the saw mandrel and at the same time tore off his left leg about the knee, crushed his left arm, and otherwise injured him so that he died before noon. The other mill hands fortunately were still at breakfast, so none were injured. Wilson & Burton, the mill owners, will sustain a loss of near $2000.

Mill (124).—Two persons were killed and five injured on June 29, by the explosion of a second-hand steamboat boiler then in use at a mill in Sabina, Texas.

A Warning Against Aniline Ink.

However convenient it may be for defendants in breach-of-promise cases, or for other persons similarly situated, that the documents by which it is sought to hold them to the fulfillment of their promises should be found to have faded out and become invisible or illegible, it is certainly not for the general interest of the public that ink should be used which is liable to disappear in that manner. A writer in the *American Grocer* sounds the alarm in regard to aniline ink, which is now extensively used, especially in typewriting. He relates an incident in which the vice-president of a leading railroad refused to sign a contract having twenty-one years to run, because it was written with a typewriter in aniline ink, declaring that long before the expiration of the contract the document would be entirely faded and practically worthless. "It is growing more and more the custom," he says, "to have deeds, contracts, and valuable documents printed on a typewriter in aniline ink. This is a great mistake, for in a few years they are sure to be obliterated. During General Grant's term as President one of his Cabinet officers discovered that the records of an important branch of one of the departments had been for two years written in purple ink. He had at once issued an order forbidding its use in the department, purchased a new set of books into which two years' records were copied, and thus saved what in a few years would otherwise have been lost. It is one of the problems of chemistry to find something which will make permanent the beautiful aniline colors, but thus far all efforts have failed. I suggest, therefore, that merchants have all important papers which it is desirable to keep for a number of years written in ink which, instead of fading with age, will grow darker and more permanent. There are a number of American and foreign inks which are unexceptionable in this particular." — *Mechanical News.*

The Locomotive.

HARTFORD, AUGUST, 1888.

J. M. ALLEN, *Editor.* H. F. SMITH, *Associate Editor.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*
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OWING to the absence of the Editor of the LOCOMOTIVE, and the sudden and protracted illness of the Assistant Editor, the issues have been somewhat delayed and irregular. We trust, however, in future to be able to get the numbers out on time.

THERE being a large demand for the lectures delivered by President J. M. Allen at Sibley College, Cornell University, which were originally published in the *Scientific American* supplement, we have decided to reproduce them in the LOCOMOTIVE, and the first lecture appears in this issue.

WE are indebted to Mr. Wm. Paul Gerhard, C. E., for copies of his pamphlets on "The Prevention of Fire," and "Drainage of a House." In the former, Mr. Gerhard very intelligently discusses the origin of fires from the defective construction of buildings, and especially from defective chimney flues. Many other causes of fires are also brought vividly into view. The advice which he gives for preventing fires, if rigidly followed, would reduce these calamities to a minimum. We have been especially interested in the articles on public institutions where large numbers of people and children are congregated together. The whole subject is well covered, and will amply repay a careful and thoughtful reading.

"The Drainage of a House" contains valuable suggestions in regard to plumbing, drainage, and ventilation. The subject is one of deep interest to every owner of a house, particularly those located in cities or villages where there are water and drainage systems. Zymotic diseases and many epidemics are directly traceable to defective drainage and imperfect ventilation. Had we space, we would say more on this subject; but the best way to get this information will be to read the pamphlet, which can be obtained by addressing Mr. Gerhard, 39 Union Square, West New York.

Sibley College Lectures.—1885.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

ON STEAM BOILERS.

BY J. M. ALLEN.

When we look out upon our great country or upon the civilized world, and see the rapid progress that has been made in science and the arts, we are led to inquire what is the power or influence that has crowded so much into the last fifty years. Great steamships plow the seas against wind and tide, and arrive at their destination at their appointed time. Railroads traverse our country in all directions like the threads of a gigantic net. Steam cars with their loads of passengers and freight are constantly running from ocean to ocean and from the lakes to the gulf. Acres of spindles and looms are turning out fabrics, not only for home markets, but for the markets of the world. The great iron works of the country with their ponderous machinery are converting the raw product of the mines into the material necessary for the construction of machinery and appliances that bring wealth to the nation and comfort and beauty to our homes. Who are the men that are foremost in these gigantic operations? The men who dare to strike out into new and unexplored fields, and bring such magnificent results out of apparent impossibilities? Not to undervalue the labors of men engaged in purely scientific investigations, it is the men who take the results of such investigations, apply them to the arts and bring them into practical use. These men are known as civil and mechanical engineers, and it is to this class that we are largely indebted for the development of our national resources and the great increase of our national and individual wealth.

But the work is not finished yet. Great strides are to be made in the future; we can only hint at what they shall be. But the work of development will go on until the hum of industry shall penetrate our remotest borders. The men of to-day will soon pass away, and all this important work will fall and is falling upon the shoulders of younger men. What opportunities you have in this school of preparation, endowed by liberal hands and under the direction of eminent and most capable instructors, what opportunities and possibilities are before you! Do not fail to fully appreciate all this, and let the world in the future know that the graduates of Sibley College are most thoroughly trained and fully competent to grapple with the great questions so intimately associated with our national progress.

There is one thought which is in my mind that I desire to give expression to. I am deeply interested in young men. I am anxious to see them succeed. I have seen woeful and lamentable failures of young men who possessed splendid abilities, and why? It was because they lacked that underlying fundamental quality that is essential to success. I mean good character. Without this, no man, however brilliant his attainments in other respects, can attain the highest success. Truth, in its broadest application, not only in words, but in deeds, honesty, and industry are the stepping stones to confidence, honor, and power. There is a responsibility resting on all of us that is higher than responsibility to man. A dutiful recognition of that Power which is over and above all, and in whose hands are all nature's subtile forces with which you will be called to deal, will give you light in dark hours and round up a life of activity and usefulness. It will prepare you for the contemplation of those great themes in the life beyond, where all will be made plain.

The great motive power of the world to-day is steam. It is steam that drives our steamships against wind and tide through the pathless deep. It is steam that enables the locomotive to draw its long and heavily loaded trains through the valleys and over the highlands, climbing up even the mountain sides, bidding defiance to heavy grades, and passing over their summits into the valleys beyond. When we stop to contemplate this condition of things, we cannot but be profoundly impressed with the influence of this powerful agency in the hands and under the control of an intelligent mind. It is steam that furnishes the motive power of our manufactories and mills. The tall chimneys that lift their heads high in our cities and villages indicate that there are hives of industry near at hand. The noise of ponderous machinery and the hum of spindles apprises us that the raw material is being wrought into various useful products which will ultimately be distributed over the land, possibly over the world. What is steam? Webster defines it thus: "The elastic aeriform fluid into which water is converted when heated to the boiling point." How can steam be made available as a motive power? By confining it in vessels of sufficient strength to withstand the pressure, generated by the application of heat, for the work required.

This brings us to the steam boiler, its proper construction and management, with a view to safety and economy. There are boilers of various types, but as our time is limited, I will discuss only one type, and that is the one most commonly used in this country, viz., the horizontal tubular boiler.

The material of which these boilers are constructed is wrought iron and "homogeneous steel." Wrought iron was formerly used entirely for the shells of boilers. The better qualities were made from charcoal blooms. These blooms were prepared from balls of hot iron in a semi-plastic state, which were hammered in order to work out all the scoriæ and impurities which adhered, while the series of blows upon the mass rendered it malleable, dense, and compact. The blooms were then passed through a series of grooved iron rolls, which reduced them to long, slender bars, called puddled bars.

These were then cut up into short pieces and bound together in a pile and brought to a welding heat in a heating furnace. For the better qualities of iron, these were hammered again while hot to further eliminate the impurities; afterward they were rolled into plates and prepared for market. The more the iron is worked, within reasonable limits, the more homogeneous it becomes, and the more ductile. Such iron is usually branded C. H. No. 1, which means charcoal hammered No. 1. The more ductile products are stamped F. B. — fire-box — and F.— flange. A good charcoal hammered iron, honestly made, is well suited for boiler shells, and should show a tensile strength under test of 50,000 lbs. per inch section, and a ductility indicated by 20 per cent. reduction of area at point of fracture under test. It is a lamentable fact, however, that very little of the iron stamped C. H. ever saw a bushel of wood charcoal, and in the haste with which some of it is made, the bars of the pile do not uniformly weld, hence we have laminated plates, which, when put into the boiler and subjected to heat, develop blisters and other defects. We had occasion not long since to make tests of some iron from a fractured plate which was stamped C. H. No. 1. It showed a tensile strength of 50,000 aud 52,000 lbs., with less than 8 per cent. ductility. When bent, it broke with a short fracture and hardly any fiber before reaching 90 degrees.

When a boiler is made, it is next to impossible for any inspection to detect the quality of the iron. In the sharp competition for business, a great deal of poor iron gets into boilers. It is cheaper and the boiler can be sold for less money, and with the improved machinery for flanging, drilling, punching, and riveting, the poor quality of the material cannot be detected. But when subjected to the conditions of use, the frequent repairs soon convince the purchaser that his cheap boiler is a very expensive one after all. "Homogeneous steel" is rapidly taking the place of wrought iron for boiler construction. It is only a few years since this material was thought fit for such use. Its early behavior was quite unsatisfactory, and provoked no little discussion, but with the improved methods of manufacture it is becoming recognized as one of if not the best material for boiler shells. Its ductility and homogeneity are greatly in its favor. These qualities adapt it to the strains caused by the varying conditions of heat, and being rolled from an ingot, it is almost absolutely free from laminations, and consequently from blisters when subjected to heat. We have occasion to test specimens of steel of the different makers. The results of tests of 12 specimens from one maker recently made show tensile strength ranging from 58,210 to 64,329 lbs., with a reduction of area at point of fracture in the first instance of $58\frac{15}{100}$ per cent. and in the latter of $60\frac{65}{100}$ per cent. In another case, where 6 tests were made all from the same maker, the highest were 57,900 and 55,020 lbs., with a reduction of area for the former of $55\frac{4}{10}$ per cent. and for the latter of $58\frac{6}{10}$ per cent. Elongation in 8 inches for the former, $25\frac{6}{10}$ per cent., and for the latter, $26\frac{1}{10}$ per cent. I regard these as remarkably good steels. We have the records of many other tests, but this will be sufficient to show how a good steel should behave under test. I will say here that the company which I represent has nearly 20,000 boilers under its care, among which are several thousand made of steel, and as a whole they are doing excellent service. We have watched them for several years under the conditions of use, which is the best test, and as a result I can confidently recommend *good* steel as an excellent material for boilers. But I will say here that there is a liability to get a cheap steel. Hence we are liable to have the same trouble that was spoken of in regard to iron. The only safe way is to secure pieces or coupons from the plates before the boiler is made, and subject them to test.

There has been considerable discussion in regard to the different methods of riveting boiler plates together, that is, as to which is best — hand riveting or machine riveting, I should say both may be very good and both may be very bad. Hand riveting is so well understood that little need be said about it. In both, the size of rivet hole and the rivet should be adapted to the thickness of plate. The most perfect joint is that where the strength of the net section of plate (after the holes are punched) is nearly equal to the shearing stress of the rivets. The usual method of laying out rivet holes for double riveted joints is to pitch them, or put them apart from center to center 2 inches or 2½ inches. If a ¾ inch rivet is used, requiring a $\frac{13}{16}$ inch hole, it will be found that so much of the plate has been cut away that the strength of the net section remaining will be only about half that of the shearing stress of the rivets. This is wrong ; the rivets should have a wider pitch. To this, many boiler makers will object, claiming that with wide pitches they cannot make a tight joint. The trouble probably is that the rivet holes are not laid out so as to come fair, hence a "drift pin" must be used, and the plate becomes buckled and the joint leaks. If the work is well laid out and well done, there will be no trouble. A drift pin should never be used to bring holes fair that ride one over the other. Suppose we wish to rivet a joint of ⅜ inch plates with ¾ inch rivets ; what should the pitch be ? For a double riveted joint, we would punch or drill the holes $\frac{13}{16}$ of an inch in diameter and pitch them from center to center 3¼ inches. We would also pitch the rivet lines 1⅝ inches apart. This would give a strong joint and a tight joint if the work was well done.

Now about machine riveting. One of the great difficulties is the careless handling of material to be riveted. It is sometimes hung up by a rope or chain running over a pulley, and raised or lowered so as to bring the rivet holes in a line with the axis of the steam piston which drives the rivet. If the center of the hole and the axis of the driving piston do not coincide, the rivet will be imperfectly driven. In the better class of riveting machines, there are two pistons, one within the other. The outer one moves first and holds the plates in place, and the other follows and drives the rivet. It is the careless way in which the work is done that has brought discredit on machine riveting. Much could be said on this subject, but time will not permit. It was formerly the custom, after the boiler was riveted together, to chip off the edges of the lap with a cold chisel preparatory to calking the joint. This work was often carelessly done. The corner of the chisel was allowed to drag, and a channel was cut along the edge of the plate, which greatly weakened it. The surface of the iron was sometimes cut through, and we know that when this is done on a bar of iron, it is easily broken by a sharp blow. Attention being called to this subject by a careless workman, we made the following experiment to ascertain, if possible, why it was that a bar of good iron was so easily broken by cutting a channel across its surface.

When we wish to break a bar of iron, we usually cut a channel with a cold chisel around the entire bar at the point where the break is desired. This having been done, we place the bar on an anvil with the channel slightly over its edge. A smart blow on the outlying portion will cause a fracture, which at first sight has all the appearance of crystallization. Now, if we take this same bar and cut a channel on one side, and subject it to the same treatment with the channeled face up, the crystalline appearance will show slightly, in close proximity to the bottom of the channel, but the main body of the bar will be bent and partly broken, displaying a fiber with a long, silky appearance.

Again, if we take this bar with no previous preparation, and subject it to the same treatment, we shall find that, instead of breaking, it will simply bend, showing no fracture whatever. The question arises, why, with the same blow, do these different specimens of iron show such widely different results? It has been said that the blow on the cold chisel disturbed the fiber of the iron, weakening it and putting it in condition to fracture at the point cut. Being desirous of demonstrating this matter, and for reasons given below, we obtained a bar of iron $1\frac{1}{4}$ inches wide and $\frac{5}{8}$ inch thick. Instead of using a cold chisel we made use of a file, and cut a channel around the entire bar. We then placed the bar on an anvil with the channel slightly over the edge, struck the outlying portion a smart blow, and it flew from the bar like cast iron. The fracture presented a crystalline appearance. This experiment satisfied us that something other than the disturbance of the fiber by the cold chisel was the cause of this sudden disruption and consequent crystalline appearance.

Some have argued that when the *original* skin of the iron was broken or cut, the strength was greatly reduced, and that fracture in bending was well nigh certain.

To settle this theory, we cut again a channel around the bar, and put it upon a planer and planned away the surface for some distance each side of the channel until the channel was entirely "planed out." The bar was reduced in thickness nearly one-third, but the "*original skin*" of the iron was gone. We next subjected this to the same treatment as described above, and it bent beautifully, with no indication of fracture. This demonstrated to our satisfaction that the "*original skin*" of the iron was not, in this kind of strain, what saved iron from fracture. (It should be stated here that iron of good quality has been broken with an apparently crystalline fracture, where no channeling or previous preparation had been made — see Kirkaldy's experiments on wrought iron and steel — but the circumstances were different from those under discussion here.) When we bend a bar of iron slowly, the fibers on the convex or outer surface of the bend are disturbed very greatly comparatively, and this distention or elongation of fiber decreases as approach is made to the other side of the bar, where a crumpling of the surface fiber will take place.

From a careful examination of the bent portion, the different layers of fibers, so to speak, appear to have slipped or slid one over the other to an extent depending upon the degree of strain brought to bear upon each. Sections cut from the bent portion, when examined with a microscope, show, more or less distinctly, that the laminæ and iron threads have become disturbed and loosened in their cinder envelopes, particularly on the outer side of the bend. If the bending is repeated back and forth several times, the loosening up of the fiber is distinctly seen without the aid of a glass.

Having briefly considered the action of iron fiber in the process of bending, we return to the question of fracture. Why does the bar break suddenly and with a crystalline appearance under a smart blow, at the point marked or channeled with a file? When a bar of iron is bent, the outer fibers receive the strain first, breaking its severity as it is transmitted to those underlying. The disturbing force is distributed over the entire portion of the elongated fiber, diminishing each way from the point of greatest strain. Now, it will be seen that by cutting a channel through the outer layer of fiber the strain is confined to the point where the channel is cut. The fiber on either side to the depth of the channel is not acted upon at all, and exerts no influence as a protection to the underlying layers of fiber; hence, when the blow is received, the effect is confined to the channel, the fiber having little or no opportunity to protect itself, and it breaks short off. When a channel was cut in the bar on both sides, and then planed out, the bar was virtually restored to its normal condition, and its behavior was the same as when in its original condition.

Had we space, allusion might be made to inferior qualities of iron, where in piling the center portions are very poor indeed, while the outside bars are of unexceptionably good quality. This kind of iron presents a good surface, but in bending and breaking, its inferior quality is readily discovered. But the experiments which we made were with good bar iron.

Now, the object of these experiments was this: We not unfrequently find boilers fractured along the edge of the outer lap of the sheet, both transverse and longitudinal, and we further find a great many boilers where the chipping tools have been most carelessly used. The immense force confined in a boiler under pressure is little understood by those not familiar with the laws of steam ; and when we take into consideration the fact that this immense pressure is striving to force the surrounding iron into a true cylindrical form, we shall gain some idea of the great strain brought to bear along the lap of the joints — the points deviating farthest from a true cylinder — and the importance of having the iron of the best quality and free from all defects by the careless use of chipping tools, or otherwise.

The fractures found at joints, both longitudinal and transverse, are brought about by expansion and contraction, or by fretting of the iron from uneasy seating of the boiler in its setting ; and it will be readily seen that any defect in the iron at or near the point of greatest strain is very liable to result in fracture. Boilers are sometimes met with that are at least one-third less capacity than they should be for the work required. The engine requires more steam than they can easily and steadily carry, hence at every revolution the draught is so great that the hand of the pressure gauge will vibrate through an arc measuring a variation of from ten to fifteen pounds. The boiler feels the accumulating pressure resulting from fires fiercely urged, and expands to its utmost to accommodate it, until the opening ports conduct the steam to the cylinder and afford it momentary relief. With this slow but continuous process of bending back and forth, is it any mystery that boilers finally "give out" ? And if, instead of good, sound iron, there are defects at the points of greatest strain, need we look for mysterious agencies when boilers rupture, burst, or explode ?

The bracing of the heads of boilers above the tubes in tubular boilers should receive attention. It is true that the flange of the head has good holding power, but the flat portions, if unstayed, are liable, under the high pressures, to vibrate and develop weakness or fracture at the flange.

The area of the flat surface should be estimated, also the pressure upon it, and a sufficient number of braces used to provide for that pressure. If the braces are of iron of known strength, say 50,000 lbs., a factor of safety of 5 would give 10,000 lbs. on each brace of inch section, and the number of braces should be sufficient to provide for the load on the flat surface.*

The tubes in a tubular boiler should never be set "staggered." That was the former practice, but it impedes circulation, and provides a place for sediment to settle on the tubes. They should always be set in horizontal and vertical rows, and should never be nearer than 3 inches to the shell of the boiler, and further, they should never be carried down near the bottom of the boiler ; but, on the contrary, there should be a good water space or room on the bottom of the boiler. The fire from the furnace first strikes the bottom of the boiler, hence there should be a good body of water there. The practice of crowding a boiler full of tubes is all wrong.

An easy experiment can be made to show that the tubes down near the bottom of a

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* The rule adopted by the Hartford Steam Boiler Inspection and Insurance Company is to allow only 7,000 pounds load on a brace of one inch sectional area.

boiler are of little or no use. It is this : Take a clean pine stick, and place it in front of the row of tubes near the center of the boiler at the front end. Leave it there a day, and then examine it. You will find that the top of the stick will be nearly or quite burned off; as you examine farther down, you will see that the scorching and charring grows less and less, until, at the bottom of the tubes, it is hardly discolored. This shows that very little of the escaping gases go through tubes near the bottom of the boiler. There should always be sufficient tube area to easily carry off the escaping gases, but it will be found that the levity of the gases naturally leads them to seek exit through the upper tubes, hence all superfluous tubes near the bottom of the boiler are worse than useless.

The deposits of sediment and scale in boilers are often very troublesome. In some sections of the country, the geological formation is such that the waters carry more or less lime and magnesia in the form of carbonates or sulphates. These are sometimes mixed with iron and other ingredients that make a hard and troublesome scale. The only way we have found to render aid in such cases is to carefully analyze the water, and then advise some solvent that will aid in detaching the scale; but in these cases, the boilers must be frequently cleaned, and all the sediment and such scale as can be detached, removed. There is usually some counteracting material that will soften the scale and help to keep the boilers clean, but some of the worst cases have occurred where the water was naturally good. There have been cases where there were several mills on the same stream. Those higher up would discharge their refuse or dyes into the stream, causing great trouble to all their neighbors below. We have known of some cases where chemical works or hardware manufactories have discharged acids into the stream to the great damage of the boilers in the mills farther down. These are fruitful causes of boiler deterioration, and if not carefully watched will ultimately lead to disaster.

This brings us to the great question of boiler explosions, but our time will allow us to do a little more than allude to the subject. Boiler explosions were formerly attributed to mysterious agencies, and there are some who still cling to that theory, even in the face of satisfactory evidence of weakness or carelessness, or both. After twenty years' study of this subject among thousands of steam boilers, I am satisfied that there is little or no ground for mystery here. The principal causes of boiler explosions are *poor material*, *fault in type*, *poor workmanship*, and *careless management.* Material and workmanship have already been alluded to. There are new types of boilers devised every year, but the majority of them have but a short existence.

The tendency to employ cheap engineers is no doubt a fruitful cause of disaster, and under careless management the best boiler may be ruined in a week or less. The desire for excessive pressures, especially on boilers that have been some years in use, and that are not of sufficient capacity for the work required, is another fruitful source of disaster. Steam users in many cases forget that with the enlargement of their works for increased production, they should add correspondingly to their boiler power. They often try to provide for this increase of product by ordering their engineer to increase the pressure on the boilers. This is all wrong, and it invites disaster.

Much could be said on this subject, but we must pass it by for want of time. (At this point the lecturer exhibited some specimens of iron and steel which had been treated with acids, showing the fiber and the flow of metal under pressure. Some very interesting results from experiments on steel plate were shown, also specimens from stub twist and double twist gun barrels. The latter displayed the interlacing of fiber, and the proof prints were very beautiful.)

Before closing, I desire to say a word about experts and expert testimony. As mechanical engineers, your indorsement or approval of this or that machine or scheme will be often sought. Let me advise you to indorse or approve nothing that you do not thoroughly understand, and, further, never sell your opinion for money. A large fee is very tempting bait, but if the scheme back of it is not all right, let it alone. It is an easy matter to forfeit public confidence. If a man is known to be in the market for the highest bidder, his opinions will have little weight with intelligent men. You have a good example before you of an expert whose opinions are widely sought because they are valuable and honestly given. I refer to the Director of this College, Dr. Thurston. Set your mark high, and work up to it, step by step, through honest, patient, and painstaking work.

The Fastest Run on Record.

So much has been written recently in regard to the remarkable performances of express trains on the two great lines between London and Edinburgh, by which the distance of 400 miles was covered in seven and a half hours, that it is well to recall the still more remarkable performance of a special train on the New York West Shore & Buffalo Railway July 9, 1885. On that occasion the run of 422.6 miles from East Buffalo to Weehawken was made between 10.04 A. M. and 7.27 P. M. or in 9 hours 23 minutes. In accomplishing this the engines were changed three times and the train was stopped by other occasions ten times, besides slowing up for several grade crossings. The train dispatcher's record, which was published by *The Railway Age* immediately after this remarkable performance, showed that extraordinary rates of speed were attained at numerous points, in many instances running over 70 miles an hour, several times reaching 75 miles, and in a few cases recording the terrific rate of 84 miles per hour, a speed which probably has never been equaled, so far as any authentic records show. The history of this great performance has been concisely retold in a large blue print transcript from the train dispatcher's sheets, a copy of which has been received from general passenger agent Lambert. It gives the distances and speed between every one of the stations, with a summary for the principal stations and detailed information in regard to character and weight of train and locomotives, etc. As a specimen of the speed accomplished we re-produce the table for the west end of the Buffalo division showing "speed between stations in nearest even miles per hour, deducting actual stops, plus two minutes per stop for losing and gaining headway."

	East Buffalo.	Bowmansville.	Clarence.	Akron.	Alabama.	Oakfield.	Elba.	Byron Centre.	Bergen.	Churchville.	Chili.	Genesee Junct.	Red Creek.	Pittsford.	Fairport.	Macedon.	Palmyra.	Port Gibson.	Newark.
East Buffalo	—	64	61	61	59	62	62	64	65	65	66	68	67	67	66	66	65	67	67
Bowmansville	...	—	56	59	57	61	61	64	65	65	66	69	68	68	66	66	66	67	67
Clarence	...	...	—	62	58	63	63	65	66	66	68	70	70	69	67	67	66	68	68
Akron	...	...	...	—	54	63	63	66	67	67	69	71	70	70	68	67	67	68	68
Alabama	...	...	..	...	—	74	70	72	74	71	72	75	74	73	70	69	68	70	70
Oakfield	...	...	...	...	...	—	65	71	70	70	72	75	74	72	69	69	68	69	70
Elba	...	...	...	...	...	...	—	76	73	72	74	77	76	74	70	69	68	70	70
Byron Centre	...	...	...	...	..	...	...	—	70	70	73	78	76	73	69	68	67	69	69
Bergen	...	...	...	...	...	...	...	...	—	69	75	83	79	74	69	68	67	69	69
Churchville	...	...	...	...	...	...	...	...	...	—	78	87	81	75	69	68	66	69	69
Chili	...	...	...	...	...	...	...	...	...	...	—	—	84	73	66	66	64	67	68
Genesee Junc.	...	...	...	...	...	...	...	...	...	...	.	—	57	64	59	61	60	64	65
Red Creek	...	...	...	...	...	...	...	...	...	...	..	...	—	66	59	61	61	65	66
Pittsford	...	...	...	...	...	...	...	...	...	...	...	...	...	—	50	59	59	64	66
Fairport	...	...	...	...	...	...	...	...	...	...	...	...	...	...	—	65	62	69	70
Macedon	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	—	57	74	73
Palmyra	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	—	—	84
Port Gibson	...	...	...	...	...	...	...	...	...	...	...	...	..	...	...	...	...	—	72
Newark	...	...	...	..	...	...	...	...	...	...	...	...	...	...	..	...	...	...	—

Some of the figures given in this table are almost incredible and yet they are taken from official records and most of them are equaled in the tables for the three other divisions of the run in question, from 75 to 82 miles per hour being repeatedly recorded.

The following is the summarized running record for all divisions, showing the principal stations only.

DIST.	STATIONS.	TIME.	REMARKS.
0.0	Buffalo	....	
3.4	East Buffalo	10.04	Took train from Niagara Falls Branch.
		11.00	W. N. Y. & P. grade crossing.
64.3	Genesee Junction	11.07	Took water and oiled.
		11.41	
96.8	Newark	11.50	Changed engines.
		12.48	
147.7	Syracuse	12.55	Stopped for lunch and took water.
194.2	Utica	1.54	
		2.04	
205.1	Frankfort	2.10	Changed engines.
		2.48	
235.7	Canajoharie	2.56	Stopped for water.
		3.29	
266.5	Rotterdam Junction	3.29	Stopped by block.
		4.07	
297.8	Coeymans	4.13	Changed engines.
337.8	Kingston	5.01	
		6.20	
373.7	Cornwall	6.20	
		6.50	
392.8	Haverstraw	6.51	Stopped by block.
426.0	Weehawken	7.27	

A table is given showing the physical characteristics of the road, from which it appears that of the entire line 30.18 per cent. is level, 35.62 per cent. up grade going east and 34.20 per cent. down grade in the same direction. The up grade averages 16.32 feet per mile and the down grade 19.51. The alignment shows 82.06 of tangents and 17.94 of curves. The line it will be seen is more favorable than the average of American roads for a fast run, although many of the great English railways are still better adapted to speed. The train consisted of engine, baggage car, and two official cars, and weighed 155 tons. The engines all had 18x24 inch cylinders and their maximum weight including tenders loaded was from 170,500 to 172,000 pounds. Three of the engines burned bituminous coal and one anthracite. Altogether this West Shore run may be pronounced the greatest on record, and it is certainly to be hoped that no attempt will be made to beat its astonishing speed which reached a maximum of 84 miles per hour.—*The Railway Age.*

A CEMETERY OF ANCIENT GAUL. — At a meeting of the French Académie des Sciences, M. Bertrand read a very interesting report upon the Gallic cemetery recently discovered at St. Maur-les-Fossés, near Paris, by M. Ernest Macé, who has presented most of the objects discovered there to the Museum of National Antiquities. The objects discovered are identical with those found hitherto in the departments formed of that part of Gaul which Cæsar allotted to the Belgians. The tombs are dug to the depth of about 3 ft. 6 in., and they vary in length from 6 to 7 feet, while in width they are from 2½ ft. to 3 ft. Most of the tombs had been walled round to a height of from 12 to 14 inches to keep back the sand at the sides, and the body is placed immediately upon the sand and covered with a row of large flat stones to keep it down. In every case the bodies are laid with the face upwards, the sword in the right hand, fastened by a jointed iron belt near the head. On the right-hand side is the point of a lance, the handle of which is placed between the legs, having probably been broken as a token of mourning at the funeral. Among the other objects discovered is a sword in a good state of preservation, with the chain still attached to it. This sword is thirty-two inches long, the sheath being in iron, while the hilt and the guard are ornamented with three heavy nails meant to represent a sort of shamrock leaf. M. Bertrand states in his report that though it is impossible to specify the exact date of these interments, there can be no doubt that the bodies are those of warriors of Gaul, armed exactly as the warriors of the Belgian provinces were at the time of the War of Independence, while, having regard to the care taken in the arrangement of the cemetery, he comes to the conclusion that St. Maur-les-Fossés was an advance post for the defence of Lutetia. M. Ernest Macé hazards the suggestion that the bodies are those of warriors killed during the attack by Labienus upon that city, but this theory is not spoken of by M. Bertrand, whether to confirm or reject it. — *London Times.*

The steamship *Great Eastern*, which has passed through so many vicissitudes since her launch 30 years ago, has been beached near Liverpool with a view to being broken up. It is stated that the iron hull is perfectly sound and that her structural strength is more than ample. Her engines, especially those driving the screw, are, however, very inefficient, and unable to propel her more than 5 or 6 knots per hour. The fine lines and good model of the *Great Eastern* would enable her to make long voyages at 20 knots per hour, if modern triple expansion engines were used. Her great depth and displacement make her singularly steady and easy in a sea that causes smaller vessels to roll and pitch violently, but the very features that make her steady militate against commercial success. Few bars can permit the passage of a vessel which can with advantage be loaded to draw 37 feet 6 inches aft, and fewer docks can admit a vessel of 83 feet beam and measuring 680 feet on the water line. The greatest actual load displacement of the *Great Eastern* is stated at 39,000 gross tons, while the displacement of the next largest merchant vessel afloat, the *City of New York*, is 14,500 tons. The largest man-of-war afloat, the Italian ironclad *Lepanto*, has a displacement of about 14,850 tons. This enormous disproportion of size explains the commercial failure of the *Great Eastern.* Her enormous bulk was necessary to carry the slow moving, extravagant engines and bulky low pressure boilers of the time she was designed, 1853-54, but the innumerable improvements permitting the free use of steel and high pressure steam have enabled more powerful and economical engines to be made with less metal, while ships are now safely navigated without the double skin and other precautions which gave the *Great Eastern* a strength that is now considered unnecessary. A far smaller, and, therefore, less costly, modern ship will now fulfill more than was expected of the *Great Eastern* by her designer and builder, Brunel and Scott Russell.

The *Great Eastern* has, moreover, always been an unlucky ship, and has brought trouble and loss on all who have ever had anything to do with her. Robert Stephenson, George Stephenson's only son, assisted at the unfortunate launch, took a chill, and died in a few weeks. Brunel, her designer, possibly the most brilliant and versatile engineer of his time, survived her launch, but died during her first voyage, which was marked by a fatal explosion. Her first captain, Harrison, was drowned by the upsetting of a row-boat. None of these mishaps had the slightest connection with the merits of her design, but like other accidents, had a very disastrous influence on her commercial success.

The Locomotive.

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Sibley College Lectures.—1886-87.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

STEAM BOILER EXPLOSIONS.

By J. M. Allen, of Hartford, Conn.

It was my privilege nearly one year ago to speak in this hall on the subject of steam boilers, their construction and management, with a view to safety and economy. The importance of proper construction and management is forced upon us almost daily by the accounts of steam boiler explosions, often attended with great loss of property and life.

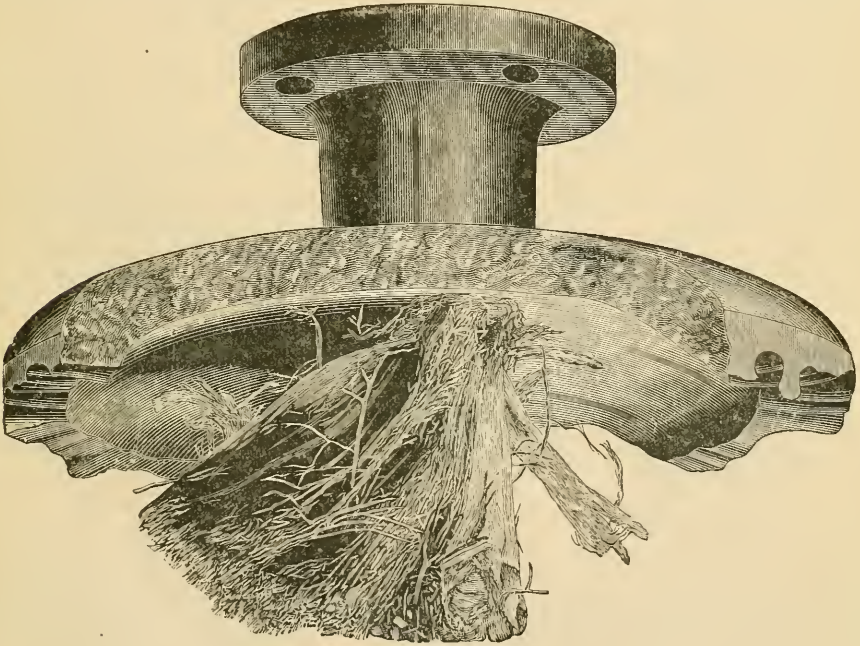

Fig. 1.

During the six years ending January 1, 1886, there were 992 boiler explosions in this country, by which more than 1,500 persons were killed, and many more injured. A large amount of property was destroyed and damaged, beside the loss resulting from delays in rebuilding and replacing boilers and machinery destroyed or rendered useless. These figures are taken from a record which has been kept for many years in the office of the company with which I am connected. They are gathered through our agents in all parts of the country, also from the daily papers. The list may not contain every case of a ruptured or exploded boiler, but it is perhaps as near correct as any such list could be made. The loss or damage to the owners of these mills or works can be only roughly estimated. In some cases it has amounted to $10,000 and even $20,000, while in others it would be covered by a few hundred dollars.

If we assume an average of $3,000 in each case, it gives a grand total of about $3,000,000. These facts are of sufficient importance to lead to earnest inquiry and investigation into the cause of these frightful accidents. The importance of such investigations was recognized more than fifty years ago. The whole subject was shrouded in mystery, and some of the theories put forth were laughable. One of the earliest was that all boilers were exploded by electricity. This theory is said to have become popular in this country more than fifty years ago, from the explosion of a locomotive on the Baltimore & Ohio Railroad during a thunder storm. It was asserted that it was struck by lightning. Subsequently, another exploded on a clear day, but as the subject of

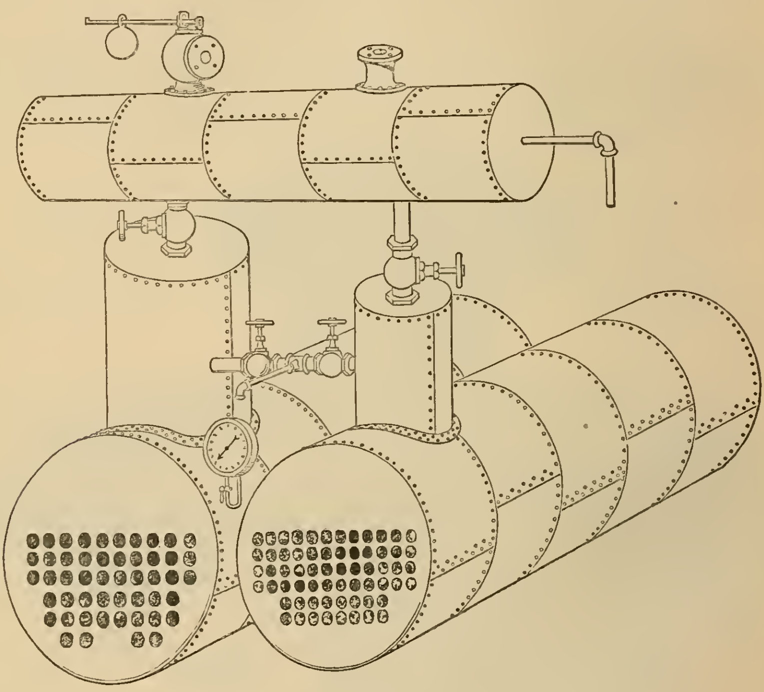

FIG. 2.

boiler explosions had at that time been little studied, and as there seemed to be no ready explanation, it was assigned to the same cause. About this time, at the request of the Treasury Department of the United States, the Franklin Institute, of Philadelphia, instituted a series of experiments to test the truth or falsity of the various causes assigned for the explosion of steam boilers. Before speaking of the experiments of the Franklin Institute, I will say a word about the theory of explosions from electricity. Some forty years ago, in England, a locomotive at rest was found to emit brilliant sparks while the safety valve was blowing. This was thought by some to be conclusive evidence that electricity was stored up in a boiler under pressure, and that, under certain conditions, it might act with explosive results. This led to a careful investigation of the subject by men of high scientific attainments. The result was that the presence of electricity in a jet of steam issuing from an orifice was not due to free electricity within the boiler, but to the friction of the escaping steam upon the inner surfaces of the discharging channel.

If electricity should be developed in a steam boiler by ebullition, or in steam when confined under pressure in an iron boiler in perfect electric communication with the earth, it could not be collected, but would be immediately conveyed away. Prof. Faraday investigated this matter, and his conclusions were :

1st. "The production of electricity is not due to any change in the state of the liquid contained in the boiler.

2d. "A current of dry steam produces no development of electricity. The production of electricity is due to the friction in the nozzle of the drops of water formed by the partial condensation of the steam.

3d. "Increasing the pressure of the steam increased the development of electricity by increasing the friction of the issuing jets of steam and water.

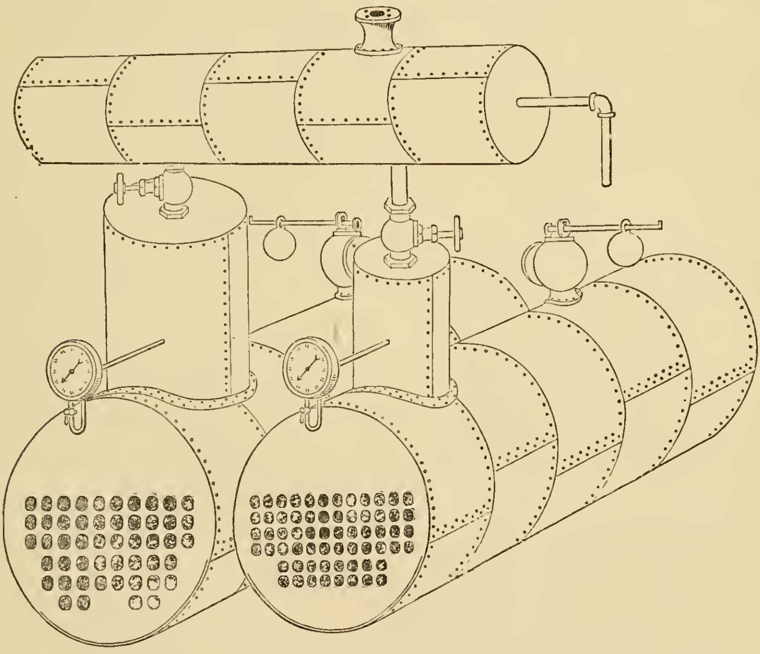

Fig. 3.

4th. "The same results were obtained from compressed air, discharged through the boxwood nozzles, as from steam discharged under the same circumstances. When the air was perfectly dry, there was no development of electricity ; when the air was humid, and contained, besides, a very little pulverulent matter, the friction of discharge produced electricity in the same manner as when steam was employed in the experiments."

The boiler which was used in these experiments was insulated on glass supports or legs, and yet the experiments under these most favorable conditions conclusively showed that electricity could not be counted among the causes of boiler explosions.

To return to the experiments of the Franklin Institute. Among the causes of boiler explosions to be investigated were the following: 1st. That injecting water into a boiler in which there was no water, but only hot, unsaturated steam. This would be a case of extreme "low water" or no water at all. The theory was, that when water was thus injected into a boiler containing hot and unsaturated steam, the water would immediately flash into steam of lower temperature, but of sufficient pressure to rend the boiler in pieces. Without going through with this experiment in detail, I will simply give their conclusions, which are as follows: *

"We see that in no case was an increase of elasticity produced by injecting water into hot and unsaturated steam, but the reverse; and in general that the greater the quantity of water thus introduced, the more considerable was the diminution in the elasticity of the steam." There is a very prevalent opinion that injecting water into a hot boiler in which the water has been allowed to get very low is a fruitful cause of boiler explosions.

This is called the "low water theory." It is maintained that the water, coming in contact with the hot plates, suddenly flashes into steam of great pressure. Assuming that the severe overheating of the plates has taken place, and water is suddenly thrown upon them, there is reason to be believe from the foregoing that the steam disengaged would not be sufficient to greatly increase the pressure already in the boiler. We know that plunging a mass of red hot iron into three or four times its weight of cold water disengages comparatively little steam, and there is no good reason for believing that any more steam would be disengaged if the iron were disposed of in the form of a boiler, and heated to the same temperature. But there are other arguments against this theory. If I remember correctly, a government commission was appointed in 1873 to make some experiments with a view to ascertain the cause of boiler explosions. Among those experiments was one bearing upon this theory. They injected water into an overheated or hot boiler. The result was, contorted plates, leaky seams, and a general demoralization of the boiler, but no explosion.† It must not be inferred from this that no damage arises to a boiler that has been overheated from low water, nor that after such an experience a boiler is suitable for use. On the contrary, it may have been so strained and weakened as to be totally unfit for use at any pressure. I have no doubt that this has been the indirect cause of many boiler explosions. The engineer or fireman allows the water to get low — very low; the plates are overheated and weakened, the strength of the iron is greatly reduced, but instead of drawing the fires and ascertaining what damage is done, he immediately starts the pump, and thinks to cover his carelessness by filling the boiler with water. His fires are urged to keep up steam, but the boiler has been so weakened that it is utterly unable to sustain the pressure, and it "gives out," or "lets go," with more or less destructive results. Another cause which had many advocates was investigated by this Franklin Institute Commission, viz.: "decomposed steam." This is often called the "gas theory." It is this: The steam coming in contact with hot iron is decomposed, that is, the hydrogen is set free, which, uniting with a certain portion of oxygen, forms an explosive gas, which is sufficient to account for many of the destructive explosions.

The experiments of the commission extended over several days, and in one or two instances they succeeded in producing a combustible gas. But other experiments proved that this result was due to the packing of the hand-holes at each end of the experimental boiler. This packing, consisting of cloth and putty, was highly heated, and the cloth mainly disappeared. They further showed, at least satisfied themselves, that when the bottom of the boiler was heated to redness, no hydrogen was liberated by the decomposition of the water injected. Their conclusions were that "water in contact with heated iron in a steam boiler, the surface being in its ordinary state, clean, but not bright, is not decomposed by the metal."

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* See *Journal Franklin Institute*, volume for 1836.

† Prof. Thurston informs me that the commission that made the experiments at Sandy Hook did succeed in exploding a boiler by injecting water into it when the plates were red hot. But very little energy was developed, and it could not be considered as among the causes of destructive boiler explosions. See *Scientific American*, 1875.

At a meeting of the American Academy of Sciences, in 1877, it was shown that steam could be decomposed by simple heat into the constituent gases of water, viz.: hydrogen and oxygen. The apparatus consisted of a flask in which water was heated, a tube conveying the steam to a closed platinum crucible, where it was again heated by a spirit lamp, and a tube which carried thence the superheated steam and the liberated gases to an ordinary pneumatic trough, where the mixed gases were collected in a test tube while the steam was absorbed. The gases thus collected were exploded by a lighted match. But the question arises, Could this or a similar condition of things take place in a steam boiler? In order to produce an explosive gas in a steam boiler, a large portion of the plates inclosing the steam space must be raised to a bright red heat, then the steam must be condensed by the injection of cold water, which must not come in contact with the red-hot plates, for if the plates are cooled down, how is the explosive gas to be ignited? These conditions are hardly supposable in a steam boiler.

The injection of feed water into a red-hot boiler would weaken the plates and joints and very likely produce rupture. This theory has few advocates now among

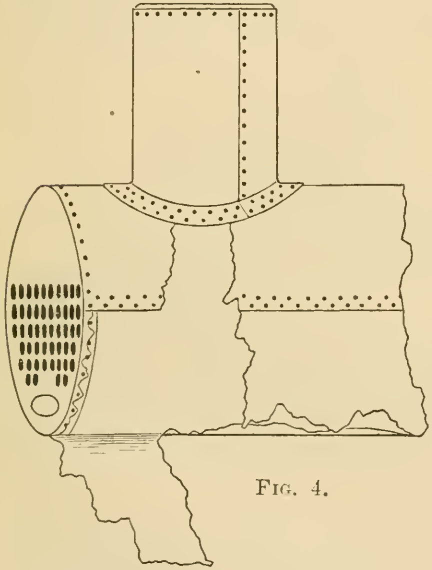

Fig. 4.

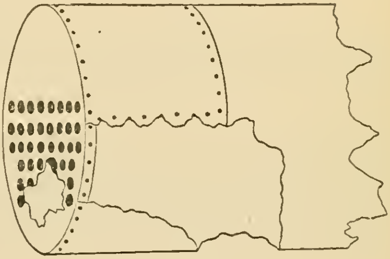

Fig. 5.

those who have made the subject a study. The opinions of Professors Faraday, Taylor, and Brande go to show that the cause of boiler explosions by the decomposition of steam is without any support whatever. Another theory, which has some advocates, is that known as the de-aerated and superheated water theory. It is sometimes known as the Donny theory, because advanced by M. Donny, in 1770. It is this: That water completely deprived of air may be raised to a very high temperature without ebullition, and that under these conditions it has explosive tendencies.

Superheated water would be water heated above the boiling point, due to the pressure on the water at the time, without giving off vapor. If this were possible in a steam boiler, it would be a source of great danger. Many persons have attributed violent and destructive steam boiler explosions to this cause. But we have no evidence whatever that these conditions ever exist in a boiler. The conditions absolutely necessary for the production of superheated water, according to the experiments of Prof. Donny, were: "No portion of the surface of the water can be exposed to the atmosphere or any other vapor or gas." Again, the contact of a solid body or the smallest particle of air or gas is fatal to the success of the experiment; and again, if steam once begins to form, it goes on and cannot be stopped until the water is all evaporated. These conditions could not exist in a steam boiler. The experiments of Mr. A. Guthrie, formerly United States Supervising Inspector of Steam Boilers, were conclusive in showing that this theory had little or no foundation as a cause of boiler explosions. The results of his experiments were published originally in the *American Artisan*, and can be found in the August LOCOMOTIVE, 1882. I have spent some time in telling you what, in my judgment, are not causes of boiler explosions, and you are no doubt impatient to learn by this time what are some of the causes of these frightful accidents.

A well-constructed steam boiler of good material cannot be exploded except by great force. Knowing the quality of the material, the type of boiler, and assuming that it is well constructed, we can easily calculate the force or pressure of steam which it is capable of resisting, and the pressure which would burst such a boiler asunder would be much higher than any pressure which would ever be allowed on such a boiler under the ordinary conditions of use. A boiler explosion under such circumstances would be called an explosion from over-pressure, and such accidents do not occur except from carelessness or oversight in their management. A stop valve may be closed or the safety valve may be inoperative from corrosion or other cause, rendering relief impossible.

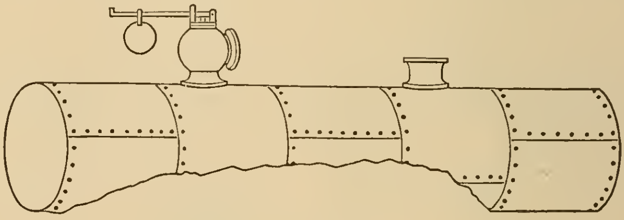

FIG. 6.

The following illustrated cases will show that through carelessness a boiler may be exploded by over-pressure. In a Southern city, the fire sheets of a boiler became weakened, and repairs were necessary. The boiler was connected with another boiler, but a stop valve in the main steam pipe between this boiler and its companion allowed it to be shut off and put out of use for repairs. The boiler was 48 inches in diameter and 31 feet long, with two flues, each sixteen inches in diameter and 27 feet long. Each boiler was provided with a safety valve attached to the nozzle on cast iron head of dome. The main steam pipe was also connected with this nozzle. While the men making repairs were at work in the boiler, hot water from the condensed steam that leaked through the stop valve trickled down upon them and greatly annoyed them. To prevent this, one of the men made a pine plug to fit the hole in the nozzle, and drove it in from the inside. When the repairs were completed, the men gathered up their tools and got out of the boiler, entirely forgetting the pine plug. The man-hole was put in place, the boiler filled to proper height with water, and the fire started. The boiler is said to have behaved very strangely. No steam could be raised. But after an hour or two, the top of the dome was raised several hundred feet, and was found a long distance away the following day. Fig. 1 gives a correct view of it when it was found.

This was a case of explosion from over-pressure. The boiler was abundantly strong for the ordinary pressure required, but the only outlet for the steam was securely closed, and the safety valve rendered useless. Another case of explosion from over-pressure occurred in a Western town. There were two boilers set and connected together as shown in Fig. 2.

It will be seen that there are stop valves between the domes and the steam drum, on which the safety valve for the two boilers was located. This arrangement was made so that one or both boilers could be used. The owner was warned of the danger of such an arrangement, and advised to put a safety valve on each of the boilers, as shown in Fig. 3.

But he neglected to do so. And one day, after shutting off one boiler, he built a fire under it, forgetting to open the stop valve. There being no escape for the accumulating steam, the boiler was blown in pieces, as shown by Figs. 4, 5, and 6. There are no doubt many explosions from over-pressure through carelessness, similar to these cases.

Mr. Fairbairn was of the opinion that all boilers exploded from over-pressure, that is, that the pressure used or allowed was greater than the ability of the boiler to withstand. The element of carelessness entered into his calculations, but his opinion was that no boiler exploded except from excessive pressure. His experiments were made many years ago, since which time the use of steam power has vastly increased, and with its increase, boiler explosions have increased as well. We have indisputable evidence that boilers, even those which appear to be good boilers, explode with great violence, at

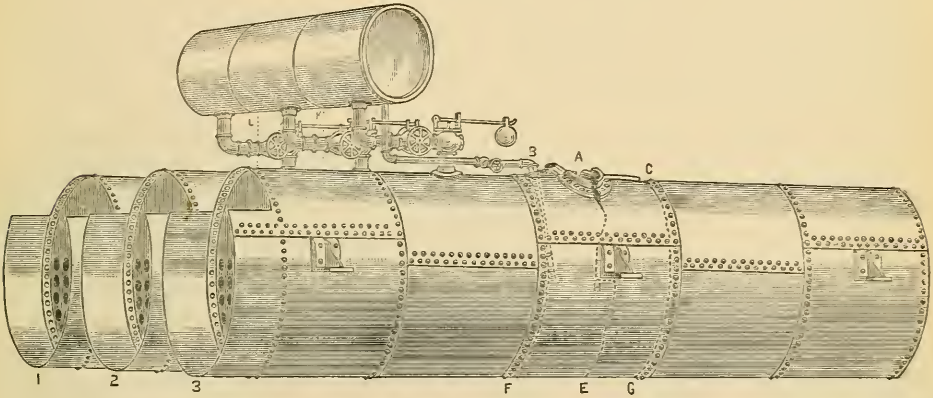

Fig. 7.

Showing the relative position of the boilers 2 and 3, the two that exploded, breaking first at the man-hole of No. 3. B F, A E, and C G, secondary lines of rupture. K L, dotted lines showing location of brick piers built for the support of the steam drum, upon the mid walls of the setting.

ordinary pressures and at comparatively low pressures. When we examine the fragments of such exploded boilers, we rarely fail to find some hidden weakness from corrosion or from some defect in material or construction. The careless use of the drift pin in the construction of boilers have no doubt been the cause of many accidents. I have been in boiler shops where this instrument was wickedly used. The rivet holes failing to come fair when the plates were brought together, one riding over the other, the drift pin was used to so adjust them that a rivet could be inserted. The drift pin, under the blows of an 8 or 10-pound sledge hammer, with a handle four feet long, causes great distress of the material, and if it does not fracture under the treatment, it is fair to assume that a strain is brought to bear which under ordinary steam pressure will be aggravated, until from weakness and utter inability to "hold on" longer, rupture occurs.

Another case of explosion from carelessness is illustrated by the annexed figures.

Fig. 7 shows the boilers as they appeared just before the explosion. The boilers were nearly new, each 54 inches in diameter and 17 feet long. After using them for some months, some changes were made in the steam drum connections, which being completed the boilers were put in use. The man-hole plate of one did not fit tightly; probably from some small portions of the old gasket adhering to the seat. Steam issued from the joint, and instead of waiting until the work of the day was over, so that the cause of the leak could be ascertained, two men secured a wrench with a long handle, and endeavored to force the man-hole plate on to its seat by screwing down the nut of the bolt that held it in place. They were not successful in stopping the steam leak. So a long piece of pipe was secured and slipped over the handle of the wrench, and with this increased leverage these two men exerted their whole force to bring the man-hole plate into place. The frame of the man-hole, which was cast iron and sufficiently strong for the purpose intended, was fractured by this careless and violent usage. The rupture extended into the sheet, and a very destructive explosion followed. The pressure of steam on the boilers at the time was about 80 pounds. This shows how important it is to secure men of intelligence and good sense to properly care for boilers under steam.

Another defect is grooving, which arises from a channeling of the plate. This is caused by some strain, generally brought to bear from the uneasy resting of the boiler in its setting. It may arise from strains caused in construction. But it generally appears along the edge of the lap of both horizontal and girth seams. The continued bending back and forth of the metal loosens up the fiber, and opens it to the attack of any impurities that may be in the water. The channels or grooves extend sometimes nearly through the plate; fracture occurs, and disaster is very liable to follow. A boiler originally well constructed and strong may become weak from low water — I mean by this, overheating from low water — and be in a condition inviting rupture or explosion when used under ordinary working steam pressure. The deposits from bad boiler water work great mischief. Their accumulation in the form of scale of greater or less thickness on the plates of boilers is a source of much trouble and danger. Plates become overheated and burned, and have little ability left to withstand the pressure within. These are some of the conditions attending the use of boilers; and when I remember how many of these cases there are, the wonder is that more boilers do not rupture and explode. In a horizontal tubular boiler 60 inches in diameter and 16 feet long, ready for use, there would be 1,135.91 gallons, or 9,465.8 pounds, of water. When we start the fires under the boiler, the heat is communicated to the water, which rises in temperature until at 212 degrees Fahr. it begins to emit steam from its surface. The steam, however, is formed at the heating surface of the boiler, and forces its way up through the water to its surface. As the fires are continued, this process goes on with great energy, and violent ebullition is the result. If there is no outlet for the steam thus generated and the safety valve is weighted to say 80 lbs., the steam will accumulate in the steam room above the surface of the water, until it reaches a pressure of 80 lbs. to the square inch, when it will begin to issue from the safety valve. The temperature of the steam and water at this pressure is 324 degrees Fahr., or 112 degrees above the temperature of steam at atmospheric pressure. The velocity of discharge of steam at this pressure is about 1,450 feet per second, or at the rate of 16 miles a minute, or 960 miles an hour. The pounds of steam discharged per minute per square inch of opening at this pressure would be about 82 pounds, which multiplied by 4.56, the volume of one pound of steam at 80 pounds pressure, will give us 373.92 cubic feet. I give these figures in order to give some adequate idea of the velocity of steam under pressure of 80 pounds. At 100 pounds pressure, its actual velocity of efflux would be not less than 1,600 feet per second. But from investigation, we have good grounds for believing that steam alone at this pressure would not be sufficient to cause a disastrous explosion, even if rupture were to occur. Steam cylinders of engines sometimes fail. The steam is nearly at boiler pressure, and the cylinder is usually of cast iron, but the pieces are not thrown violently away. The pressure is immediately released and its force is gone. We must look, then, for some other cause than steam alone for destructive boiler explosions.

To refer again to the boiler with a steam pressure of 80 lbs., what are the conditions? We have a boiler 60 inches in diameter under 80 lbs. pressure of steam. The quantity of water is 168.17 cubic feet, or 1,135.91 gallons, or 9,465.8 pounds. This water is heated up to a temperature due to the pressure of steam, or 324 degrees Fahr. All this contained heat in excess of 212 degrees is ready to flash into steam if it had the opportunity, but the superincumbent pressure of steam on the surface of the water holds it in subjection, as a reservoir of power from which to draw as the steam above is used. If we now suppose a rupture to occur above or near the water line, the steam already formed would rush out at a velocity, at first, of at least 1,450 feet per second. The steam space of the boiler would be nearly emptied before the heat contained in the water could so far overcome the inertia of the water as to disengage additional steam. The steam which would rise from the water, carrying a great quantity of water with it, would strike with great velocity upon the upper part of the boiler, and in my judgment be sufficient to rend the boiler in pieces and project the broken parts to a great distance. I have always found that the most destructive boiler explosions were those where there was evidence of the usual supply of water. In discussing one of the experiments at Sandy Hook in 1871, Prof. R. H. Thurston presented the following calculations of the

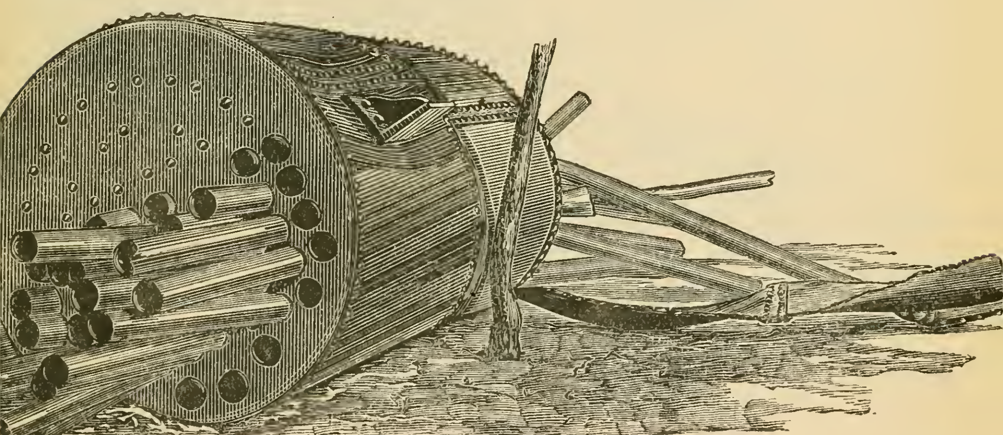

Fig. 8.

Rear view of the part of No. 3 boiler which is shown in Fig. 7.

energy stored up in the boiler and of the work done by the liberated forces. The steam boiler referred to weighed 40,000 pounds, and contained about 30,000 pounds of water and 150 pounds of steam in the steam space, all of which had a temperature of 301 degrees Fahr., when, at the moment before the explosion, the steam pressure was 53½ pounds above that of the atmosphere. Prof. Thurston says: "When the explosion took place, the whole mass at once liberated its heat until it had cooled down to the temperature of vapor under the pressure of the atmosphere." I will not follow Prof. Thurston's calculations through, but he concludes that the maximum possible effect of these liberated forces was sufficient, had it acted in one direction, to have thrown the boiler more than five miles high. As it was, with the liberated forces acting in all directions, portions of the boiler were projected from 200 to 400 feet high. You can find this discussion in full in the *Journal of the Franklin Institute* for March, 1872.* I quote this with great satisfaction because it so fully corroborates the views which I have always maintained from the examination of many boilers which have exploded under the conditions common to boilers in use. The question now arises, Why do not all boilers that rupture explode with such violence? It depends on the locality of the rupture, and its dimensions. If a crack or fracture occurs on the bottom of a boiler and does not extend to any great length, the water will run out no faster than the steam is liberated into the steam space; but a large rupture at or near the bottom of the boiler, sufficiently large to suddenly discharge a large quantity of water, would be followed alike with destructive results. For by this great disturbance in the steam space of the boiler, the disengaging steam from the water, together with the water, would act upon the shell with great force and destructive results.

[The lecturer here displayed photographs of exploded boilers under these conditions.]

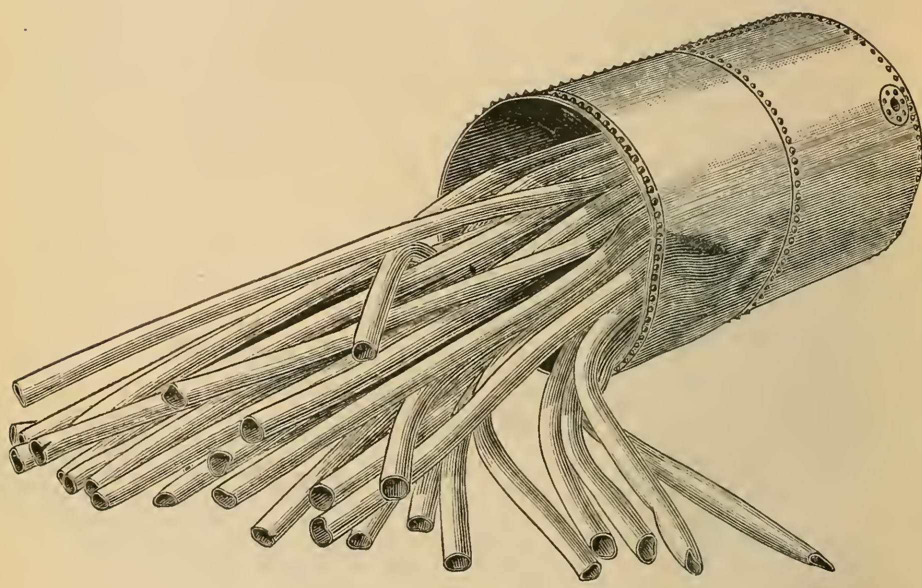

FIG. 9.

Another cause of boiler explosions is the effort to connect boilers under different pressures of steam by opening the stop valve between them. The water races from the boiler of higher pressure to that of lower pressure with a velocity and force due to the difference of pressure and volume of water so disturbed. Very destructive explosions have resulted from carelessness of this nature. [Photographs of boilers exploded from this cause were also shown.] I desire now to call your attention to a case that is of special interest as bearing upon the many theories of boiler explosions which have been advanced from time to time. The drawing (Fig. 10) illustrates the explosion of a rotary bleacher, such as are used in paper mills. It was 20 feet long and about 5 feet in diameter. The plate ruptured at the man-hole or stock door, and instead of quietly

* See especially Trans Am. Soc. Mech. Engs., 1884, and *Journ. Frank. Inst.*, Dec., 1884, for Professor Thurston's latest paper on this subject, giving the amount of this stored energy.

dropping its load, it exploded with great force, entirely demolishing the mill and causing great destruction to life and property. This vessel was 150 feet from the boiler which supplied it with steam. There was no fire near it, and no heat save that due to the pressure of steam which supplied it. The pressure of steam was about 50 lbs. Here we have a case which will be difficult of explanation by any of the "mysterious agency" theories. It certainly was not electricity, nor de-aerated water. There were no overheated plates, hence no place for decomposed steam. But there was an explosion that caused fearful destruction. The heat in this large amount of water became destructively energetic as soon as an opportunity was given it to act. What weakness might have existed in the material I am unable to say, but there was a rupture sufficiently large to change its potential energies into terribly destructive activities. I will add that up to this time we have the record of some 30 explosions of similar vessels. They are always destructive, because the contained water at a high temperature is a reservoir of power which nothing can resist when it is once liberated. Is there any remedy for these ter-

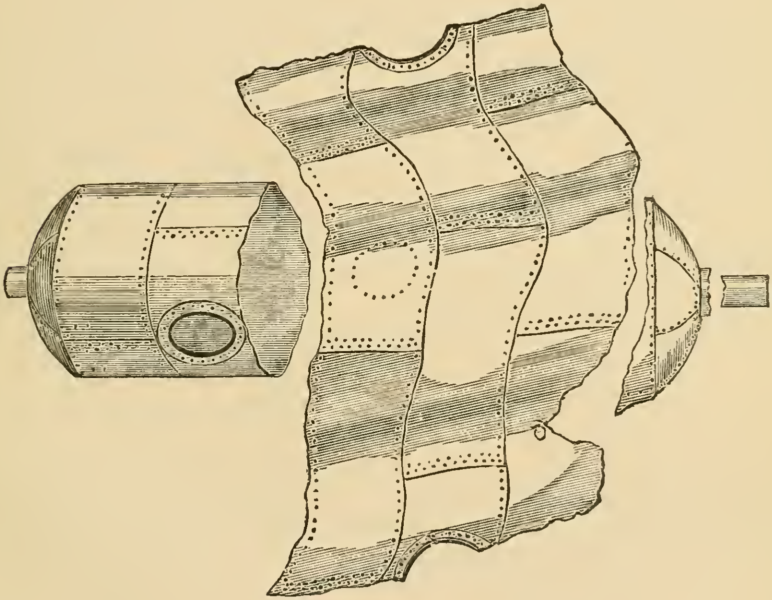

Fig. 10.

rible accidents? Yes, within certain limits. I say within certain limits, because certain conditions are involved, and first, if the material of which the boiler is constructed is of inferior quality, it can never be considered as safe at the pressures at which boilers in these days are used. A difference of a cent or a cent and a half per pound in the material often decides as to what material shall be used; for the boiler must be built for a certain price. Thus very inferior material often finds its way into boilers. Then there are defects in construction. The drift pin is wickedly used. The work is not properly laid out, and undue strains are brought to bear in different parts of the boiler, which are greatly aggravated when the boiler is subjected to the conditions of use. These defects cannot be detected by visual examination. The boiler is subjected to a cold water test 50 per cent. greater than the pressure required when the boiler is to be put in use. It shows no leaks. But this does not reveal any of the defects which may exist, and which could only be detected by cutting the boiler in pieces. Another source of danger is the tendency to employ cheap and ignorant men to have the care of boilers. Some steam users utterly fail to comprehend the responsible position of an engineer who has charge of the steam plant of a large mill. Some of the cases of explosions which I have cited go to show the ignorance and carelessness of men who are intrusted with these responsible duties, and in this connection I desire to say a word for the competent stationary engineer. He stands before his engines and boilers day after day, watching with care every detail, and upon his efficiency depends to a certain extent the successful operation of the whole plant. The economical use of fuel is, in a great measure, in his hands, provided the boilers are properly constructed, set, and connected. It is economy to employ intelligent men for such responsible duties, and pay them adequately for it. There has been of late an effort made on the part of stationary engineers to organize themselves into associations for the purpose of mutual improvement. It is a movement in the right direction, and so long as such associations are kept free from politics and other disturbing influences, they should be encouraged. Another means by which boiler explosions can be greatly reduced in number is by thorough inspections. These will not prevent carelessness nor some other of the causes which lead to boiler explosions. As I have already said, it is next to impossible to detect the inferior quality of the material when once the boiler is completed and set. But a careful inspection does detect the defects and weakness of such a boiler after it has been put in use, and I have no hesitation in saying that many very destructive explosions have been prevented by careful inspections. To sum up, then, I will repeat what I have often said. Boiler explosions are mainly due to inferior quality of material, faults in type, poor construction, and ignorance and carelessness in management. We must be honest in whatever we do. Money making is the ambition of all or nearly all, but if it is made at the expense of honesty, it brings little comfort. A person once detected in a dishonest trick will find it difficult to gain the confidence of the public afterward.

[The lecture was illustrated by large drawings and numerous photographs.]

Inspectors' Reports.

JULY, 1888.

During the month of July, 1888, there were made by the inspectors of this company, 4,401 inspection trips, 10,217 boilers were examined, 4,894 were thoroughly inspected, both internally and externally, 609 were subjected to hydrostatic pressure, and 38 were condemned, being found unit for further use. 8,009 defects were reported, of which 740 were considered dangerous, as per the following detailed list:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	856	31
Cases of incrustation and scale,	1,068	44
Cases of internal grooving,	61	23
Cases of internal corrosion,	430	65
Cases of external corrosion,	404	40
Broken and loose braces and stays,	125	15
Settings defective,	223	8
Furnaces out of shape,	264	11
Fractured plates,	193	94
Burned plates,	140	25
Blistered plates,	304	19
Cases of defective riveting,	1,875	145
Defective heads,	66	21
Serious leakage around tube ends,	988	59

Nature of Defects.	Whole Number.	Dangerous.
Serious leakage at seams,	336	28
Defective water-gauges,	113	17
Defective blow-offs,	68	19
Cases of deficiency of water,	11	0
Safety-valves overloaded,	38	9
Safety-valves defective in construction,	35	14
Defective pressure-gauges,	338	40
Boilers without pressure-gauges,	12	10
Unclassified defects,	61	3
Total,	8,009	740

In looking over the above list of defects, it will be noticed that cases of *defective riveting* exceed all others. This is a defect chargeable directly to the boiler maker, and he has no excuse for slighting this important part of boiler construction. When the rivets are all driven and the boiler is painted over with a thick coat of black paint or tar, it is nearly impossible to detect this class of defect. The boiler may show little leakage under the water test. But when put to work under the varying conditions of heat, the bad workmanship will show itself. Hence, what was bought, perhaps under sharp competition, as the cheapest boiler, may prove very expensive in repairs in the end.

Boiler Explosions.

JULY, 1888.

PRINTING OFFICE (125).—The boiler in the *State Republican* job office, Harrisonburg, Va., exploded July 3, completely wrecking the furniture in the two lower rooms. Doors and windows were demolished and a bay window forced from the building. Four men were in the room when the explosion occurred. J. A. Almond, an employee, received slight injuries.

IRON FOUNDRY (126).—The boiler at E. C. Sterns & Co's iron casting and pattern manufactory, at Oneida and West Adams street, Syracuse, N. Y., exploded July 3, seriously injuring one man, and others had narrow escapes. For several days the mud drum of the boiler had been cracked, and the Wednesday preceding the fire was put out to make repairs. It was supposed to be strong enough for use again. The strain, however, proved too great and the explosion followed. George Smith and another boy were pushing a truck loaded with castings across the engine room, which is a large one, and a part of it is used to store finished work. One of the boys heard a hissing sound coming from the fireplace and shouted, "The mud drum is leaking again." No sooner had he said this than the explosion occurred. When Engineer Edward Holihan heard the boy's exclamation, he rushed to the pump to shut off the water, and this action undoubtedly saved his life, as the side wall where he had stood was torn down, the bricks being thrown several yards. Where the pump is the wall still remains, and Holihan's injuries are from frightful scalds. His arms, face, and body are burned very bad. George Smith was hurled backward several feet, and somewhat injured. He was taken to his home in the Second ward. The boy with him was hit in the arm by a brick, and the concussion knocked him down.

SAW-MILL (127).—By the explosion of a saw-mill boiler at Romney, Va., on July 5th, one man was killed and three injured ; two fatally.

TANNERY (128).—A battery of boilers at the tannery of A. & J. Groetzinger on River avenue, Alleghany City, Pa., near Herr's Island, exploded shortly after 4 o'clock P. M., July 6, wrecking several buildings and seriously injuring six persons, three of whom will probably die. The injured are: William Wetzell, engineer, aged 30 years, leg blown off and terribly burned. Christ. Neidt, aged 27 years, bruised and scalded; injuries believed to be fatal. L. L. Farbic, aged 43 years, burned, bruised, and scalded; death probable. Otto Berghaendler, aged 28 years, bruised and scalded; will recover. John Staab, about 25 years of age, arms, face, and body badly burned; not fatally hurt. Annie Myers, aged 12 years, crushed and bruised; very serious. A large number of others, mostly employees, were slightly bruised and cut by being struck by flying débris. The cause of the explosion is believed to have been high pressure. A few minutes after 4 o'clock William Wetzell, the engineer, noticed that the pressure was higher than usual, and he started for the furnace to turn down the natural gas. Before he had time to do so, however, the explosion came, and Wetzell was blown up through the roof of the tannery, and landed in the yard outside. One side of the main building, a brick and frame structure 200 feet long, was blown out, and a portion of the front was badly wrecked. The boiler house, 50 feet long by 42 wide, built of brick, was totally demolished, and the office, which was situated across the street, was completely shattered. A heavy double wagon was blown against Wetzell's residence, sixty feet away, and the side of the house crushed in. Pieces of the boiler flew in every direction. . . . . The boilers that exploded were 26 feet long by 42 inches in diameter. They were made of steel, and have been in use six years. The damage to property by the explosion will not exceed $20,000.

HOISTER (129).—A boiler exploded at the wharf of the Wood Manufacturing Company, at the head of Fifth street, Camden, N. J., July 7, and two men were terribly, perhaps fatally, scalded. The company operate a marine railway, vessels being drawn from the Delaware River by machinery operated by a forty-horse engine and boiler. While the machinery was in operation at twenty minutes before 12 o'clock a patch was blown off the boiler with great force, and clouds of steam and a deluge of boiling water poured out. George W. Davis, a blacksmith, who came from Virginia about three weeks before, and who boards at 805 North Third street, and James Mander, a colored laborer, residing at No. 815 Cherry street, were caught in the steam and hot water and frightfully scalded. It was reported that they could not recover.

SILK MILL (130).—A seventy horse-power boiler exploded at the Adelaide silk mill, Allentown, Pa., at 7 o'clock A. M., July 9, instantly killing Frank Sterner and Henry Booreo, firemen. Hiram Sell, the engineer, was caught by the legs by a crank of the engine and pinned fast. He was terribly injured and died at 10 o'clock after one of his legs had been amputated. Oswin Ochs, a bricklayer, employed in covering one of the boilers, was shockingly scalded, but will recover. Jacob Shaffer and Robert Hilliard were slightly bruised by flying debris. The engine house, which was a separate structure, is a wreck. The engine is not greatly damaged and only two of the other boilers of a battery of six were displaced. None of the 900 employees were injured, though they were greatly frightened by the explosion.

SALT WORKS (131).—At 12.10 o'clock P. M., July 12, an accident occurred at the American Dairy Salt Company's experimental works at the foot of Court street, Syracuse, N. Y., by which two men narrowly escaped death by scalding. The works are run by steam power generated in two boilers encased in a brick wall. One is a tubular boiler and the other a Root boiler. The latter is the one farthest from the canal and is said to be proof against dangerous explosion. Instead of the fire passing through flues in the water, the water and steam pass through flue pipes through the fire. It was one of these steam flues on the east side of the boiler which burst and the accident shattered the brick wall on that side. The escaping steam and hot water filled the fire space and burst open the fire door, throwing the engineer and fireman to the floor. While in this position they were deluged with escaping steam.

BREWERY (132).—A terrific explosion occurred in Wm. Lemps' brewery on Cherokee Street and Utah Avenue, at 3 P. M., July 15th. In a boiler-house, separated from the main building, are seven boilers, all of which were in use. There was an over-pressure of steam on the seventh, or more western boiler, and the head gave way. The other six boilers and furnaces were shattered, and the roof of the building blown to splinters. The engineer, also the man in charge of the boiler-room, were out of the building when the explosion occurred. Fortunately no one was injured. The damage is estimated $3,000.

Steamer (133).—A disastrous explosion occurred July 20, about twenty-five miles above Louisville, Ky. The pipes that supplied steam from the boiler to the engine on a river steamer burst and caused a terrible scene. The men were nearly all asleep in their bunks at the time, and all were killed or badly injured, some of them being literally roasted by the escaping steam. The following-named were found dead or died soon after being found: William Page, William Harrington, Robert Jones, William Bigley, Charles Luster, George McCann, and William Kelly. When the boat reached Westport, everything, according to the first mate's story, was running smoothly. When they were two miles above Westport suddenly there was an explosion. . . . . The officers of the boat can give no explanation of the accident, and claim the machinery was inspected last February, and was then in excellent condition.

Coal Mine (134).—A boiler explosion at the coal shafts of Williams & Moss, at Zions, near Henderson, Ky., July 22, killed David Stone, the engineer, and Moses Haskins, the fireman, and fatally scalded Frank Throop and Alexander Longnecker.

Locomotive (135).—The locomotive Peohatcong, which was drawing a coal train on the Delaware, Lackawanna & Western road, near Clark's Summit, exploded with terrific force July 31, killing Fireman Oscar Kreidler and fatally injuring Engineer Irvin Stern. Fireman Kreidler was at work at the tank when the explosion took place, and the rush of hot water struck and carried him some distance away. He was scalded from head to foot. He was carried to the Lackawanna Hospital in Scranton. He died a few minutes after his admission. Engineer Stern had his jaw, arm, and hip broken, and sustained a severe gash on the back of the head. His recovery is considered impossible. He is about thirty-five years old, and his home is in Portland, N. J. The boiler and cab of the dismantled locomotive were blown a distance of twenty-five feet into a field, while the frame and wheels remain on the track. The "Peohatcong" was a culm burning locomotive, built expressly to consume the waste coal which lies in large heaps in and about Scranton.

Locomotive (136).—The boiler of one of the large and powerful locomotives which had only been in service about a month on the Germantown & Norristown Branch of the Philadelphia & Reading Railroad, exploded with terrific force a few minutes after 11 o'clock p. m., July 31, at Columbia Avenue Station, Philadelphia, Penn., causing the almost instant death of the engineer and fireman, and badly injuring and scalding several other people. The killed were: Andrew Pond, engineer, aged 30 years, of No. 220 Armat street, Germantown; Peter Grakelow, fireman, aged 31 years, of No. 620 North Ninth street. The injured were: Charles M. Ryan, driver, aged 22 years, residing at No. 1407 Camac street, badly scalded about the face and body; Elmer Metz, night train despatcher, foot badly crushed by a piece of the boiler falling on him; a colored man, name unknown, who was scalded by the escaping steam; James Brien, of No. 926 Bainbridge street, scalded about face; George L. Van Vert, of No. 1228 Frankford avenue, slightly scalded; L. P. Denny, of Tenth and Oxford, slightly injured by a piece of iron. The train was the 10.35 p. m. accommodation from Chestnut Hill, which place it left on schedule time, and stopped at Columbia Avenue Station at 11.04. The passengers, of whom there were quite a number, had left the train, and the conductor, Daniel Hickey, had given the signal to go ahead, when a hissing noise was heard by those remaining in the cars, and the people congregated in and about the station as the train moved on for about twenty feet, and was immediately followed by a deafening report caused by an explosion of the boiler. . . . . The force of the explosion had turned the large locomotive completely upside down and thrown it on the track. It was much battered and bent and will prove almost a complete wreck. After searching around the wreck for some time the unconscious body of Fireman Grakelow was found about ten feet ahead of the engine, lying in the middle of one of the tracks. He was discovered by one of the brakemen partially buried beneath a lot of iron and coal, and after some difficulty was taken out. He was carried into the waiting-room, and an examination disclosed that the front part of his head had been mashed in. A physician was summoned, but Grakelow expired before he arrived, without speaking a word. The dead body of Engineer Pond was found about fifty feet down the track, terribly crushed and scalded. His death must have been almost instantaneous.

Threshing Machine (137).—A boiler explosion occurred July 31 at Forestville, near Raleigh, N. C., where a portable steam engine was used on the farm of P. H. Mangum to run a threshing machine. A colored man named Mose Mangum was killed instantly, and Mr. Mangum, who had just ridden to the spot on horseback, was struck on the breast by a ponderous fragment of iron and knocked violently from his horse, receiving fatal internal injuries. Several others received serious injuries.

Incorporated 1866.

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The Locomotive.

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Sibley College Lectures.—1887-88.

BY THE CORNELL UNIVERSITY NON-RESIDENT LECTURERS IN MECHANICAL ENGINEERING.

IV.—DETERIORATION OF STEAM BOILERS—WEAR AND TEAR.

By J. M. Allen, M. E., Hartford, Conn.

When a boiler is completed and set to work, destructive forces more or less severe become active, and they must be carefully watched, or the working age of the boiler will be materially shortened. The forces may be mechanical or chemical, or both. The mechanical forces are those usually arising from bad design, bad workmanship in construction, with the exercise of little judgment in the matter of setting. A boiler should be so designed, constructed, and supported, that under the conditions of use the

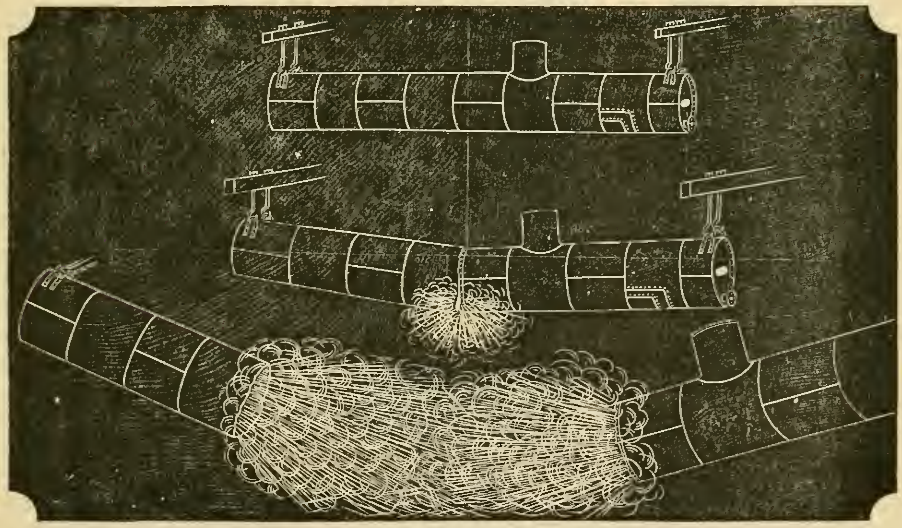

Fig. 1.

strains will be as uniformly distributed as the conditions will allow In externally fired boilers it is well known that the bottom or fire sheets are more expanded than the top sheets. Hence it becomes necessary to have such arrangements made in the setting or support that the boiler shall rest easy and have opportunity to adjust itself to these conditions. In long cylinder boilers this strain often becomes quite severe, and if the boiler is tightly bound up in brickwork, fractures are very liable to occur. To compensate for this, various plans for supporting long boilers have been devised. In some cases the brackets or beams supporting the boilers have rested on volute springs, in other cases equalizing beams or bars are used. In some cases quite elaborate apparatus has been devised. The point to be attained is to so support the boiler that the load will be properly distributed under the changes of form to which the boiler may be liable under heat. Were it not for the elasticity of the metal, these long boilers could not adjust themselves to this severe strain, but when well constructed and properly set they have stood the test for many years. Usually these long boilers, from forty to sixty feet in length, are used in iron works, and are heated by the waste gases from the smelting furnaces. The gas enters the boiler furnace under more or less pressure, and when ignited will present one continuous sheet of flame from the furnace to the rear end of the boiler. In order to fully utilize these gases, the long boilers are used. It is a question whether shorter boilers of a different type may not be used with safety and equal economy. Another form of cylinder boiler from twenty-eight to thirty feet long is used in connection with reheating furnaces in iron works, the gases being utilized for fuel. These boilers are often supported by resting simply on walls at each end. When the metal is being run off, the furnace doors are thrown wide open and a current of cold air is allowed to flow into the furnace and along the bottom of the boiler. The walls are very hot, and the temperature of the steam and water in the boiler is that due to the pressure. The sudden cooling of the fire sheets causes contraction, and a severe strain is brought, especially on the girth seams. These not unfrequently crack from rivet hole to rivet hole, and in a number of cases I have known the boiler to break into two parts, each part flying off in opposite directions, Fig. 1.

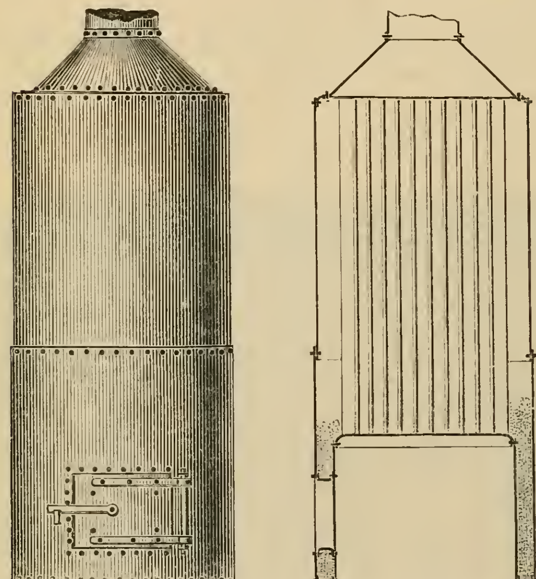

FIG. 2. — AS BOILERS ARE OFTEN BUILT.

A current of cold air should never be allowed to strike, for any length of time, the fire sheets of a hot boiler, and such boilers should always have rods not less than one inch sectional area, running from head to head, sufficient in number to hold the boiler together under such circumstances. With this provision for safety, if a leak was noticed at any girth seam, the boiler could be put out of use and the extent of the fracture ascertained and suitable repairs made, thus preventing what otherwise might cause a serious accident.

Internally fired and fire box boilers have their weak points as well. There are narrow passages for the collection of sediment and formation of scale, and in these narrow passages the circulation is very imperfect, and wasting and corrosion is very liable to take place. I will, however, say that this type of boiler is very much used, and with economical results. There is economy of space also, which is often an important consideration. But boilers with water legs and narrow water passages should be frequently examined, so that the difficulty, if such exists, can be discovered and remedied before the progress of deterioration has gone to a dangerous extent. Boilers with narrow water passages, whether vertical or of the horizontal type, should be supplied with a sufficient number of hand-holes to make the work of cleaning out sediment comparatively easy. The following illustrations (Figs. 2 and 3) will show how vertical boilers are often constructed, also how they should be constructed to overcome the difficulties mentioned.

Another important, yes, all important, matter is good workmanship in construction. If a boiler is bunglingly put together there will be severe local strains that under the conditions of use will be greatly aggravated. If the parts of the boiler do not fit well, and are brought into place by severe hammering and wrenching, what can we expect of such a boiler when put into use under a pressure of eighty or ninety pounds to the square inch? It will leak and give any amount of trouble to the user, and it will be fortunate if it does not burst or explode, carrying death and destruction in its flight. The "drift pin" seems to be one of the great evils in a boiler shop, although few boiler-makers will admit that they use it, except to keep the plates in place while they are being riveted together. But I sometimes step into a boiler shop, unknown and unannounced, and I have seen the cruel use of the drift pin. Work has been poorly laid out, and the rivet holes which have been punched do not come into place, so that the holes in the different places are not coincident, one will ride over the other, and instead of using a reamer to cut away the intruding metal, the drift pin is resorted to, and strong men with hammers or sledges of eight pounds weight will drive the drift-pin until one hole is elongated to a third or a half greater than its original diameter. The rivet is driven and its expanded head covers the defect, and the exterior appearance of the boiler is very fair, but who can tell what strains and weaknesses have been caused, which, when the boiler is put into use, will develop into troublesome and possible dangerous defects? I am sometimes surprised that men will allow such work to go out of their shops. There is a moral responsibility connected with this business that should rest more heavily on some at least of the boiler-makers in the country than their work would indicate, and in this connection allow me to say that a man's work is a pretty good indication of his character. Honesty and truthfulness lie at the very foundation of character, and these qualities show themselves in a man's life and work quite as much, yes, more, than in his words. Another potent cause of the deterioration of boilers is the water which is used causing deposits of sediment, formation of scale, and often having corrosive tendencies. We have a great variety of waters in this country, chemically speaking. In many sections of this country we find the underlying strata to be largely sulphate and carbonate of lime. This formation is of wider extent than any other. Then there are also chalybeate waters, magnesia, alumina, silicate, and waters carrying more or less organic matter. All of these waters give more or less trouble. In carbonate waters, the carbonate of lime and magnesia are frequently thrown down in the form of a fine

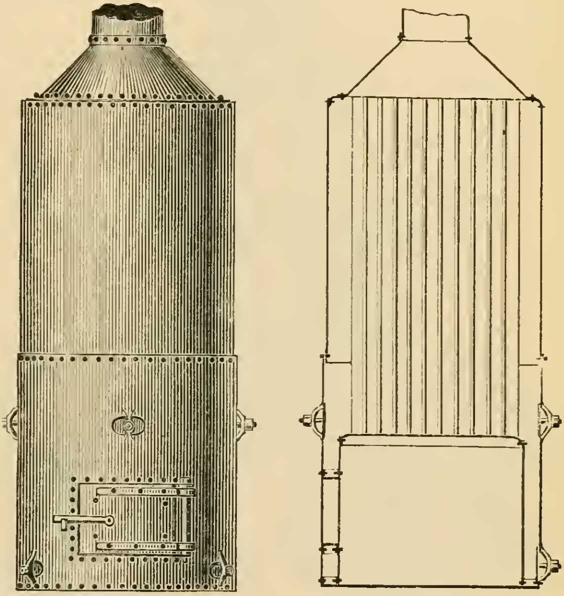

FIG. 3. — AS THEY SHOULD BE BUILT.

powder, which settles along the joints at the lap; this often causes leaks. Another practice which aggravates these cases is returning the exhaust from the engine to the boiler. The oil thus carried into the boiler in combination with the impurities in the water makes a pasty substance that adheres to the plates, keeps the water from contact, causing overheating and often rupture. In fire-box boilers where there are water legs and narrow water passages, this deposite often becomes a serious matter. Open heaters should not be used for collecting drips, if there is any oil used, but where the drips come from slashers or drying rooms, there will be no trouble. To utilize the heat in the exhaust from the engine, a pipe or coil heater should always be used. By such an apparatus all danger is avoided. I have mentioned above some qualities of water which are found in different sections of the country. In many cases the water is so bad that it is not fit to be used in boilers, and would not be used if a better supply could be found. Some very difficult problems come up for solution in connection with the water supply for boilers. Our rule is first to analyze the water, and then, knowing what impurities are carried in solution, we are better able to decide what the remedy must be. If the impurity is mainly carbonate of lime or magnesia, it is usually thrown down in the form of a fine powder. Frequent blowing is necessary, that is blow down two gauges of water two or three times a day. This should be done in the morning before the mill or manufactory is started up, the impurities having had time to settle during the night. Then, again, after the dinner hour, just before starting the engine. This practice faithfully carried out will greatly relieve the difficulty. But in addition to this, there should be a good pipe or coil heater, and the sediment from that should be blown out often. It sometimes occurs that the impurities do not readily settle on to the bottom of the boilers, especially if the boilers are hard worked, and circulation is rapid. In such cases a surface blow is desirable and important; the object being to remove, as far as possible, the impurities from the water. To give you a correct impres-

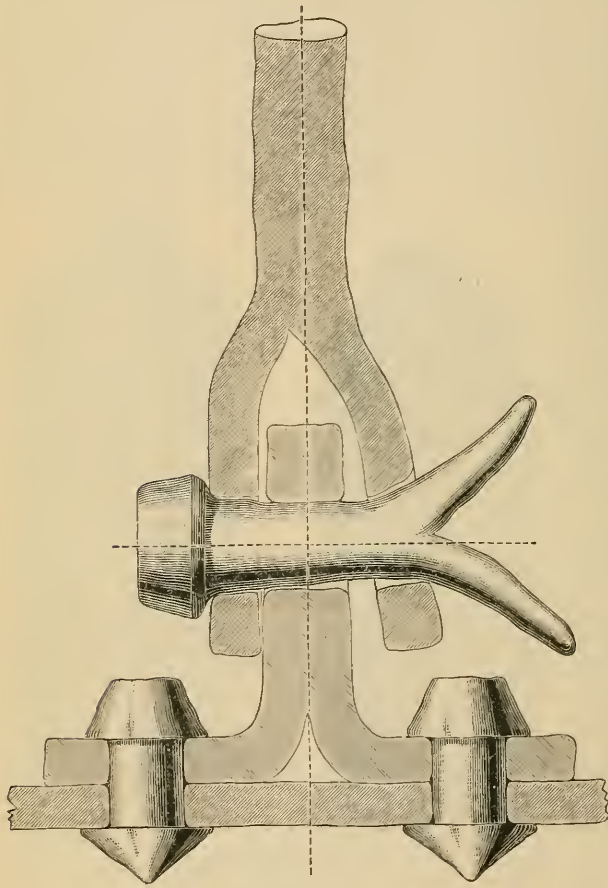

FIG. 4.—SHOWS A BRACE FASTENING TO HEAD OF BOILER AS THEY ARE SOMETIMES MADE. (This is no exaggeration.)

sion of the character of some waters used in boilers, I copied the following from our laboratory records: In spring water from Nashville, Tenn., we found in 100,000 parts, insoluble and sparingly soluble solids 17.6 parts, readily soluble solid matter 35.2 or a total of 52.8 parts, or 30.82 grains to a United States gallon. In another case, water from a well at a chemical works, we found in 100,000 parts, insoluble and sparingly soluble solids 25.6, readily soluble solids 71.2, total 96.8 parts, or 56.52 grains in a United States gallon. In another case not far from Hartford, water from an artesian well, we found in 100,000 parts:

Insoluble and sparingly soluble, ...	12.4
Readily soluble, ...	32.4

Total, 44.8 parts, or 26.15 grains in a U. S. gallon.

Similar waters have been found in artesian wells in different parts of the Connecticut Valley. This valley was once an ancient sea, long before the sandstone formation, and in boring deep wells strata are struck containing chloride of soda, sulphate of soda, carbonate of lime, also nitrate of potash. In some cases beds of Glauber's salt are struck, a sort of neutral sulphate of soda and very cathartic. This water, with care, could be used in a boiler, but frequent blowing would be imperative, also thorough cleaning at stated periods of at least once in two or three weeks.

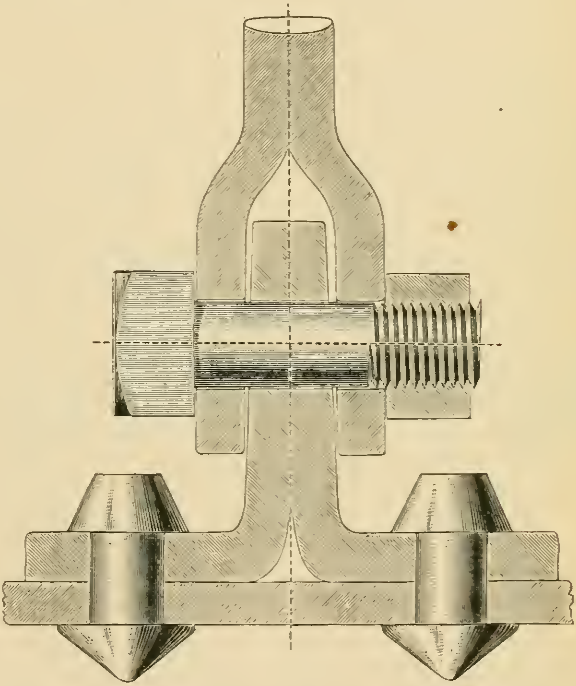

Fig. 5. — Brace Fastening as it should be.

We had occasion to analyze some water from a mine in Illinois, and found in 100,000 parts:

Insoluble and sparingly soluble, ...	28.1 parts.
Readily soluble, ...	83.5 "

Total in 100,000 parts, 11.16, or 65.17 grains in a U. S. gallon.

This water had in addition to sulphuric and carbonate acids, and sulphureted hydrogen and nitric acids combined, chloride of soda, sulphate of soda, carbonate of lime, carbonate of soda, carbonate of potash, and carbonate of iron. It was wholly and utterly unfit for use in boilers. It would not only have made a hard scale, but it was corrosive and would rapidly eat away the iron. An artesian well was bored in the vicinity of this mine, and was even worse than the mine water. Analysis showed:

Insoluble and sparingly soluble, ...	26.4 parts.
Readily soluble, ...	231.2 "

Total in 100,000 parts, 257.6 parts.

This water if used in a 60-horse power boiler, would deposite at least 250 pounds of sediment a week. It could not be safely used. I might continue this record over many pages, but it is sufficient to show the quality of some of the worst waters we have to deal with. You will very naturally inquire, What do you advise to be done in these cases of bad water? It is often a very puzzling question. If carbonate or sulphate of lime predominate, a very good antidote is carbonate of soda. Especially is this good in case of carbonate of lime. It prevents it from readily forming a scale, and if attention is given to blowing and cleaning, the difficulty can be easily overcome. We usually recommend from eight to ten pounds of soda ash dissolved in warm water to be introduced into the boiler about once or twice a week. This can be done by putting a branch into the suction pipe of the pump and connecting this branch by a hose to the pail or vessel containing the solution. In some cases we use one part, by weight, of catechu to two parts of soda ash. Tannin works well in some cases, and a solution made from boiling the leaves of the eucalyptus tree has found much favor on the Pacific coast, and is being introduced in this part of the country. There is no grand panacea

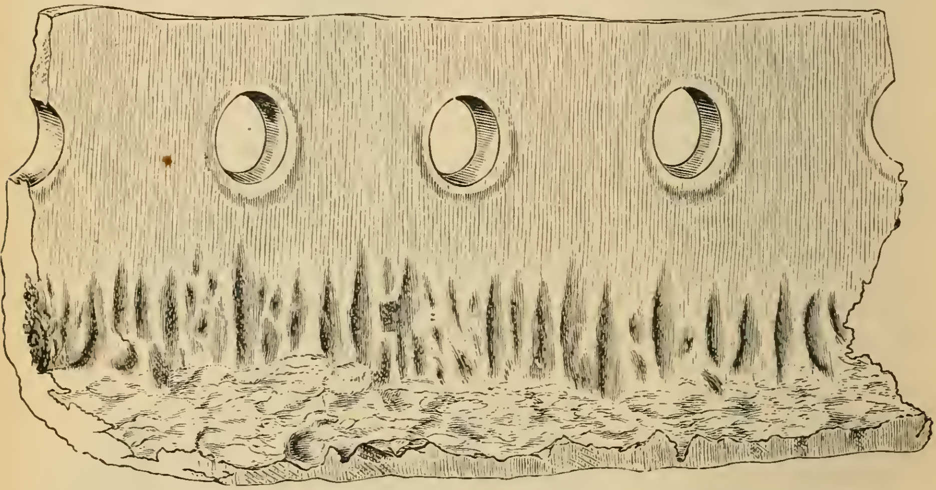

FIG. 6. — PART OF A HEAD OF A BOILER BADLY CORRODED AND PITTED BY WATER FROM A SWAMP.

that will cure all these maladies. We must know something about the case before we can remove the disturbing cause. It will be readily seen that if attention is not given to these cases, the result will be not only annoying, but dangerous. Hard scale will accumulate on the fire plates of the boiler, resulting in overheating, and greatly weakening the boiler. The question of the waste of fuel is also an important one, for steam cannot be economically generated in a boiler where the plates are covered with scale. We all know that scale is a very slow conductor of heat, hence, in addition to the loss here, the plates are worn way and become greatly weakened. The question of corrosion is a serious one in some cases, and is difficult to manage. Water from swamp lands often has corrosive tendencies (Fig. 6), and in rivers and streams on which a number of manufactories are located, discharging their spent dyes and refuse, becomes very much contaminated, and gives serious trouble to the mills located down the stream. Law suits not unfrequently grow out of river contamination, and we have been summoned into court in a number of such cases. Our advice has always been for the parties to combine and lay a water main from the pond of the upper dam to the mill lowest down, of sufficient capacity to supply them all with good water. Another difficulty which is often encountered, and which at first seems paradoxical, is corrosion or pitting from pure water. Corrosion in boilers in the absence of free mineral acids can proceed from three principal causes:

1. The purity of the water.

Water is an almost universal solvent, and dissolves most substances to some extent. In the absence of substances in solution to prevent that action, even pure water would attack iron and corrode it, but except in the case of distilled (condensed) water returned to a boiler with the return pipe coming near the shell, this condition can hardly be said to exist, as even rain water contains from one to three parts per 100,000 of impurities.

2. The presence of air and dissolved gases in the water.

This is in all probability the most fruitful source of corrosion (except the acid decomposition of grease, oil, etc.). Water, unless recently boiled, contains varying amounts of dissolved gases, which are expelled at boiling temperatures. It has the peculiarity of holding a larger proportion of oxygen in solution than air has, usually about 33 per cent. more in water free from oxidizable matter. This under proper conditions would combine with the iron, rusting it rapidly, and when oxidation had once begun, forming a rust spot, heat and moisture would rapidly continue the work.

Water also contains varying and sometimes large amounts of carbonic acid gas. This by some authorities is equally injurious with the oxygen, but as when existing in large amounts it is almost invariably associated with lime and alkalies, which have been found to prevent corrosive action in practice it is probably not especially harmful.

Oxygen and nitric acid occur in rain water and newly fallen snow, and the purer and more aerated a water is, as for example rain water, snow water, and water from uncultivated upland and quick slopes, the more dissolved oxygen it is likely to contain.

3. Substances in the water causing corrosion.

A water containing more than ten parts per 100,000 of solid matter usually contains considerable lime as carbonates, some soda and potash salts, and is alkaline. Such a water is not likely to corrode a boiler. A water with only four or five parts of solid matter (though it may contain also considerable dissolved oxygen, etc.) may be almost, if not quite, neutral, or even slightly acid. This acidity may come from dissolved organic matter, which if from fields or woody districts the water is likely to carry in considerable amount. This woody extractive matter is easily decomposable, and some of the complex acids, so called humic, crenic, apoorenic, oxalic, etc., present, or formed under the action of decomposition, act very unfavorably on the iron of the boiler. This woody or especially peaty matter also contains tannic acid and gums in many cases, and has been observed to so varnish the inside of boilers in some places as effectually to prevent corrosion where otherwise it would be expected.

The presence of certain salts in solution has a very injurious effect on boilers, even in small amounts. Waters containing nitrates, and especially ammonia salts, as ammonia chloride, seems to be especially bad.

Water, therefore, exposed to the leaching from vaults, etc., is especially undesirable, even though a water strong is salt and alkalies from a common sewer might not be harmful to the boiler. The action of oil and tallow, etc., decomposing to oleic and margaric acid in the boiler, in the absence of alkalies, and especially with a coating of sulphate scale to prevent free circulation of the water at the corroding points, is well established.

It occurs, perhaps frequently, that a water at some seasons of the year, making quite a scale is, at others, quite soft and charged with air and gases and partly dissolves that scale. This may go on indefinitely, until an unusually wet season, or a very clean or new boiler with the water quite pure, may suddenly develop injurious pitting from the absence of matter to counteract the effect.

FROM ROWAN — PART OF A TABLE BY WAGNER.

Iron, loss of Weight in per cent. in water.

	One week.	Six weeks.
Distilled water (flask half filled), ...	0.44	2.46
Distilled water (*i. e.*, more air), ...	1.01	5.18
With magnesia chloride, ...	1.31	3.05
With soda and potash chlorides, ...	0.84	3.41
With ammonium chloride, ...	1.15	4.16
With potash, ...	0	0
With soda carbonate, ...	0	0

I have now given you some of the causes that result in the wear and tear and deterioration of boilers. The subject is an important one, and the young consulting engineer will often find himself greatly puzzled to ascertain the true cause of the difficulty. He must not only be familiar with the true principles of construction and setting of boilers, so that wear and tear shall not result from unnecessary and undue strains, but he must know something of the sources of the water supply. A general knowledge of the geology of the country will be helpful. I believe that the broader a man's culture is, the more valuable his services will be. While technical education is all important, and without it the great problems which are so intimately connected with our growing industries could not be solved, a man need not be always in a rut. Another point. We have been considering the question of wear and tear as applied to steam boilers. The ambitious and industrious young engineer is in danger of being so absorbed in his profession as to forget himself, I mean his physical condition, his health. In testing metals we learn that there is a point known as the limit of elasticity. Beyond that is the permanent set, from which there is no recovery. Bear in mind that human fiber may be subjected to a strain that exceeds the elastic limit. Hence, I repeat, take good care of your health.

I trust it will not be out of place if I say in closing, let your work, quite as much as your words, indicate that truth lies at the foundation of every undertaking.

Inspectors' Reports.

AUGUST, 1888.

Total number of inspection trips made during the month of August, 1888, 4,299, boilers examined 8026, boilers inspected internally 3334, subjected to hydrostatic pressure 565. In all there were reported 7341 defects, which led to the condemnation of 46 boilers. Our usual analysis of defects is given below :

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment, - - - -	517 -	- 35
Cases of incrustation and scale, - - - -	843 -	- 49
Cases of internal grooving, - - - - -	28 -	- 13
Cases of internal corrosion, - - - - -	339 -	- 30
Cases of external corrosion, - - - - -	437 -	- 40
Broken and loose braces and stays, - - - -	86 -	- 15
Settings defective, - - - - - -	151 -	- 20
Furnaces out of shape, - - - - -	243 -	- 12
Fractured plates, - - - - - -	145 -	- 30
Burned plates, - - - - - -	135 -	- 20
Blistered plates, - - - - - -	199 -	- 9
Cases of defective riveting, - - - - -	2,001 -	- 329

Nature of Defects.	Whole Number.	Dangerous.
Defective heads,	66	27
Serious leakage around tube ends,	1,275	161
Serious leakage at seams,	285	56
Defective water-gauges,	118	21
Defective blow-offs,	54	6
Cases of deficiency of water,	10	5
Safety-valves overloaded,	44	17
Safety-valves defective in construction,	42	9
Defective pressure-gauges,	263	52
Boilers without pressure-gauges,	11	2
Unclassified defects,	49	5
Total,	7,341	963

Boiler Explosions.

August, 1888.

Thresher (138).—The boiler of a steam thresher near Vallejo, Cal., exploded Aug. 1st. Engineer had his jaw broken, and the fireman was killed.

Steamer (139).—The steamer *City of Richmond* of the Portland, Mount Desert and Machias line, burst a boiler Aug. 2, while off Rockland, eastward bound. The steamer *Penobscot*, from Bangor to Boston, took off the *Richmond's* Boston-bound passengers. She was not badly damaged, and none of her passengers were injured.

Chemical Works (140).—Adam Flate, a resident of No. 221 Railroad Avenue, Jersey City, N. J., was severely, but not fatally scalded, Aug. 5th, by the bursting of a steam boiler at the cream tartar factory on Steuben Street. Flate is employed at the factory and was in the engine-room at the time the boiler burst. The escaping steam burnt him about the back.

Asphalt Boiler (141).—Thomas Tyler, an engineer with the Pacific Paving Company, had a miraculous escape Aug. 10th. He was standing on top of an asphalt boiler at the corner of Berry and Fifth Streets, San Francisco, Cal., preparing to screw down the lid, when the boiler burst with a terrific report and he was hurled to the ground senseless. The lid blew off and struck him on the breast, inflicting severe internal injuries. His head was badly cut by his fall, and his cheek and face were damaged.

Saw-Mill (142).—Report reached Las Vegas, N. M., Aug. 14th, of a boiler explosion at the saw-mill of S. A. Clements, twenty miles above. It was stated that four men were killed and several wounded. One of those killed was Ferdinand Clements, a nephew of S. A. Clements.

Saw-Mill (143).—The boiler of Prosser's saw-mill at Blooming Valley, two miles east of Shelby, Mich., blew up Aug. 16th. Engineer C. L. Dodge was instantly killed, and a mill hand named Roby, died soon after. The owner, Delos Prosser, will probably die. Two others were badly hurt. The mill is a total wreck. A ramshackle boiler is said to have been the cause of the explosion.

Thresher (144).—The explosion of a boiler attached to a steam threshing machine near Limestone, Tenn., Aug. 18th, instantly killed a white man, C. Cowper, and fatally injured a colored man.

Saw-Mill (145).—Sunday afternoon, Aug. 18th, a party of boys built a fire under the boiler of Taft & Co.'s saw-mill, Alkire, Ky. An explosion occurred, in which three of the boys were either killed or fatally hurt.

Saw-Mill (146).—The boiler at Jackson's saw-mill, three miles west of Atlanta, Tex., blew up Aug. 21st, killing the colored engineer outright, and wounding the fireman so severely that he died shortly afterwards. The mill is a complete wreck.

Printing Office (147).—A boiler explosion occurred Aug. 21st, at the establishment of the Iowa Printing Co., by which a corner of the old Exposition building was blown out. The boiler was an old one which the company expected to abandon this fall, and the breaks were underneath. The damage amounted to about $200. The engineer had just stepped out of the room or he might have been killed.

Saw-Mill (148).—Fred. Twenty's portable saw-mill, operating two miles south of Kenton, Ky., on Cruser Creek, exploded Aug. 22d, tearing the mill into atoms, and scattering it for half a mile. Twenty's son, aged 18, was thrown fifty yards over a fence into a cornfield. He was scalded and his skull fractured. He cannot live. Alonzo Hordon had his hand broken by a piece of pipe. The engineer was inexperienced. The mill is a total loss. The explosion was heard for miles. Fireman Frank Connelly was badly scalded.

Paper Mill (149).—The boiler of the Whiting paper mill at Neenah, Wis., exploded at an early hour Aug. 23d, killing 18 persons and injuring 18 others. A special from Neenah says: At 11.30 o'clock last evening, the large paper mill owned by George Whiting, situated on the island between this city and Menasha, was destroyed by fire. While the burning structure was surrounded by a crowd of spectators the battery of boilers exploded. The roof and walls were thrown outward, and sent a shower of bricks and timbers among the spectators. Eighteen persons were killed, seven fatally injured and a number seriously hurt. The mill was a three-story building, built four years ago at a cost of $100,000, and was operated day and night. When the flames broke out about 50 men were in the building. About 1.30 o'clock, while the building was a mass of flames, the explosion occurred without warning. The dead are as follows: John Moore, Joseph Bridges, William Gueltz, Thomas Dougais, Frank Sheffer, Gilbert Mericle, Frank Mandover, Frank Muncmer, Chris Laighouser, John Leichowger, John Hoffman, Lewis Roesche, Joe Bull, William Johnelke, Thomas Jetters, —— Shoewelsji, Sylvester Jeijhouse, and a man unknown. Fatally injured: Albert Hoechmer, Benjamin Crouse, Joseph Smith, Joe Smidt, John Tuller, —— Tingle, —— Goeltz. The loss on building is $100,000; insured for $52,000. The fire caught in the boiler-room in a large quantity of fuel, shavings, etc. When the department arrived and began playing upon the flames the mill was doomed. The immense revolving bleach was in the heating-room adjoining the fire-room. It was filled with straw and rags. When the roof over the heating-room fell in the firemen turned the hose over the bleach, and instantly an explosion occurred, and ten tons of boiler débris shot out of the building and across a side track, through a throng of spectators, mowing them down like grass. The immense mass of iron shot out into an open lot two hundred feet away. In its passage it struck the heads of the onlooking bystanders, as nearly all the killed and injured were hit on the head. The scene was indescribable. The blow, so sudden and crushing, stunned those it did not kill and maim.

Cotton Factory (150).—The boiler at James W. White's cotton mill, Bremond, Texas, exploded Aug. 25th, killing W. L. Wooten; fatally wounding his two sons, John and Silas, and seriously injuring Ignatius Strumski, Deny Chambliss, Matt Busby and Buck Walton. The mill was demolished.

Threshing Engine (151).—The boiler of a threshing machine on the farm of Frank Stranahan, near Corry, Pa., exploded Aug. 25th, killing William Clough and Arthur McRay instantly, and seriously injuring two other men.

Steamer (152).—By the collision of the steamers *City of Chester* and *Oceanic* while passing through the Golden Gate, San Francisco, during a heavy fog on the morning of Aug. 22d, the *City of Chester* was sunk in ten minutes. Just as she was going down her boilers exploded. Fifteen persons lost their lives by drowning and by the explosion.

Locomotive (153).— A freight locomotive on the Lehigh Valley railroad was pushing a train up the mountain near Wilkesbarre, Pa., Aug. 29th, when the boiler exploded with terrific force. Joseph Van Horn, the fireman, was in the act of shoveling coal into the furnace at the time, and he received the full force of the explosion. He was thrown fifty feet in the air. He died at the hospital. Michael Dorsey, engineer, remained seated in the cab and escaped injury. Several cars were thrown off the track by the force of the explosion.

Pumping Engine (154).— The boiler of a portable engine used for pumping at the works of the Denton Ice Company, Denton, Texas, exploded Aug. 29th, and so great was the force that the boiler was carried a distance of forty paces and over a derrick fourteen feet high. Robert Kirkpatrick, 18 years of age, who had charge of the engine, was engaged at the time of the explosion with Mr. John Benson, the foreman of the works, making a coupling. He was blown eight or ten feet, and his right leg was torn from his body and he was badly cut on the back of the head. He lived only a few hours and was not conscious after he received his injuries. Mr. Benson's right leg was broken above the knee, and a small piece of iron was driven through his right hand. His leg has been set, and the fourth finger has been amputated. Though very seriously hurt he has a fair prospect of recovery.

Saw-mill (155).— The boiler at Uhler's saw-mill, ten miles north of Springfield, Ill., exploded Aug. 30th, killing Noah W. Turner, aged 44; William Martin, aged 22; and mortally wounding William Yocum, aged 23. The body of Pickard was blown two hundred yards and struck a tree. It was found half an hour after the explosion by following a track of flesh and limbs. The head has not yet been found. William Martin was blown a distance of one hundred and fifty yards, but was not badly mutilated. William Yocum was found in the débris of the mill with his left leg crushed, his jaw broken, and a great gash in his throat. At last reports he was still alive, but the doctors gave no hope for his recovery. The explosion was due to the water getting low in the boiler and cold water being turned on. Turner was the boss at the mill and was running the engine during the temporary illness of the engineer.

Saw-mill (156).—About 8 o'clock a. m., Aug. 31st the boiler of a steam wood-sawing machine belonging to F. Michel, exploded while in operation on the south side of D Street, between Third and Fourth Streets, Portland, Oregon. It seems that the explosion was caused by allowing the boiler to become empty and then introducing cold water into it. There was considerable steam up, and two buckets of water were poured into the tank which supplies the boiler. The machine was started, and in an instant the explosion took place. A section about two feet long of the upper portion of the boiler was torn off, and after describing a circle in the air it fell in Prof. Bullock's yard, fifty feet from the machine. There were a number of children sitting on the fence only a few feet away, and this section passed over their heads in the yard beyond. Had any of the children been struck by the flying fragments serious consequences must have resulted. Strange as it may seem, none of the men operating the machine were injured, as the force of the explosion expanded itself upward. Evidently the parties did not understand their business or they would have known that the boiler was empty, nor would they have poured cold water into the heated boiler. The authorities should see that none but competent men run the steam wood-sawing machines, as they are operated at our doors and on our streets.

September, 1888.

Iron Foundry (157).— The boiler of the Perry Stove Works at South Pittsburg, Tenn., exploded Sept. 3d, instantly killing Charles Taylor, the superintendent of the works; J. B. Mills, a machinist; M. Donovan, foreman of the mounting department; George N. Carter, a leading jeweler of the town; William Plumblee of Winchester, Tenn., and William Watson, a moulder. William Gross, a machinist, and Rock Scugger, a moulder, were fatally injured. Had the explosion occurred half an hour later the loss of life would have been appalling. The cause of the explosion is a mystery. Perry's stove works moved to South Pittsburg from Albany, N. Y., a year ago, and only a few months ago were entirely destroyed by fire. The firm were just getting in running order again.

FLOUR MILL (158).— The steam boiler in George E. Ketcham & Co.'s flour mill, Eleventh avenue and Sixty-third street, New York, gave way Sept. 5th, a slight explosion following. William Stewart, 52 years old, of Newburg, and John French, 23 years old, of No. 227 West Sixty-seventh street, were scalded by the escaping steam.

THRESHING ENGINE (159).— By the explosion of the boiler of a steam thresher at Seymour, Ind., Sept. 6th, William A. Bennette was instantly killed. Henry Kearns and Wesley Alexander were terribly crushed and scalded. Five other employees, George McElfresh, John Lampart, Basil Weekly, Ross White, and Ambrose Thompson were bruised and scalded, but none dangerously. Charles Dabb, a young farmer, was hurled one hundred feet through the air, but escaped uninjured. The killed and fatally wounded are all married men and men with families. The boiler was old and worn out.

THRESHING ENGINE (160).— The boiler of Goulette & Letson's threshing outfit, Ellendale, Dakota, exploded near the Manitoba depot, Sept. 5th. A crew of ten or twelve men were engaged near by, and of this number eight were either killed outright or badly injured. C. J. Goulette was blown six rods. He was badly scalded and bruised, but not fatally hurt. An old man named McLean was instantly killed. Four young men, named McKenzie, Johnston, Memory, and Griffin, sons of prominent citizens, are terribly wounded and cannot recover. The other two injured will undoubtedly recover. The explosion scattered fire in all directions, and in a few minutes the prairie grass was blazing around the victims of the disaster, some of whom would have perished in the flames but for the arrival of people in the neighborhood who had heard the noise.

MINE (161).— The boilers at Hart & Palmer's mine, Glouster, Ohio, exploded Sept. 6th. Fortunately no one was fatally injured. Mr. Rose, the fireman, was struck by a plank on his left side and has some scalp wounds. A young boy by the name of Smith was scalded on one leg. These were the only persons injured. It is hard to tell what caused the explosion. Some portions of the boiler were picked up one-quarter of a mile away from the explosion. The loss to Hart & Palmer, besides the closing of their mine, will be between $500 and $600. The loss to the men employed will be considerable, as the mine owners were crowded with orders and work good.

BRICK-YARD (162).— A terrible boiler explosion, by which two persons lost their lives and two others received fatal injuries, occurred Sept. 7th, at Ingham's Mills, a small village near Little Falls, N. Y. The killed are: Arthur Leavitt and Adam Keiser, Jr., both aged seventeen. The injured are: Adam Keiser, Sr., both legs broken; and Jacob Keiser, one leg broken and injured internally. The sad affair has caused great excitement. The particulars of the accident, as nearly as could be learned, are as follows: Adam Keiser owns and operates a brick-yard at Ingham's Mills, and employs a large number of persons. Connected with his works is a steam engine, used in pressing the brick. At about noon to-day the boiler exploded with terrific force, filling the air with dust and pieces of timber and iron. A large number were soon attracted to the scene. Among the débris could be seen the dead and dying, and no time was lost in rescuing the sufferers. The cause of the explosion is attributed to the placing of a wet brick on the safety valve of the boiler. A team of horses which stood near the boiler were also instantly killed.

Saw-mill (163).— The boiler in the steam saw-mill of Frank Morse, situated in Worcester, Vt., exploded Sept. 8th, with terrible force. The mill was torn to pieces and Mr. Morse was instantly killed, his body being terribly mangled. Four employees were badly injured, but it is thought they may recover. The explosion is supposed to have been caused by a lack of water in the boiler.

Iron Works (164).— A most distressing accident occurred at Brierfield Iron Works, Bibb County, Ga., Sept. 12th. By carelessness or oversight the boiler of the engine used to run the ore-washer was allowed to become dry, causing a terrific explosion, which injured, more or less, six or seven persons, some of them fatally. The particulars of the accident and names of the unfortunate victims could not be obtained.

Saw-mill (165).— The boiler in a saw-mill near Powell, Ark., exploded Sept. 13th, killing two men and destroying the mill.

Locomotive (166).— A Baltimore & Ohio freight engine, on a side track at Ankenerstown, three miles south of Mansfield, Ohio, exploded Sept. 14th, just as a passenger train was passing. The engineer, fireman, and several others were killed.

Mill (167).—A terrific explosion took place at the National Milling Company's establishment at Cleveland, Ohio, Sept. 15th. Two men were killed and a number of others seriously injured.

Hoisting Engine (168).— At 9:30 a. m., Sept. 16th, while the C. V. line steamer *Frost* was being hauled out upon the carriage at the St. Lawrence Marine Railway in Ogdensburg, N. Y., for the purpose of surveying her hull and repairing any damage that might have occurred by running upon the shoal near Crossover Light, last week, and when she had been hauled to nearly the place designed, the boiler which furnished the steam for the engine exploded. The explosion came from the bottom of the boiler, the force was a little upward and north and south. Fortunately no one was hurt. The boiler was located in a house on the easterly side of the blacksmith shop. The fireman discovered it was leaking and called the attention of another workman. They concluded it was best to vacate the premises, and had only got to a place of safety when the boiler exploded. The boiler went out of the northerly end of the house, cutting away the easterly side of the smoke-stack and curving a little to the east landed about thirty feet away. The smoke-stack fell with a crash. At the southerly end of the building the doors were blown open and the coal and iron on that side scattered. A piece of iron from the firepan in front of the boiler was thrown a distance of 150 feet across the railroad track, and some pieces were thrown much farther.

Saw-mill (169).—The boiler in J. W. Brown's saw-mill at Point Mountain, W. Va., exploded Sept. 17th, killing two of the force, a man who was passing, wounding three others, and totally wrecking the building.

Strawboard Mill (170).—A globe rotary straw cooker, one of a set of four in the Beloit Strawboard Company's paper mill, exploded Sept. 18th, wrecking the building and badly injuring one man. That great loss of life was averted seems marvelous, for a few minutes previous to the time of the accident, that part of the mill swarmed with busy men, mill operatives, and farmers hauling straw. Daniel Whitston, a mill hand, was the only man hurt, being badly injured by a falling wall. The rotary had been running about an hour and a half, and the pressure on the steam boilers which supplied the cooker was thirty-five to forty pounds. The rotary was supposed to have been constructed of extra heavy boiler iron of good quality, but the appearance of the fractured parts would indicate inferior iron. The globe separated about the center. The mill was a fine stone and frame structure and a model institution, and its capacity was twenty tons daily.

Saw-mill (171).— About 2 o'clock p. m., Sept. 19th, the boiler at McHamilton's saw-mill, on the Missouri, about two miles east of Blair, Neb., exploded. The fireman, Henry

Alexander, and Henry Morrill, the engineer, were instantly killed. Several others, who were in the mill at the time, were slightly scalded. John Noll was badly hurt about the head, but will recover. Morrill leaves a wife and several children. The boiler had been in use about a year.

——— (172).—The steam dome blew off one of the boilers at King's, Colo., Sept. 20th, injuring two men, one probably fatally. The names of the men were not learned.

SAW-MILL (173).—The boiler in J. H. Freeny's shingle mill, East Saginaw, Mich., exploded Sept. 24th, killing Noah Smith, the fireman, and seriously injuring M. Jones, William Wooley, and Fred. Hartford.

SAW-MILL (174).— The boiler in Berry Kuykendall's saw-mill, near Hartford, Ky., exploded Sept. 24th, and Kuykendall was torn in a thousand pieces. Tom Bryant, the fireman, had his head and arm torn off; Mrs. Kuykendall, wife of the mill owner, was badly scalded and will die; Ansel Wilson, a neighbor, had an arm and rib broken.

HOISTER (175).— The boiler of a donkey engine, employed in hoisting ballast from the ship *Lancashire Castle*, at Portland, Or., exploded Sept. 25th, sending the top of the boiler higher than the masthead. Willi: m Thompson, the engineer, was scalded in the face and body.

COAL MINE (176).— At 7:30 A. M., Sept. 26th, a shock and a boom that startled the people of Dunmore, Petersburg, and Green Ridge, attended the explosion of one of the boilers at No. 5 shaft of the Pennsylvania Coal Company, on the eastern edge of Scranton, Penn. The boiler-house was situated parallel with the engine-house, a supply-house intervening. There were five boilers in the nest, each about fifty feet long and three feet in diameter. The outer boiler was the one which exploded. The break occurred about ten feet from the head. The forward piece took a course about three feet from the ground and went like a shot into the culm dump, which is located just back of the breaker. It ripped off the steps leading to the breaker and smashed other attachments to the building. The other part of the boiler was driven back through the brick smoke-stack. The boiler house and the stack were demolished and the other boilers tossed one upon the other. A fortunate circumstance of the explosion is that nobody was hurt. The breaker was in operation and filled with boys and men, yet not one of them sustained a scratch. Bricks and timber were hurled with great force against the building, but they fell back harmlessly.

STEAMER ( ).— A terrible explosion occurred on board a large iron mud-carrying steamer, *No.* 1 *Chaloupe*, at Aspinwall, on Sept. 18th. The steamer had just been repaired at the Panama railroad shops at Christopher, Colon, and had started on her trial trip, having on board, in addition to her crew, Mr. Groner the master mechanic of the Panama Railroad Company and Hugh Graham and Andrew McIntyre, the latter having recently been the captain of the huge American dredge *City of Paris*. Suddenly the safety valve blew out and an explosion occurred which caused the loss of six lives, the destruction of the vessel itself, that of another steamer in the vicinity, while an iron lighter near by was cut in two as if by a knife.

THRESHER (177).— The boiler of a steam thresher, about four miles from Coshocton, Ohio, exploded Sept. —, seriously scalding four men and damaging surrounding property.

SAW-MILL (178).— A large five-flue boiler exploded at the saw-mill of J. W. Landis, Franklin, Ind., Sept. 26th. The engineer was killed, others badly injured and the engine house completely wrecked. One portion of the boiler was projected over the high piles of lumber in the yard and landed in a meadow 590 yards away.

SAW-MILL (179).— A portable saw-mill boiler on Crusie Creek, about four miles south of Visalia, Ky., exploded Sept. 28th, with terrible and deadly effect, two being killed and the mill blown to atoms.

High Pressures.

The tendency towards high pressures of steam in these days is becoming somewhat alarming, especially when excessive pressures are desired on boilers of large diameter. When the change was made from 48-inch boilers to 54 and 60 inches in diameter, it became necessary to see that the material and construction was such that the pressures required could be safely allowed. The difference in diameter of these large boilers, from the former types, was not taken into consideration by steam users generally. There seemed to be an impression that a boiler, no matter how large its diameter, could be safely used at any pressure desired. We were once told by a steam user that the larger the boiler, the better able it was to be used at high pressure, and he enforced his argument by saying that a large horse was stronger than a small one. With such crude ideas in regard to boilers, it is not strange that the desire to use boilers of large diameters at very high pressures is common; even boiler makers are not unfrequently imbued with similar ideas. They forget that the strength of the boiler is measured by its weakest point, and that point in horizontal tubular boilers is the longitudinal joint or seam. To make this more evident, we will illustrate it as follows: Suppose we have a boiler 60 inches in diameter. If we take a ring from this boiler one inch wide, we have in the entire circumference 188 inches and a fraction, or 188 square inches. If we put on this a pressure of 100 pounds to the square inch, we have 18,800 pounds tending to burst the ring asunder. This would be equivalent to nearly 9½ tons. Now multiply this by the length of the boiler in inches, and we have the force within the boiler, tending to rend it in pieces, which is found to be more than 1,700 tons. Now, we will suppose that we have a similar ring from a boiler 72 inches in diameter. We find that there are 226 inches in the circumference, or 226 square inches. If a pressure of 100 pounds per square inch was applied to this ring, the entire pressure would be 22,600 pounds, or 11 3-10 tons. If the boiler was 16 feet long, the entire internal pressure would be more than 2,137 tons. By such calculations we gain some conception of the destructive forces pent up in a large boiler under a high pressure of steam. As stated above, the seam or joint is the weakest point in the boiler. (We assume that the boiler is constructed of good material, and that the workmanship is good.) If the joint is single riveted, it has only about 56 per cent. of the strength of the solid plate. If it is double riveted, it has a strength rarely exceeding 75 per cent. of that of the solid plate. So however excellent the solid plate may be in tensile strength and ductility, only three-fourths of that strength can be depended on. But that gives us the bursting pressure, or the point where the quiescent force is exceeded by the .divellent force. There must be a factor of safety which may be 6, or in exceptionally well-built boilers, it may be 5 and in some rare cases 4. The percentage of the strength of the joint is no greater in the 72-inch boiler than it is in the 60-inch boiler, and if the same pressure is used, the strain on the large boiler is greater in proportion to the larger area of internal surface. This fact is often overlooked or forgotten, both by the purchaser and boiler maker.

If a high pressure is desired on a boiler of larger diameter, it should be plainly stated when the boiler is contracted for. Then a special joint can be made that will have a greater percentage of strength than the ordinary double riveted lap joint. Boiler makers cannot be too particular about these points in the construction of large boilers. To illustrate this still further, we will assume that a boiler 72 inches in diameter is constructed of 3-8 inch steel, with a tensile strength of 60,000 pounds, and the required ductility. The longitudinal joints to be double staggered riveted, rivets to be pitched 3¼ inches from center to center, and three-fourths of an inch in diameter, what would the maximum safe working pressure be? We find from the construction of joint that it would have 75 per cent. of the strength of the solid plate, which would reduce the strength to 45,000 pounds per square inch. Now multiply this by the thickness of plate (three-eighths of an inch) and we have 16,875 pounds as the strength of the boiler, including joint. We now divide this by the radius of the boiler, 36 inches, which gives us nearly 469. We must now divide this by the factor of safety 5, and we have as a safe working pressure 93 pounds to the square inch.

In boilers exceptionally well constructed, and where the plates have been selected and tested by coupons cut from them, a factor of safety of 4 may sometimes be allowed, though rarely. The foregoing will serve to show how important it is to recognize well-established rules in boiler construction. When boilers are built right and run at a safe pressure, they will give long service, and frequent repairs will not be required, unless there is carelessness in the care and management. We shall have something further to say about high-pressure boilers in the future.

The Locomotive.

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Electric Welding of Metals.

Our illustrations this month show one of the most remarkable results arising from the recent development in and application of electricity. Its influence upon the working of metals will be so great that it is difficult at the present time to comprehend it. We refer to the electric welding of metals by the process invented by Prof. Elihu Thomson, of the Thomson-Houston Electric Company.

Hitherto welding has been confined to wrought iron and steel, and the most perfect welds had only about seventy-five per cent. at their best of the strength of the solid bar. Other metals than these could not be welded by any means whatever. The process of welding iron by the blacksmith is at the best crude and imperfect.

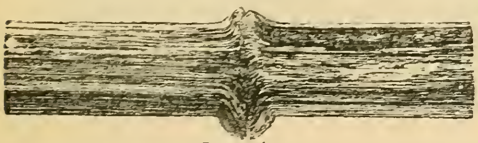

FIG. 1.

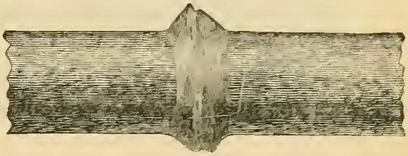

FIG. 2.

Now all this seems destined to be suddenly changed in all industrial works. Not only iron is perfectly welded in a very short period of time, but all kinds of metals can be welded with equal facility not only to each other but to any other kind of metal. Moreover the line of junction of the welded pieces — in the case of iron at least — is stronger for an equal sectional area than the original bar, this being due apparently to the fact that the fusion of the metal by the electric current eliminates the cinder present in all wrought iron bars, so that the line of junction of the welded surfaces is more homogeneous and consequently stronger than the original section of the bar.

The principle involved in this new art is that of causing currents of electricity to pass through the abutting ends of the pieces of metal which are to be welded, thereby generating heat at the point of contact, which also becomes the point of greatest resistance, while at the same time mechanical pressure is applied to force the parts together. As the currents heat the metals at their point of junction to the welding temperature, the pressure follows up the softening surface until a complete union or weld is effected, and as the heat is first developed in the interior of the parts that are to be welded, the interior of the joint is as efficiently united as the visible exterior. This is the weak point about an ordinary weld, as may be seen by reference to the accompanying figures. Figure 1 shows full size a piece of half-inch iron welded by electricity, the electrotype being made directly from the specimen, which was filed down to the center line to obtain a section through the center, and then etched with acid, the engraver's services not being brought into requisition at all. The difference between the character of the weld and that done at the ordinary forge is well shown by comparing Fig. 1 with Figs. 3, 4, 5, and 6, which show ordinary welds, the electrotypes being made in the same manner as in the case of Fig. 1, and first appeared in the LOCOMOTIVE in April, 1884, the object being at that time to show the imperfections of the ordinary weld, 5 and 6 showing the result when the attempt was made to weld iron and steel together. We regret that we have no specimen of iron and steel electrically welded, but the welds of dissimilar metals by the electrical process are, we are informed, just as perfect as between two pieces of iron.

Fig. 2 shows the external appearance of the electrically welded bar; it shows the upsetting of the ends of the bars as they are brought together. Removing this projecting portion with a file or in the lathe so that the bar has a uniform diameter, and pulling apart in a testing machine, the break nearly always takes place outside of the weld.

FIG. 3.

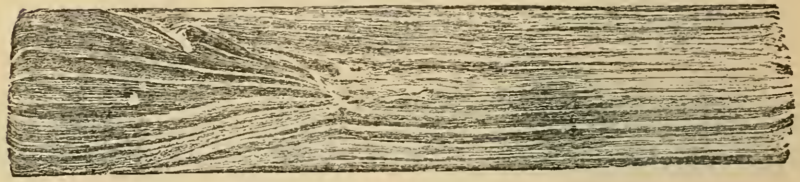

FIG. 4.

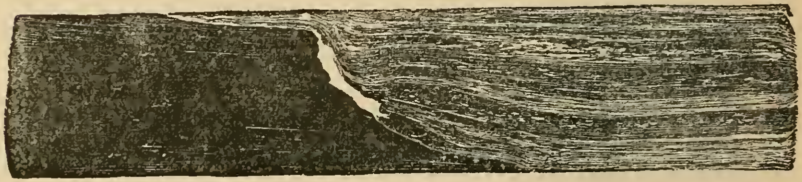

FIG. 5.

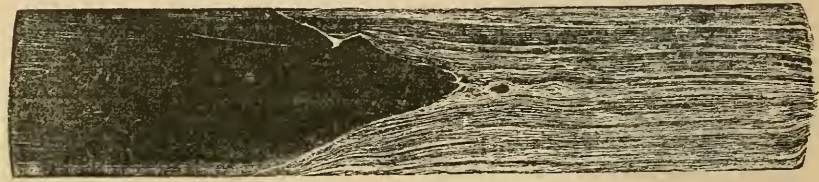

FIG. 6.

The machines built by the Thomson Electric Welding Company are generators of electricity so constructed as to produce in the most economical manner the low-pressure currents needed to do the work. They are of sizes and types suited to the kind of work to be done. They are built to be driven by a belt in shops where there is no dynamo used; where a dynamo is used for any purpose whatever its current can be used for welding by utilizing it in a properly designed machine of what is called the indirect type.

The amount of power required to do this welding is used for so short a time that its cost is really nothing, a few seconds only being required to weld the largest bars. Twenty horse power is the amount actually consumed in welding a half-inch bar, as shown in our cuts, the actual time consumed in welding being not over three to four seconds, as was witnessed by the writer recently.

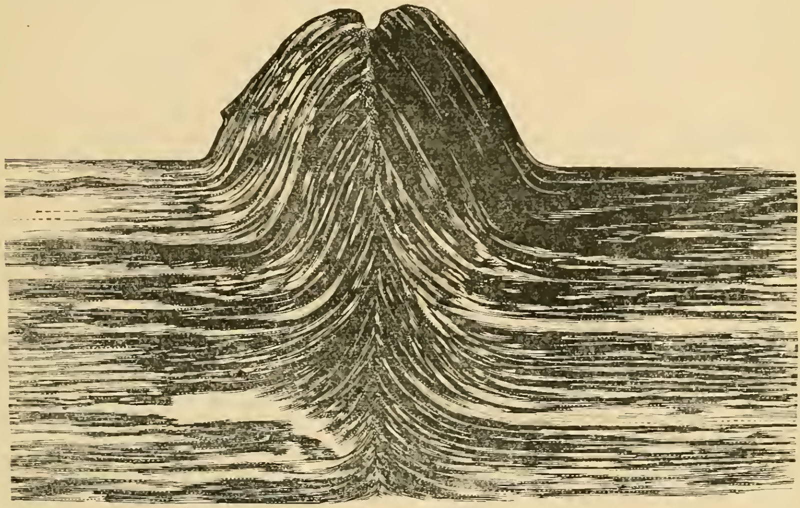

Fig. 7.

In Fig. 7 an attempt has been made to show on an enlarged scale the section in Fig. 1. This is a difficult matter to do; but under a power of about 40 to 50 diameters on a compound microscope, the denser and more homogeneous structure of the iron through the line of the weld is beautifully shown. With an ordinary weld the microscope is not as a rule needed to show actual separation of the surfaces supposed to be welded.

Inspectors' Reports.

September, 1888.

In the month of September, 1888, our inspectors made 4,197 inspection trips, visited 7,926 boilers, inspected 3,488 both internally and externally, and subjected 622 to hydrostatic pressure. The whole number of defects reported reached 7,331, of which 510 were considered dangerous; 31 boilers were regarded unsafe for further use. The defects in detail were as follows:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	520	22
Cases of incrustation and scale,	761	31
Cases of internal grooving,	30	11
Cases of internal corrosion,	283	18
Cases of external corrosion,	493	41
Broken and loose braces and stays,	120	13
Settings defective,	160	11
Furnaces out of shape,	252	7

Nature of Defects.	Whole Number.	Dangerous.
Fractured plates,	173	50
Burned plates,	153	21
Blistered plates,	223	9
Cases of defective riveting,	1,895	22
Defective heads,	48	20
Serious leakage around tube ends,	1,196	110
Serious leakage at seams,	247	22
Defective water-gauges,	185	24
Defective blow-offs,	61	10
Cases of deficiency of water,	4	1
Safety-valves overloaded,	50	19
Safety-valves defective in construction,	36	11
Pressure-gauges defective,	277	25
Boilers without pressure-gauges,	4	4
Unclassified defects,	160	8
Total,	7,331	510

There are so many ruptures and explosions of steam boilers in the country that it seems as though every man who owns a boiler would be anxious to see that his pressure gauge is correct. Yet every month we find a large number of defective gauges, many of which are dangerous; and we always find some few boilers without any gauge whatever. The gauges examined in September and found to be defective, were in error by amounts that ranged from + 20 lbs. to – 30 lbs. There were numerous cases in which they registered 20 lbs. too much or too little. When we consider the number of defects that are constantly coming to light, the wonder is, not that there are explosions, but that there are so few of them.

Boiler Explosions.

OCTOBER, 1888.

COAL MINE (180). — A boiler at the Chicago Coal Company's shaft, at Streator, Ill., exploded Oct. 3d, killing Tony Kitmos, the engineer. A searching investigation of the cause of the explosion will probably be made.

DWELLING (181). — A boiler exploded in the house of Mr. E. W. Chapin, of Northboro, Mass., Oct. 4th, resulting in a complete demolition of the house; some of the fragments being blown to a great distance. By an extraordinary piece of good fortune the members of Mr. Chapin's family were in the back part of the premises and thus escaped. The cause of the explosion is unknown.

BUTCHERNG ESTABLISHMENT (182). — The head of the 50-horse-power boiler, in the butchering establishment of Charles A. Blumhart, Baltimore, Md., blew out, Oct. 7th. It passed through a skylight, but did no further exterior damage. The damage to the boiler is estimated at $1,000.

MACHINE SHOP (183). — The boiler in Leitelt's Machine Works, Grand Rapids, Mich., exploded Oct. 9th, instantly killing Gustave Werner, the fireman. The loss upon machinery and buildings is about $2,000.

TRACTION ENGINE (184). — The boiler of a traction engine exploded Oct. 16th, on a farm near Highland, Ill., resulting in the instant death of Chris Rafferman, owner of the engine. Hugh Rice received serious injuries; William Hensel had both legs and an arm broken; William Arbert one arm and one leg broken and Julius Schneider was seriously injured.

Sugar House (185). — A boiler in the Woodlawn Sugar-house, Houma, La., exploded Oct. 19th, killing one white man and three negroes and wounding two other men.

Locomotive (186). — The boiler of engine No. 1, of the W. V. R. R., exploded at Pleasant Valley, Pa., Oct. 19th. The occupants of the engine quarter, Wm. Decker, his son, and a colored tramp, escaped unhurt; which was something miraculous, considering the way the building and engine were demolished.

Locomotive (187). — The boiler of locomotive No. 430, of the Philadelphia and Reading Railroad Company, exploded Oct. 23d, at Glen Carbon, Pa. The engine was idle at the time and the crew were seated in the cab and on the tender eating their dinner. Conductor John Gangloff and Brakeman John Culman, of Cressona, were killed. Engineer John McGovern, Fireman Samuel Dietrich, and Brakeman Marburger were injured, none of them fatally. The explosion was caused by a deficiency of water in the boiler.

Locomotive (188). — The boiler of freight engine No. 173, of the Norfolk and Western railroad, Engineer Nickson in charge, while taking water at Blue Ridge station (Va.), exploded Oct. 23d, with a concussion that fairly shook the hills around. All escaped without injury except the fireman, Mr. C. L. Mitchell, who at the time of the explosion was shoveling coal into the furnace. Mitchell was blown high into the air and landed at the foot of an embankment in an insensible condition. He was not materially injured by the fall or force of the explosion, but his body was severely scalded.

Hoister (189). — The boiler of the engine used in hoisting coal from boats to a coal pocket on the steamer *City of Kingston's* dock, Rondout, N. Y., exploded Oct. 25th. No one was injured and the damage was slight.

Saw-Mill (190). — The boiler at the steam saw-mill of Esh & Beller, operating in Brady township, Huntington County, exploded Oct. 27th, about noon, and was badly wrecked. The engineer, John King, and an employee, John Sankey, were in the shanty adjoining the boiler, eating their dinner at the time of the explosion. They were stunned by the shock, and before they could make their escape they were enveloped in the steam and hot water and were badly scalded. It is not known what caused the explosion. It is said that sixty pounds of steam was all that was necessary for working purposes, but that the safety valve had been set to blow at 100 pounds per square inch.

Tug Boat (191). — The tug *A. W. Lawrence* exploded her boiler while cruising in the lake off North Point, Wis., Oct. 30th, killing Captain John Sullivan, Engineer John Sullivan (cousin of the captain), Fireman Edward Sullivan and Lineman Thomas Hendley. The boat was blown to pieces. Frank McGowan, the cook, and Thomas Dooly, a chance visitor on the tug, were picked from among the floating debris by the crew of of the tug *Merrill*, which happened to be close by. Both were severely bruised and cut. The men who lost their lives were all residents of Milwaukee. The boat was comparatively new, but had an old boiler and engine.

Business Block (192). — The boiler in the basement underneath the headquarters of the Cleveland and Thurman Wholesale Dry Goods Club, at 343 Broadway, New York City, exploded Oct. 30th, and the engineer, Michael Gilmartin, was scalded so severely that his wounds are likely to prove fatal. No one else was injured, and but little damage was done.

A Simple Method of Keeping Correct Time.

It is not generally known that there is available to every one a most simple and accurate method of regulating a clock or watch, when access to Standard Time at short intervals is inconvenient or impossible. It consists simply in observing the time at which any particular star sets, or passes the range of two fixed objects, on different nights. It is necessary to have the correct clock time to *start* with; after that, a clock may be kept within a very few seconds of Standard Time for any number of years without any difficulty.

The sun cannot be used for this purpose for the reason that there are only two days in a year when it is on the meridian of a place at noon *by clock time.* It may be as much as 14½ minutes fast, or 16¼ minutes slow on different days; and besides, the determination of its altitude with any degree of accuracy, requires the use of special instruments, and much skill in observation.

To determine the time by observation of a star, on the contrary, is a matter of great ease, and no instruments are necessary. The mode of operation is as follows: Select two fixed points for a range of observation. If a westerly window can be chosen which faces any building anywhere more than 25 to 30 feet distant, we have as good a post of observation as we can desire. Drive a nail, or stick a pin into the window jamb; or, if anything more substantial is wanted, fix a thin piece of metal, with a *very small* hole in it to sight through, in any convenient place, so that you can observe the time any star sets, or sinks below the roof of the adjacent building, or whatever may be chosen as the more remote sight. Then choose some well-defined star, the brighter the better, and with your timepiece set right (to start with), observe the time it passes the range of your sights. The exact time, as well also, as the date of this observation should *be recorded*, then to find out at any subsequent time, how much your watch has varied from correct time, observe the same star, and recollect that *it sets just* 3 *minutes and* 55.90944 *seconds earlier on any given night than it did the preceding night.* Thus if our first observation was taken some night when the star set at 9 hours 15 minutes, and 23 seconds; and at our second observation, taken just one week later, it set at 8 hours, 47 minutes, and 52 seconds, we would know that our watch had kept correct time. If it had set at 8 hours, 45 minutes and 52 seconds, we would know that our watch or clock had *lost* 2 minutes during the week. And similarly for any other variation. If the time at which it had set had been 8 hours, 49 minutes, 52 seconds, we should see that our watch had *gained* 2 minutes, and so on.

If the location of our sights admit of it, we should select a star 90°, as nearly as possible, from the pole star, for its apparent motion will be greater than that of one near the pole, and the liability of error will be diminished. If a suitable selection can be made, the error need not be more than three or four seconds, and it will not be accumulative.

From the fact that any given star sets nearly four minutes earlier each night, it is evident that it will after a while, begin to set during daylight. Before this occurs it will be necessary to transfer the time to some other star, which sets later. Thus we see that the later in the evening our first observation is taken, the longer the same star may be used. To transfer the time, of course is very simple, you merely have to observe the star you have been using, note the time, and also the error and rate of variation of your watch; then as late as convenient the same evening, select the new star, observe its time, and from the data of the first observation, calculate the exact time of its setting, or passing the range of your sights. This is a very simple matter and requires no explanation. Then use the new star as long as possible, and transfer to another, and so on.

To facilitate observation and calculation, the following table from *Trautwine's Pocket Book* is inserted:

TABLE SHOWING HOW MUCH EARLIER A STAR PASSES A GIVEN RANGE ON EACH SUCCEEDING NIGHT.

Night.	Min.	Sec.	Night.	Hour.	Min.	Sec.	Night.	Hour.	Min.	Sec.
1	3	55.91	11	...	43	15.01	21	1	22	34.11
2	7	51.82	12	...	47	10.92	22	1	26	30.02
3	11	47.73	13	...	51	6.83	23	1	30	25.93
4	15	43.64	14	...	55	2.74	24	1	34	21.84
5	19	39.55	15	...	58	58.65	25	1	38	17.75
6	23	35.46	16	1	2	54.56	26	1	42	13.66
7	27	31.37	17	1	6	50.47	27	1	46	9.57
8	31	27.28	18	1	10	46.38	28	1	50	5.48
9	35	23.19	19	1	14	42.29	29	1	54	1.39
10	39	19.10	20	1	18	38.20	30	1	57	57.30
							31	2	1	53.21

U. F. S.

Early Railroading in New England.

By SAMUEL NOTT, C. E.

THE LOCOMOTIVE for the months of January, April, and June, 1888, contained some notes about early New England railroads; and a few more may be interesting. The use of the flat bar iron rail, laid on continuous wooden stringers, found but little favor, and, excepting the Housatonic Railroad from Bridgeport, Conn., to Pittsfield, Mass., and the Hartford & New Haven (perhaps in part only), and a few branches, no other roads were tracked in that way, and all those so tracked were soon laid with a wholly iron rail in place of the flat bar and wooden stringer. Stone sleepers or ties about seven feet long and one foot cross section were used on one of the Boston railroads first built, and naturally most of them were soon broken crosswise, and had to be clamped with iron to make them act as ties. Except in the case here referred to, wooden sleepers were used. On the Boston & Worcester Railroad (now the Boston & Albany) trenches were dug, the centers of them being under the rail centers; these were about three feet deep and two feet wide, and were filled with small rubble stone. The trenches were not drained and did not work well, and were soon abandoned as not worth their cost.

The Eastern Railroad track (1838) and some others were laid on hemlock plank sills; the sleepers or ties for the track, one at about every three feet, came next; and then the cast iron chairs, one for each rail, on each sleeper. The rails were then laid and held in the chairs by a wrought iron key driven tight. Those keys were the dread of track-repairers, as it was found to be very difficult to keep them driven up well. Soon all the railroad constructors came to the simple form of rail in general like that for many years past in use on all the railroads, laid in the simple way now common, namely, having only a good well-drained gravel track bed for the sleepers, good sleepers and plenty of them, as their aim, and coming as near as they could to perfection on those points. The first rails were in lengths of fifteen feet maximum, with a small proportion of twelve feet lengths. The maximum increased soon to eighteen feet, and later to thirty feet, the usual length for many years past. The rolling stock of the present day would break down one of those early tracks, without any movement of the trains.

EARLY RAILROAD BRIDGES.

Among the earliest of the railroad bridges was the plank lattice,—the Burr bridge, as it was known, — an ingenious and useful bridge for spans of about 100 feet. It was usually made of three-inch plank lattice work, secured with wooden pins, the distance apart of the planks, the number used in making the thickness of the lattice truss, and also the diameter of the pins, varying as the span was longer or shorter. That made a very stiff truss, but when once settled below its proper line of track surface, it could not be readjusted, and it was also too narrow compared with the height to be kept plumb readily.

In the year 1840, or close to that year, the Howe truss bridge was invented by the late William Howe of Springfield, Mass. The railroad engineers of those days at once saw the great advantages of that bridge, and adopted it with avidity. It had a width of base for each truss sufficient to be readily kept plumb, and was very simple in construction. It was also easily readjusted if it settled below the proper line. It took the lead in wooden bridges for railroads for spans up to about 150 feet, and some few were built of over 200 feet span, till iron bridges became available for railroad use. The Enfield bridge, crossing the Connecticut River above Windsor Locks, for common travel, is a remaining specimen of the Burr; and the lately removed New York & New England Railroad bridge was a very good specimen of the Howe bridge, and at the time it was superseded by the iron bridge now in place it had been in constant use about thirty-nine years. In that time the weight passing over it had vastly increased; but even so, the original bridge was such that by one device and another the engineers made it safe and useful through all those years; and what is most remarkable of all, in the case of a wooden bridge, it also escaped all harm from fire, — the one great risk of a wooden bridge. Now that the day of wooden bridges is over in New England, they deserve here a passing commendation. They filled a want, and did it well. Let the iron and steel bridges beat them for safety and convenience, if they can.

Pile bridges have done good service for the railroads from the first, and must here have a good word in general, and one case deserves special mention. Early in the century a pile bridge was built for common travel across the deep and swift Piscataqua River at Portsmouth, N. H. In 1840 that bridge was bought by the railroad companies interested in extending the Eastern Railroad easterly from Portsmouth to Portland, Me., with a view to use the bridge as best they could both for the railroad trains and for common travel, and after much study of the case that bridge was improved and made suitable for railroad use; and by careful attention and improvements to meet the ever-increasing needs of the traffic, is even now the bridge used by the Eastern Railroad at that place, on the same general plan as at the start in 1843. The extension of the Eastern Railroad from Portsmouth to Portland, before referred to, is an illustration of the efficiency and economy of the early railroad engineers and managers. There was a railroad located and built in 1841–2, fifty miles in length, equipped sufficiently for two passenger trains and one freight train each way daily, and so worked with success, at a total cost of less than $1,100,000, up to June, 1843, including cost of land, construction, and equipment, and the difficult river crossing named above.

The good State of Massachusetts must also here have a word commendatory, for aiding by her credit some of the earliest railroads. The Western Railroad (now the Boston & Albany) and some others would have been bankrupts in their earlier years but for the prompt loan of such credit, by which easy loans of money at low rates of interest were readily effected. While the cases were pending in the Legislature, they were ably urged editorially in the Boston *Daily Advertiser* by the late Nathan Hale, the father of the New England railroad system; and were opposed by the Boston *Post*. But the State aid plans were carried, and no doubt wisely, in those earliest cases of such aid.

The Locomotive.

HARTFORD, NOVEMBER, 1888.

J. M. ALLEN, *Editor.*

H. F. SMITH, A. D. RISTEEN, } *Associate Editors.*

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.*

MR. ARTHUR S. FERRY, who has been connected with the Hartford Steam Boiler Inspection and Insurance Company the past year as Special Agent, has recently been appointed General Agent. His address will be Hartford, Conn.

Gross Carelessness.

A very serious and even criminal piece of carelessness was recently reported to us by one of our inspectors. While he and two assistants were inside a battery of boilers making an examination, a man in the employ of the company owning the boilers opened a valve on an adjacent battery, and the steam and condensed water acting together crushed the valve on the boilers they were in. Their lives were saved by the presence of mind of the foreman, who saw what was the matter and closed the lower valve at once.

Not long since a similar incident happened to another inspector. He was in the last of a battery of cylindrical boilers, when some one turned on steam at the other end. Hearing the roar as the steam and water rushed into the boilers at the further end of the battery, he sprang to the man-hole and escaped just in time to save his life. Had he been a moment later, or had the boiler been more complicated in construction, so as to oblige him to crawl about between stays, he would inevitably have been scalded to death.

Carelessness of this kind cannot be too severely rebuked. It reflects not only on the man who does the mischief but also on the company that employs such a man. No valve should be *touched* while anyone is inside any boiler. Then if anything happens it will be an accident; affairs like these we have mentioned cannot be called accidents.

Obituary.

LUCIUS J. HENDEE.

The Hon. Lucius J. Hendee, president of the Ætna Insurance Company, died on the 4th day of September last, at the age of 70 years. Mr. Hendee had been one of the directors of the Hartford Steam Boiler Inspection and Insurance Company for twenty-one years, having been elected to that office in October, 1867. During the early years of the Company's history, when the field was new and untried, there being no landmarks or precedents to follow, his counsel and advice were invaluable. No member of the Board took a deeper interest in the Company's prosperity than Mr. Hendee, and in his removal by death the Company loses one of its most valuable and helpful directors.

Personally he was a most genial and companionable man. His interest in young men was a marked characteristic; and in social and religious circles he was greatly respected and beloved. By his death a prominent figure is removed from the business and social circles of the city; but his memory will ever be cherished with affection by those who knew him.

A. C. GETCHELL.

In the death of Mr. A. C. Getchell of Cleveland, Ohio, which occurred September 7, 1888, the Hartford Steam Boiler Inspection and Insurance Company is deprived of the services of one of its oldest, most trusted, and capable inspectors. Mr. Getchell came into the employ of the Company as Chief Inspector for the Department of Northern Ohio in 1870. During the years up to the time of his death, he manifested a deep interest in the business of the Company. Mr. Getchell had peculiar fitness for the duties of his position. Having had a wide experience in steam engineering as connected with lake navigation, also with the details of railroad practice and stationary steam engineering, he brought to his position rare qualifications. He was faithful in details and uncompromising in his integrity. As a man among men, Mr. Getchell was much respected and had many enthusiastic admirers. He had a kind word for every one, was genial and companionable to all who were worthy of his confidence. His loss will be deeply felt, not only among his associates, but by all who knew him. He had the fullest confidence and respect of the officers of this Company, and their sympathies go out warmly to the bereaved members of his family.

Copper Steam Pipes.

COPPER STEAM PIPES FOR MODERN HIGH-PRESSURE ENGINES.*

BY MR. W. PARKER.

Chief Engineer Surveyor to Lloyds Register of British and Foreign Shipping, Member of Council.

As might have been expected, the disastrous explosion of the main steam pipe and consequent loss of life that occurred on board the Royal mail steamer *Elbe* in September last, and a similar explosion on board the North German Lloyd's mail steamer *Lahn*, have led to investigations as to the cause of these accidents; and, further, the whole subject of the manufacture of coppor steam pipes has been considered generally, and experiments carried out with the view of ascertaining the behavior of the different kinds of commercial copper under various conditions of treatment and at various temperatures. A summary of the investigations and the results of these experiments will not, I think, be without interest to these meetings.

The s. s. *Elbe* was built in 1870 by Messrs. J. Elder & Co., and fitted with ordinary compound engines. In February of last year she was placed in the hands of Messrs. Oswald, Mordaunt & Co., of Southampton, for the purpose of being fitted with new boilers to work at a pressure of 150 pounds per square inch, and of having her compound engines converted into triple-expansive ones. This work was completed, and the vessel was running her official trial in Stokes Bay, when the main steam pipe abreast of the after boilers burst, and all in the stokehole at the time, numbering eleven persons, were killed by the sudden outrush of steam.

The s. s. *Lahn* is a new vessel built by the Fairfield Shipbuilding and Engineering Company last year. In March last, while on her second voyage across the Atlantic, her steam pipe burst in a somewhat similar manner, but the loss of life was less in this instance than in the case of the *Elbe*.

* Paper read at the thirtieth session of the Institution of Naval Architects at Glasgow, July 25, 1887.

It was natural to suppose that the bursting of copper steam pipes, such as those of the *Elbe* and the *Lahn*, would be found to be attributable to defective workmanship or material, and that due care had not been exercised in the manufacture of the pipes; but these investigations go to show that elements of very serious danger enter into the ordinary methods of making brazed copper pipes, especially when intended for high-pressure steam.

The steam pipe which exploded on board the *Elbe* was $9\frac{3}{8}$ inches in diameter inside, and 6 feet 6 inches long, the thickness of the copper was .276 inches, corresponding to No. 2 imperial wire gauge; it was brazed in the usual manner, with a lapped joint, and to all appearance seemed a well-made pipe. The copper had been obtained from a first-class manufacturer in Birmingham, and analysis has shown it to be chemically of the best quality.

The pipe itself had been tested by hydraulic pressure on two occasions, once for the satisfaction of the builders to a pressure of 300 pounds per square inch, and a second time by the owner's representative to 350 pounds per square inch. These tests had been sustained in a perfectly satisfactory manner, and so far as could be judged, every care had been exercised by the makers to produce as good a piece of workmanship as possible.

Test-pieces were cut from the exploded pipe, and the copper away from the locality of the brazing was found to have an ultimate tenacity of 33,000 pounds per square inch, with an elongation before fracture of 33 per cent. in a length of 5 inches, so that the bursting pressure for this pipe, in its cold state, should have been about 1940 pounds per square inch, being thirteen times the working pressure, or, taking the actual thickness of the copper at the fracture as measured after the explosion, and which was found to be $\frac{3}{16}$ inches, the pipe should still have borne an ultimate pressure of 1220 pounds per square inch, or 8.8 times the working pressure.

In order to ascertain the actual strength of the portions of the pipe adjacent to the exploded part, a piece of the pipe, about 30 inches long, was cut from the portion still intact of the length which exploded, and two other similar pieces were prepared from the next adjoining length of pipe. These short pieces were fitted with flanges and tested to destruction by hydraulic pressure, and in each case the pipe burst in exactly the same way, namely, through the copper near and parallel to the brazed seam, commencing near to one of the flanges.

The pieces taken from the same length where the explosion had occurred, gave way under a hydraulic pressure of 780 pounds per square inch, the fracture exhibiting a granular and in part a discolored appearance.

Of the two pieces cut from the next adjoining length of pipe, one burst at 600 pounds per square inch with the same granular and partly discolored fracture, as if the metal had been injured or partially cracked through during the operation of brazing; and the other burst at 1140 pounds per square inch, the fracture being granular but not discolored.

This great diversity in the bursting pressures for pipes of the same dimensions and material, and the similarity in the character and position of the fracture in each case, together with the fact that the pressure at which the strongest of these lengths burst was still not more than five-eighths of the calculated bursting pressure, seemed clearly to indicate that the material had been injured in the neighborhood of the seam by the operation of brazing.

Some very careful experiments to ascertain the effect of increased temperatures upon sheet copper were made by the Franklin Institute in America as long ago as 1837, when strips of copper were pulled asunder in a properly designed machine at temperatures ranging from 122 degrees to 1332 degrees Fahr., and, as will be seen by the following table, the falling off in strength as the temperature increased was very considerable, until at 1332 degrees Fahr., or a bright red heat, the tenacity was *nil.*

EXPERIMENTS MADE AT THE FRANKLIN INSTITUTE, AMERICA, IN CONNECTION WITH AN INVESTIGATION INTO THE STRENGTH OF BOILERS.

Temperature above 32 degrees.	Diminution of Strength.	Temperature above 32 degrees.	Diminution of Strength.
deg.		deg.	
90	0.0175	660	0.3425
180	0.0540	769	0.4389
270	0.0926	812	0.4944
360	0.1513	880	0.5581
450	0.2046	984	0.6691
460	0.2133	1000	0.6741
513	0.2446	1200	0.8861
529	0.2558	1300	1.0000

These results were substantially corroborated by a series of experiments made by Dr. Kirk and myself after the *Elbe* explosion.

From the table it will be seen that at 360 degrees Fahr., or the temperature of steam of 150 pounds pressure, copper has about 15 per cent. less tensile strength than when cold. But allowing for this falling off in tenacity, the steam pipe of the *Elbe* at 150 pounds steam pressure should still have had a factor of safety of 8½.

Carefully examined through a microscope the difference in the structure of the copper in the neighborhood of the brazing where the exploded pipe and those afterwards tested gave way, and the structure in that part of the pipe away from the brazing was very marked, and was clearly to be ascribed to the heating of the copper during brazing.

Test-pieces were cut from the pipe near the brazed seam where the rent had occurred, and it was found that whereas the copper from other parts of the pipe showed a tenacity of 33,000 pounds per square inch with an elongation of 33 per cent. in 5 inches and 59 per cent. contraction of area as recorded above, in these pieces the tenacity was only 24,418 pounds per square inch, the elongation only 4.6 per cent., and the contraction of area at the fracture only 13 per cent. This result was amply confirmed by testing other strips cut from the same locality; they each showed that the copper near the brazing had lost its ductile qualities and much of its tenacity.

In order to obtain further information on this point, the following experiments were made:

1. A strip of good copper was cut from a sheet and bent and broken cold.

2. A similar piece was raised to a heat above that necessary for brazing, when it became red hot, and broke with its own weight.

3. A piece was raised to the same bright heat as No. 2, allowed to cool, and then broken cold.

4. A piece was raised to the above brittle heat, at which it was partially broken through, then allowed to cool, and the fracture completed when cold.

The appearances of these fractures were very interesting; the first had the fibrous silky appearance of a good copper; in the second piece the fracture was coarse and blackened by the heat; but the third specimen seemed to have almost completely regained its tenacity and ductility on cooling, the copper in its normal state having a tenacity of 35,212 pounds per square inch with an elongation of 40 per cent. in 5 inches, and a contraction of area at the fracture of 39.9 per cent.; and the third specimen, although it had been raised to a blistering heat, was, when cold, found to have a tenacity of 31,337 pounds per square inch, with an elongation and contraction of area at fracture practically the same as the normal copper, which would appear to show that, although the copper should be overheated in brazing, if not otherwise injured, its qualities will be substantially regained on cooling.

The fourth piece was partially broken while hot, and the appearance of that part of the fracture was discolored by the action of the heat, but the part that was allowed to cool had its ductility restored, and afterwards broke with a bright fracture. This experiment was repeated a number of times, with similar results, and the fractures corresponded exactly in appearances not only with that of the exploded pipe, but also with those of the other pipes which were experimented upon, and which burst at pressures of 600 pounds and 780 pounds per square inch respectively.

The only difference in these fractures was the depth to which the partial crack, as shown by discoloration, had extended.

In this manner the exact appearance of the fractures of the exploded pipe, and of those experimental pieces which burst at the low pressures, was reproduced artificially by burning the copper and treating it in the way described.

From this it will be seen that, should a copper pipe be over-heated during the brazing operation, and seeing that the metal becomes perfectly brittle at not much above the brazing heat, the pipe might accidentally be cracked while in this brittle condition; and, although the section of metal still remaining intact might be sufficient to sustain the cold water test pressure, yet the hot steam and accompanying strains might develop and deepen the crack, and the pipe ultimately give way at the working pressure.

This I consider to be the true explanation of the explosion of the *Elbe's* steam pipe, and also that of the s. s. *Lahn*.

A serious element of danger is thus shown to exist in the present practice of brazing large, heavy copper pipes intended to be subjected to the high pressure now so common. It is generally admitted that welds or brazed joints in any material must possess certain elements of uncertainty and the above experiments show this uncertainty to be greatly increased in the case of copper worked over a fire.

How to eliminate these elements of danger becomes an important question. Various alternatives suggested themselves, as, for instance, that the copper might be worked cold and the joint made by a riveted seam, that brazed pipes might be served with wire or have strengthening bands fitted at short intervals (both of which systems I find are now resorted to), or that steel pipes might be used, the seam being riveted.

While these points were under consideration, I had brought to my notice by Mr. W. Elmore, a method of making copper pipes of any required diameter, length, or thickness by electro-deposition, and I was instructed by the committee of Lloyd's Register to proceed to Mr. Elmore's works and witness the operation of making these pipes, with a view to reporting thereon for the information of the committee. The process is briefly as follows: A mandrel is surrounded by ordinary unrefined Chili bars arranged upon strong supporting frames in a depositing tank of sulphate of copper, and the copper is dissolved or decomposed, as will hereafter be explained, and is deposited in the form of pure copper on the revolving mandrel, leaving the copper in the form of a shell or pipe, of any thickness required, fitting closely to the mandrel. When the required thickness has been deposited, the pipe and mandrel are exposed to the action of hot air or steam, then the copper expanding more than the iron admits of the mandrel being drawn, leaving the copper in the form of a pipe, without a seam, perfectly round and true both internally and externally; or the pipe may be expanded or made larger by rolling or other mechanical means, and then the mandrel withdrawn.

(*To be continued.*)

Locomotive Boilers.

It is understood very clearly now that a locomotive with an inefficient boiler is like a man with an unhealthy stomach, and that the source of power and speed in locomotives, as in human beings, is in their digestive organs. Locomotive builders and those in charge of the motive power of railroads have been slow to recognize the importance of sufficient boiler capacity, and for a long time the aim of the designers of these machines seemed to be to ascertain the minimum size of the steam-generator that would answer for the service in which they were to be employed. The attitude of mind in which such engineers seemed to entertain the question was apparently similar to that of inexperienced persons in relation to frictional bearing-surface. The natural man, who has never passed through a period of contrition for his shortcomings — which experience of hot bearings is sure to impose sooner or later — seems to abhor amplitude of bearing-surface. Hot boxes appear to be as essential to quicken the perceptions of young mechanics and engineers, with reference to this subject, as the fires of sheol are to awaken the consciences of sinners generally. So with reference to boilers. The unregenerate mechanic seems to abhor large boilers. It is only when he has been through a sort of penitential experience with locomotives, when one of them gets out of steam in trying to pull a train up a heavy grade, and it utters what seems like a gasp, and, in the vernacular of the road, it "lays down" in despair, that he realizes their necessity. The endurance of a man, the speed of a horse, and the power of a locomotive all depend upon their breath holding out. Experience has thus finally taught those who have given due attention to the subject, that a sufficient supply of the breath of life in locomotives is dependent upon ample boiler capacity.

The question has then been asked, and last year was submitted to a committee of the Master Mechanics' Association, How big should a locomotive boiler be? The committee submitted their answer in a report to the last convention of the Association, and the rule given in that report for calculating the heating surface of a locomotive boiler for engines with cylinders 24-in. stroke, was that *the area of one piston in square inches should be multiplied by* 5.8, *and the product would be the total heating-surface in square feet.* At first sight it might appear as though this rule does not take due account of the size of the wheels, as, other things being equal, the diameter of the cylinders would be increased with that of the wheels. But the diameter of the wheels should be proportioned to the speed of the engine. Thus, suppose we have an engine with wheels 4 ft. and cylinders 18 in. in diameter, and that the wheels make 200 revolutions per minute. The area of such a piston would be 1.767 square feet, so that the spaces swept through by the two pistons, and, consequently, the quantity of steam used per minute, would be equal to $1.767 \times 2 \times 4 \times 200 = 2,827.2$ cubic feet. If an engine was built to run 50 per cent. faster, the diameter of its wheels and cylinder should be increased in like proportion, so that the area of its pistons should each be 2.65 square feet, and, therefore, if the engine ran the same number of revolutions per minute — which would mean 50 per cent. greater speed — it would consume 4,240 cubic feet of steam per minute. By the rule which has been given, the heating-surface in the one case should be 1,476, and the other 2,214 square feet. But here we encounter a difficulty. If the two engines are of a similar plan, say of the eight-wheeled American type, with four driving-wheels and a four-wheeled truck, it will be found that the running gear, cylinders, their connections, and the frames of the engine with the large wheels, must be all larger and heavier than those of the other engine, while at the same time the boiler of the one with the large wheels should be larger than that of the one with the small wheels. Let it be supposed that the weight of the engine with the small wheels is as follows:

Total weight, ...	96,000 lbs.
Weight of boiler, with water and fuel, . . .	40,000 "
" wheels, cylinders, frames, etc., . .	40,000 "
" other parts, ...	16,000 "

Now, if the size of the wheels and cylinders is increased 50 per cent., they will weigh 60,000 lbs., instead of 40,000. If this weight, added to that of the others parts, is deducted from the total weight, then there will be only 20,000 lbs. left for the weight of the boiler. That is, the boiler which should be the largest must weigh the least. In practice, slow-running engines have a larger proportion of their weight on the driving-wheels, which makes it essential that the cylinders should be larger, as is the case in ten-wheeled, Mogul, and consolidation engines, and fast-running locomotives have less weight on the driving-wheels, as in the case of the English machines with only one pair of driving-wheels, and thus the size of the cylinders is kept down, and, consequently, not so large a boiler is demanded.

It therefore seems as though the problem might be approached most advantageously from another side. Thus, supposing we determine from experience what class of engines is best suited for a given service. The weight of the rails will determine the load per wheel which may be carried, and it and the diameter of the wheels will decide what the size of the cylinders should be, which in turn will govern their weight and that of their connections. Having advanced thus far, if we take their weight, and that of all the other parts, excepting the boiler and its attachments, and deduct it from the total weight of the engine, which has been determined by the load to be carried on each of the wheels and their number, the remainder will be the weight of the boiler. It is quite safe to say that within this weight the boiler cannot be made too large, and the problem therefore is, how to make the largest boiler of a given weight, and, of course, of the requisite strength.

Under these conditions, the only way to add to the weight and size of the boiler is to reduce the weight of the other parts. To this end it is desirable to keep the diameter of the wheels as small as possible, because with a given weight on them the size of cylinders and their connections is proportioned to that of the wheels, and therefore if all these parts are small and light the boiler may be larger and heavier, and yet keep the total weight of the engine within the prescribed limits. In designing locomotives, then, it would seem that there is a decided advantage in keeping the weight of all the parts not connected with the boiler as small and light as is practicable, so that the dimensions of the latter may be increased. It is also desirable that the lightest form of construction for boilers should be adopted, so that they may be of the maximum size and capacity. Forms of construction which require the use of heavy braces and stays should be ignored, and the preference given to plans which will make a boiler of the maximum size and strength, and the minimum weight. The maxim is undoubtedly true that "within the limits of weight and space to which a locomotive boiler is necessarily confined, it cannot be too large." This being true, it would seem to be worth while in in building locomotives to give especial care to the designs of all the parts which do not form a part of the boiler, and are not attached to it, with a view to reducing their weight, because every pound taken from these parts may be added to the boiler.

With the increase of the size of locomotives another difficulty is encountered. The gauge of the rails is fixed, and, consequently, the distance between the frames — if they are placed inside of the wheels, and are of the usual form employed on American locomotives — is limited to about 42 or 44 inches. When the barrel of the boiler is made from 60 to 70 inches in diameter, the fire-box is relatively very much contracted, and the back view of such a structure reminds one of a broad-shouldered woman who is tightly laced. Under these conditions, both her vitals and those of the locomotive are unduly and injuriously contracted. To put the fire-box above the frames and thus get from six to eight inches additional width, is open to some objections, although these are, perhaps, counter-balanced by the advantages gained. To put it above the wheels is open to still greater objections.

The problem then presents itself, how to get a wider fire-box for the large engines which are demanded by the traffic of the time than is possible with the present plans of construction. This problem is daily becoming more urgent, and a solution of it would be an improvement in locomotive construction which is urgently demanded.—*The Railroad and Engineering Journal.*

The Locomotive.

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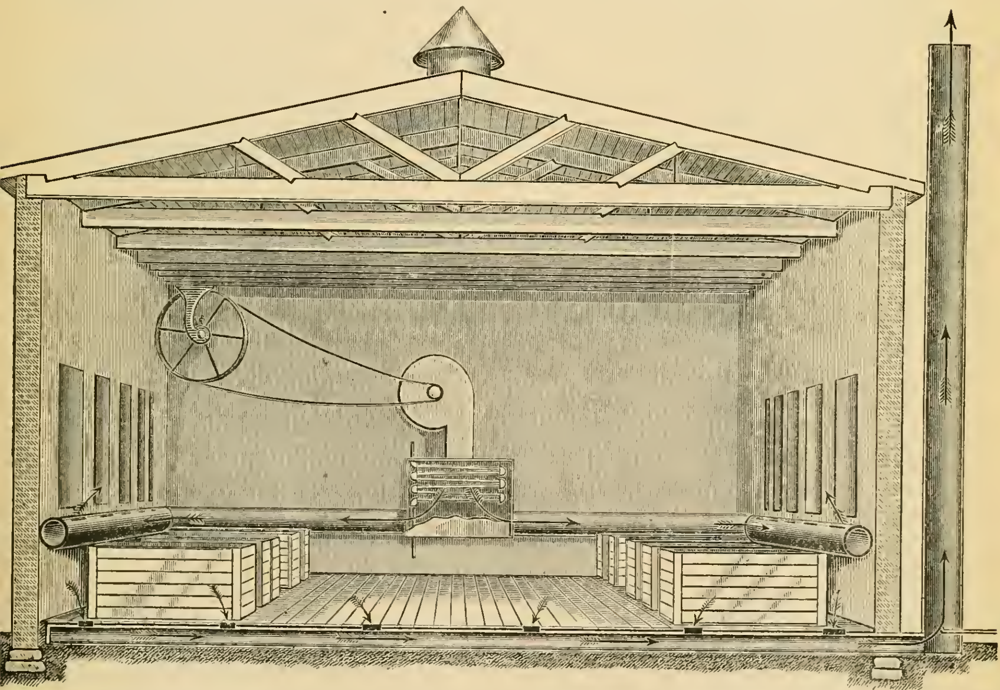
The Ventilation of Dye-Houses.

The problem of heating and ventilation is not a new one, but there are many things about it that are not yet generally understood. A clear comprehension of the laws of nature, and a strict conformity to them, would remove all the difficulties. We have had many peculiar experiences in reconstructing heating systems and examining into their workings, and we have noticed that in some cases in which plants have failed to give satisfaction it has been the ventilating and not the heating system that needed attention



and reformation. It is not our intention at present to discuss ventilation in general, but merely to call attention to one point in the manufacturing business. We have been called upon at times to offer suggestions or to make changes in the method of ventilating rooms in which the humidity of the air interfered with the work so as to cause not only discomfort but also loss. We have watched many of the attempts to ventilate dye-houses, in which the vapor from the dye-becks causes a very disagreeable fog in cold weather, the air being charged with vapor so that it precipitates its moisture upon being cooled to such a degree as to reach the dew point. Exhaust fans placed in the walls so as to throw out the vapor have been tried, and are still in use to some extent; but this does not seem to be as successful as might be desired. The drawing out of the air, producing a partial vacuum in the room, causes the cold external air to enter through the cracks around the doors and casings. This causes further condensation and fog and precipitation of water.

There would be no trouble of this kind if the ventilation were carried on in conformity with the laws of nature. Air in warm weather really has a greater humidity than in cold weather, though it seems much drier, as, owing to its higher temperature, it has a far greater capacity for carrying moisture. If air at 60° be saturated, and its temperature be then reduced to 40° or 50°, it will deposit a large part of its moisture; but if, on the other hand, it be saturated at 40° and its temperature be then raised to 60°, its capacity for moisture will be greatly increased. This fact fully explains the difficulties referred to above, in the ventilation of dye-houses and similar works. If we change the system from the exhaust system to a compression system, by passing the air over heated coils of pipe, as in the systems of indirect heating, and throwing hot currents into the room, with the ventilating flues so arranged as to produce an equal distribution of the hot air throughout the room, it can carry a much larger percentage of moisture than it is carrying. In other words, it will be *dry*, and condensation cannot take place unless the air is allowed to cool again after having become saturated at the high temperature. By so simple an expedient as this the fog and precipitation may all be prevented.

The ventilation should be so arranged and controlled by suitable dampers as to be just sufficient to keep the room dry and clear of steam. At times the changing of the air once in thirty minutes will be sufficient; at others, it may be necessary to change it once in ten or fifteen minutes. By the method of ventilation here advocated considerable can be saved in fuel if the apparatus is properly cared for. If an exhaust fan is used at a given speed and area to change the air of the room in a given time, its duty will be constant; and if the air is admitted over heated pipes, it is possible that equally good results may be obtained, if the heating coils are properly distributed and ducts are arranged in proportion to the work to be done. But when the requirements are for a less quantity of air in a given time than the capacity of the fan, if we close off the hot-air supply we once more get the cold-air drafts previously mentioned, and a portion at least of the discomfort. Therefore our preference in most cases is for the compression system. If the exhaust system is preferred, however, it should be so arranged that the outflow of the air can be easily regulated to just meet the requirements, from the maximum to the minimum. When it is practicable to place ducts connecting with the ventilators near to the floor, it may be found desirable to do so, taking out the cooler air nearer the bottom. The lighter or heated air would then be kept constantly descending, while the cold air around and near windows and walls would fall toward the floor owing to its greater specific gravity, and would be drawn into the ducts and away to the ventilator shaft. With Monitor or other forms of roof ventilators, the heated air should be taken in as near the floor as practicable, but the ventilators should be arranged if possible so as to prevent downward drafts of cold air and so as to be adjustable to the work required. In the sketch we do not intend to give details of the arrangement, but only to combine some ideas that can be worked up to suit each special case, it being impracticable to lay down any set form or system to meet all the different conditions arising in different buildings. The sketch shows a form with the heating coils set sufficiently high to allow the return of the water of condensation to the boiler-room. From the heating chamber a trunk pipe of galvanized iron runs in each direction, delivering the heated air through slots having slide dampers and placed in front of each window to intercept the cold air. From the trunk pipes coils can be placed along the wall to further heat the room and keep the wall dry and warm. A trunk and ventilating shaft is shown, with a small steam jet to perfect the draft. These may be used, should there be a preference for them. A form of Monitor or cupola ventilator is also shown, for use if the room is to be ventilated from the roof.

One question will naturally arise: Is not the use of heated air expensive for ventilation? We answer: Yes, in a measure it is; but in all good systems of ventilation and heating a portion of the fuel used must be charged to ventilation. How much, depends altogether upon the system, and upon the care with which it is constructed and managed.

Inspectors' Reports.

OCTOBER, 1888.

In the month of October, 1888, our inspectors made 5,258 inspection trips, visited 10,285 boilers, inspected 3,420 both internally and externally, and subjected 653 to hydrostatic pressure. The whole number of defects reported reached 9,239, of which 874 were considered dangerous; 39 boilers were regarded unsafe for further use. The defects in detail were as follows:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	499	22
Cases of incrustation and scale,	790	27
Cases of internal grooving,	32	9
Cases of internal corrosion,	277	30
Cases of external corrosion,	804	58
Broken and loose braces and stays,	115	19
Settings defective,	206	10
Furnaces out of shape,	327	7
Fractured plates,	180	56
Burned plates,	166	28
Blistered plates,	289	10
Cases of defective riveting,	2,434	230
Defective heads,	67	12
Serious leakage around tube ends,	1,781	185
Serious leakage at seams,	460	80
Defective water-gauges,	238	17
Defective blow-offs,	66	10
Cases of deficiency of water,	11	5
Safety-valves overloaded,	43	10
Safety-valves defective in construction,	40	10
Defective pressure-gauges,	291	31
Boilers without pressure-gauges,	8	8
Unclassified defects,	115	0
Total,	9,239	874

The number of boilers examined this month was unusually large; while the number of dangerous defects discovered was not much, if any, above the average. As usual, the cases of defective riveting are far more numerous than any others.

Every month we find safety valves overloaded, — some of them dangerously so. Overloading is often resorted to when the valve is not tight at the regular working pressure, either for want of regrinding or from any other cause. It is also practiced, often unknowingly, to make valves agree with defective gauges. When the ordinary weighted valve is used, it is a good plan to cut off the lever so that the weight cannot be shifted in the direction of danger. It is also wise to place the valves in conspicuous places so that any attempt to wedge them or tamper with them in any way, may be detected easily.

Boiler Explosions.

NOVEMBER, 1888.

THRESHING ENGINE (193). — The boiler of a threshing engine exploded on the farm of John Spayd, near Reading, Pa., on Nov. 2d, killing five men and wounding several others. The men were operating the threshing machine when the boiler burst, and were standing but a few feet from it. All five were found lying from thirty to fifty feet away, shockingly mutilated, and one man had been hurled through the weather-boarding of the barn. The building was completely wrecked, and the force of the explosion was widely felt.

BRIDGE WORKS (194). — The boiler of the Atlanta (Ga.) Bridge and Axle Works exploded on the afternoon of Nov. 2d, fatally injuring Jack Foster, the fireman, and Amos Allen, a workman.

GRAIN ELEVATOR (195). — A boiler in the basement of S. B. Stebbins' grain elevator in Boston, exploded on Nov. 5th and opened a seam in the floor above. Steam followed through the opening and badly scalded a workman on the first floor, named William Sullivan. He was taken to the Massachusetts General Hospital and it is thought that he will die.

CHEMICAL WORKS (196). — Late in the afternoon of Nov. 7th, a boiler belonging to the Lancaster Chemical Company, whose plant is situated just north of the city limits of Lancaster, Pa., exploded with terrific force, completely demolishing the building and killing one man and injuring five. The boiler was new and the reason for the explosion could not be ascertained. The Chemical Company also supplied the United States Electric Light Company with power, and in consequence of the disaster the town was shrouded in darkness.

PILE DRIVER (197). — The boiler of a pile driver on the new bridge between Detroit, Mich., and Belle Isle. exploded on Nov. 12th. Four men were injured, and Charles Boston, Jr., a son of the owner of the machine, died while he was being removed to his home in an ambulance.

FLOUR MILL (198). — Sanford & Tiffany's flour mill at Bridgehampton, L. I., was partly destroyed on Nov. 13th, by the explosion of the boiler. The west side of the mill was torn out, causing the brick walls to fall in. Engineer Sanford was found under a heap of ruins mortally injured.

SAW-MILL (199). — A 20-horse-power saw-mill boiler exploded in Hazen, Ark., on Nov. 15th. It is said that the engineer "used to pound lead into the cracks of it to stop the leaking." No one killed.

LUMBER YARD (200). — At four o'clock on Nov. 18th, the big boiler owned by the Crawford Milling and Lumber Company, Cincinnati, O., rose about eighty feet into the air and fell a short distance away. The engine-room was wrecked and all about lay brick and mortar debris. Near the boiler lay the engineer and his helper in a semi-unconscious state. They were removed to the hospital and their wounds dressed, and they were then questioned as to the cause of the explosion. The engineer stated that the boiler was kept full of water and that so far as he was aware there was no fire under it at the time. The other man contradicted this, and no satisfactory information could be obtained from either. Two years ago a boiler in this same place exploded and injured several men, and then after flying several hundred feet through the air, mangled a woman beyond recognition.

Mine (201). — A boiler exploded on Nov. 19th, at the Boston Montana Consolidated Works, at Meadville, Mont., killing M. G. Edmunds, engineer; W. O'Connor, carpenter; Jack Kramel, pipe-fitter, and Henry Winters, laborer; and fatally injuring Richard Wing, machinist; George Heckman, pipe-fitter; John Eustis, carpenter, and Foreman Hank Pickering.

Saw-Mill (202). — An explosion took place at Auburn Corners, near Grove City, Pa., on Nov. 26th, in which three men were killed and one injured. The men had gathered around the furnace in John W. Ralston's saw-mill to warm themselves and await the rolling in of some logs, when suddenly the boiler exploded and instantly killed Jesse Hall, the fireman, and so badly injured George Kelly, a sawyer, that he died in three hours. Leslie Cross, a farmer, was at the mill on business and was killed. Ralston is seriously hurt. The explosion had such force as to throw boiler and engine about seventy-five yards.

Feather Renovator (203). — A boiler in the feather renovating establishment of Joseph H. Hart & Co., on Northampton Street, Wilkesbarre, Pa., exploded with great violence at two o'clock, on Nov. 26th. Every window in the building was broken into small pieces. Three employees are said to have been thrown through the glass doors to the sidewalk. Half a dozen others also had narrow escapes from death. After the explosion the structure caught fire, but the flames were soon subdued.

Chair Factory (204). — Four men were cut, bruised, scalded, and burned beyond recognition, by the explosion of a boiler at Cochran, Ind., on Nov. 26th. These four men had remained at the furnace, warming themselves, while a large number of boys and other employees had left the fatal spot only one minute before and so escaped. By this single occurrence three women and thirteen children were left without support.

Threshing Machine (205). — A threshing machine boiler exploded near Poynette, Wis., on Nov. 26th, instantly killing Jack Tuttle, Charles York, and William Buckley, and seriously injuring three others.

Saw-Mill (206). — A portable boiler exploded in a wood-yard in Indianapolis, on Nov. 27th. It had been leaking for several days, and on the morning of the disaster the engineer began patching it. While doing so he allowed the water to get low, and when he turned on the cold water in the afternoon an explosion was the result. The entire end of the boiler was blown out, and it went crashing through the building with such force that the machinery was damaged and the house partially destroyed. The flying piece of the boiler lodged in Davidson's lumber-yard, nearly a square away. No one was injured, but the loss will be about $300.

Synagogue (207). — A very curious explosion took place iu a Jewish synagogue in New York, on Nov. 30th. There are numerous bath-rooms there and underneath these was a boiler to supply them with hot water. On that day there were many people bathing, when suddenly the boiler below went to pieces and threw down the partitions, tore up the floors, and overturned the bath tubs. A large piece of iron was blown through the bottom of a plunge bath, in the middle of the floor, and three men who were swimming there suddenly found themselves in a whirlpool, and the next minute were standing on the bottom, the water having run down through the hole made by the flying iron and extinguished a fire that had started below. Two men were badly hurt, and about $2,000 worth of damage was done. The boiler had no gauge on it, and received little or no attention.

Copper Steam Pipes.

COPPER STEAM PIPES FOR MODERN HIGH-PRESSURE ENGINES.

By Mr. W. Parker,

Chief Engineer Surveyor to Lloyds Register of British and Foreign Shipping, Member of Council.

(*Concluded from page 173.*)

The deposition of copper by electricity is not at all new. It has been in use for years for electrotyping purposes, and for separating copper from its impurities, and particularly for extracting gold and silver. But copper thus refined is wanting in cohesive properties, and without some means of increasing its density, which would give to it, at the same time, both tenacity and ductility, it would in such a form be useless for mechanical purposes. The ingenious manner in which this difficulty is overcome by the present process constitutes its most important feature.

A burnisher or planisher, composed of a small square piece of agate, being the hardest and smoothest substance suitable and available, is supported upon proper arms and levers, and the agate is allowed to press lightly upon the surface of the copper on the revolving mandrel. The burnisher is caused to traverse from end to end of the mandrel by means of a leading screw at any required speed. After it has traversed the whole length of the mandrel, it is automatically reversed, and commences its journey backwards. The speed of the revolving mandrel and the speed of the traversing burnisher is so adjusted or arranged that the whole surface of the copper is acted upon by the burnisher, the result being that every thin film of copper deposited upon the mandrel must be separately acted upon, burnished and compressed into a dense and cohesive sheet of pure copper possessing a great amount of tenacity and ductility, as will be seen from the results of the experiments and tests which I have made, and which will be referred to further on. The impurities or dross fall to the bottom of the tank in the form of mud, and when washed, dried, and smelted in a crucible, the gold, silver, etc., contained therein can be easily separated. In fact, during the operation of refining copper from the rough Chili bars, the finished article is automatically produced in the form of a pipe, and all the impurities are extracted and can be collected.

While I was present at the works of Mr. Elmore, the patentee of this process, four pipes were made. The mandrels had been revolving in the baths for about 170 hours, and the copper in this length of time had reached a thickness of .198 inches. The pipes were taken off the mandrels in my presence, and the ends of the pipes cut off, so as to present a portion of the pipes acted upon by the burnisher. The remaining portion, or rough ends, showed the nodules, or rough copper, not acted upon by the burnisher, and was in a completely brittle condition.

It is well known that the structure of ordinary electro-deposited copper is purely crystalline, and easily disruptured under stress. The adjoining faces of the crystals, of which the whole mass is composed, appear under the microscope to be separated from each other, and have very slight cohesive power.

In order to show the effect of the burnisher upon the material, I have had the structure of specimens of pieces of copper magnified under a microscope and then photographed. One photo was taken from an ordinary piece of cast copper. A second was taken from a rolled bar of copper. The difference in these two structures is very perceptible, and plainly shows the effect of work in the shape of rolling. A third shows the structure of a piece of ordinary deposited copper not burnished, and a fourth shows the structure of a piece of copper one-third unburnished and two-thirds burnished. From these photos it can plainly be seen to what extent the crystals are reduced in size, and the cohesive power of the material increased.

To describe more in detail how the decomposition of the unrefined copper is effected, and how the deposit takes place, I may state that the unrefined Chili bars are cast into slabs of the required length of the pipe, and these are arranged longitudinally in a wooden tank, in such a manner that the faces of the slabs are approximately at equal distances from, and parallel with, the surface of the cylindrical mandrel, both at its sides and underneath it, leaving the upper side open for the burnisher to travel over. The mandrel is fitted with a properly insulated spindle, running in insulated bearings, and driven by suitable wheel gearing, etc. The whole of this arrangement is immersed, as before stated, in a bath of sulphate of copper. The mandrel forms what is termed the cathode, and the copper bars the anode, of the electric circuit. The cathode is connected with the negative pole of an ordinary dynamo machine, and the anode with the positive pole. When the dynamo is set in motion, an electric current passes through the solution, and the following chemical changes take place. The sulphate of copper is decomposed. and the sulphuric acid is transmitted to the anode, there to attack and dissolve or combine with a quantity of copper equal to that which has been liberated or deposited upon the cathode.

The electric terms used in this matter of the deposition of copper are like those for electroplating and electrotyping, and it may be as well to describe them here.

1. The terms "cathode" and "anode" are synonymous with the positive and negative poles of an electric or galvanic battery.

Then to measure the volume of electricity passed between these points the term "ampères" is used as the unit, like feet or cubic feet, for measuring in the usual mechanical sense.

2. Then for expressing the force with which the volume of electricity is propelled the term "volt" is used as the unit.

3. The resistance opposed to the electricity is measured by "ohms."

4. The work done in the electrical circuit is expressed by "watts," in the same way that in a steam engine the power developed is expressed by H.P. To put this shortly:

$$1 \text{ ampère} \times 1 \text{ volt} = 1 \text{ watt}$$
$$1 \text{ watt} \times 746 = 1 \text{ E.H.P.}$$

These are the electrical terms employed by common consent in all European languages in connection with this science, and there are certain facts in relation thereto that are quite accepted.

The principal one to be noted here is that one ampère of electrical current will deposit .005084 grains of copper per second per square foot of surface in a suitable bath and under fair circumstances. At the time I had the pleasure of witnessing the tubes being manufactured, the ampères and volts were measured by Siemens' standard instruments, from which, on the above basis, the quantity of copper electrically deposited in a given number of hours could be estimated.

In this way it was easy enough to judge of the horse-power transmitted through the dynamo to deposit a given quantity of copper or a given thickness of copper pipe of a given diameter. As to quality, it was by the nature of the process almost bound to be uniform; but in this respect the photos of the magnified pieces of copper, both before and after the burnisher had been applied, and the mechanical tests I have made, are the best proofs. I may describe the latter as follows:

Two of the four pipes I witnessed being manufactured I brought to London. One of these pipes I had fitted up with strong flanges properly secured in an apparatus especially made for the purpose, and tested to destruction. The other pipe I had cut into two pieces, and one of these pieces I have kept and marked A. The other piece was cut and flattened out into a sheet, from which six test-pieces were cut and prepared for making tensile tests. I also obtained from Messrs. J. Wilkes & Sons, of Birmingham, two solid drawn copper pipes of similar dimensions, and had them cut and tested in a like manner. The piece kept is marked B.

In addition to these pipes I obtained from Messrs. Clelland & Thornburn, the well-known coppersmiths, of Glasgow, a brazed pipe of the same dimensions, made especially for my experiments, which was also tested to destruction, together with a sheet of best rolled copper, so that corresponding test-pieces could be made to those made from the electro-deposited pipe, and the solid drawn pipe.

The results of these mechanical experiments are most interesting.

Pipe A, electro-deposited, stood a pressure of 3450 pounds per square inch before it burst. The material stretched and the pipe expanded uniformly until the copper was reduced in thickness from $\frac{3}{16}$ inch to $\frac{1}{16}$ inch.

Pipe B, solid drawn, stood a pressure of 2200 pounds per square inch. It also expanded, but not with the same uniform character as pipe A.

Pipe C, brazed from sheet copper, also stood a pressure of 2200 pounds per square inch, and burst as all brazed pipes do, near the line of brazing.

The tensile strength and ductility of the copper cut from pipe A is given in the following table:

TABLE A.—*Deposited Copper.*

Marks on Specimen.	Dimensions in Inches.			Tensile Strain in Tons.		Elongation per cent.		Contraction of Area per cent.	Remarks.
	Breadth.	Thickness.	Area.	Total.	Per Square Inch.	In 8 in.	In 5 in.		
A 1	2.0	.175	.351	8.36	23.80	13.7	20.0	73	Electro-deposited copper cut circumferentially from the pipe.
A 2	2.0	.18	.36	8.36	23.22	13.0	17.5	68½	
A 5	1.0	.18	.18	4.32	24.00	12.9	16.0	82	Cut longitudinally with the pipe.
A 6	1.0	.18	.18	4.27	23.70	13.2	13.2	71	

It will be seen by these tables that the tenacity in the normal state of these three descriptions of copper — the electro-deposited, the solid drawn, and the rolled sheet — are 23¾, 20¼, and 14 tons per square inch respectively.

The very superior ductility of the pure electro-deposited copper is clearly shown by the manner of breaking, the elongation being chiefly confined to the neighborhood of the fracture; and whereas the contraction of area at the fracture in the solid drawn copper is 12.8 per cent., and in the sheet copper 45 per cent., in the deposited copper it averages 72 per cent.

The tensile strength and ductility of the copper cut from pipe B is given in the following table:

TABLE B.—*Solid Drawn Copper.*

Marks on Specimen.	Dimensions in Inches.			Tensile Strain in Tons.		Elongation per cent.		Contraction of Area per cent.	Remarks.
	Breadth.	Thickness.	Area.	Total.	Per Square Inch.	In 8 in.	In 5 in.		
B 1	2.0	.195	.39	8.0	20.5	3.75	7.1	12.8	Solid drawn copper cut circumferentially from the pipe.
B 2	2.0	.195	.39	8.0	20.5	3.75	6.9	12.8	
B 5	1.0	.190	.19	3.8	20.0	2.90	7.0	43.6	Cut longitudinally from the pipe.
B 6	1.0	.190	.19	3.8	20.0	3.10	7.0	36.8	

The tensile strength and ductility of the copper cut from sheet copper, such as would be supplied for making pipe C, is given in the following table:

TABLE C.—*Rolled Sheet Copper.*

Marks on Specimen.	Dimensions in Inches.			Tensile Strain in Tons.		Elongation per cent.		Contraction of Area per cent.	Remarks.
	Breadth.	Thickness.	Area.	Total.	Per Square Inch.	In 8 in.	In 5 in.		
C 1	2.0	.265	.53	7.46	14.0	45.0	30.0	44.5	Rolled sheet copper cut in direction in which it was rolled.
C 2	2.0	.265	.53	7.46	14.0	44.0	30.0	45.5	
C 5	1.0	.265	.265	3.72	14.0	45.0	35.5	31.0	Cut across the direction in which it was rolled.
C 6	1.0	.265	.265	3.71	14.0	42.0	33.5	31.5	

The tenacities shown by the test-pieces are confirmed by the pressures at which the electro-deposited and solid drawn pipes burst under hydraulic pressure, and, as before stated, the uniformity of the deposited material is very conspicuous.

In order to ascertain how deposited copper behaves as compared with solid drawn and ordinary sheet copper, and how its strength and ductile properties are affected by the action of heat, such as is contained in steam pressures that are now common, I have had a series of experiments made, the results of which are given below:

TABLE D.—*Table showing Effect of Temperature in Different Descriptions of Copper.*

Marks on Specimen.	Thickness.	Breadth.	Area.	Total Load in Tons.	Tons per Square Inch.	Percentage of Loss.	Temperature.	Remarks.
						p. c.	deg. F.	
	. .	. .	. .	. .	. .	. .	60	Cold.
P 1	.237	2.0	.474	6.80	14.33	. .	60	"
P 2	.237	2.0	.474	5.05	10.66	26	390	Rolled sheet copper.
P 3	.237	2.0	.474	5.00	10.55	26	390	
	. .	. .	. .	. .	. .	. .	60	Cold.
S 1	.192	2.0	.384	7.70	20.0	. .	60	"
S 2	.195	2.0	.390	5.55	14.23	25.2	390	Solid drawn copper.
S 3	.194	2.0	.388	6.10	15.7	. .	390	
	. .	. .	. .	. .	24.0	. .	60	Cold.
T 1	.179	2.0	.358	5.50	15.35	. .	390	
T 2	.179	2.0	.358	5.25	14.65	. .	390	Electro-deposited copper.
T 3	.179	2.0	.358	5.45	15.2	. .	390	

The specimens were immersed in an oil bath while they were in the testing machine, the temperature of the oil being maintained at a gas flame; and by this means the specimens were pulled asunder at the temperatures given, which correspond with the temperature of steam at 200 pounds pressure.

The results of these experiments are embodied in the preceding table, and are very interesting. The electro-deposited copper, it will be seen, as well as the solid drawn copper, stood about fifteen tons per square inch, while cold rolled sheet copper broke at about 10½ tons, at the temperature of 390 degrees Fahr.

Comparing these tests with the interesting series made by Dr. Kirk at Lancefield, to which I have before referred, and published in *Engineering* in December, 1887, I find there were twenty-three specimens of copper plates tested at the same temperature, viz.: 390 degrees. Some of these were cut across brazed joints, and others clear of the brazing.

Of the nine samples which had been cut across the brazed joint, the mean tensile strength per square inch was 10.53 tons; but they varied in strength from 8.59 tons up to 12.32, or about 40 per cent., say, 20 per cent. above and 20 per cent. below the average.

The fourteen samples that were cut clear of the brazing broke with a mean tensile strength of 11.81 tons per square inch, the variation ranging from 10.19 tons to 13 tons per square inch, or from about 10 per cent. above to 10 per cent. below the average.

Similarly comparing with the experiments made by me at the time of the *Elbe* explosion, the mean of four samples of sheet copper, at temperatures varying from 300 degrees to 370 degrees Fahr., was 9.93 tons.

Other experiments also go to show that ordinary sheet copper cannot be accorded a breaking strain of more than about 10 tons per square inch at the temperature of high-pressure steam, apart from the danger and uncertainty arising from brazing which was so disastrously exemplified in the case of the *Elbe* and also the s.s. *Lahn*. In the case of the electro-deposited copper, as also in solid drawn copper pipes, these experiments indicate a breaking strain at these temperatures of about 15 tons per square inch, or an increase of 50 per cent., and an absolute freedom from the dangers of brazing. This is a step in advance for which I am sure marine engineers will be grateful, and it comes none too soon, for our increasing high pressures have here discovered a weakness and danger that was bound to cause anxiety.

I find solid drawn pipes are now being made of larger diameter than hitherto, and I am not aware what the limit of their process of manufacture can go to; at any rate, there is no limit to which the diameters of the electro-deposited pipes can be made. Many other advantages are claimed for these electro-deposited pipes, which I have not investigated, but so far as steam pipes are concerned, it is obvious that absolute uniformity of density, thickness, and tensile strength, and true circular section (all of which are important qualities), can be obtained.

It is also established that copper deposited under a burnisher can be varied in tensile strength from the ordinary granular form to a material having high tenacity, and as it obviates the necessity for the steam pipes being put into the fire for brazing purposes, the strength and safety at high steam temperatures may be still further increased, and if so, we shall, I am sure, be further gratified.

I cannot conclude this paper, which I hope may not be without interest to the members of this Institution, and to others engaged in the manufacture and use of copper pipes, without expressing my thanks to Messrs. Maudslay, Sons, and Field for the great assistance they have been to me in carrying out a number of experiments, notably the bursting of the pipes, for which special appliances had to be devised, as also for the experiments at high temperatures; my thanks are also due to the Leeds Forge Company, who placed their testing machines at my disposal, and others who supplied me with copper and the necessary assistance and appliances for conducting these investigations.

Comparison of Decimal with the Binary and other Scales.

The following Table has been prepared for the use of machinists and other mechanics who have occasion to use ordinary steel scales as found in the market at the present time. These scales are usually divided into eighths, sixteenths, thirty-seconds, sixty-fourths, tenths, twentieths, fiftieths, hundredths, twelfths, twenty-fourths, etc. The Table shows at a glance the relative value of these divisions, and their decimal equivalents.

8ths.	16ths.	32ds.	64ths.	Decimals.	48ths.	24ths.	12ths.	6ths.	40ths.	20ths.	10ths.
			1	.015625							
				.020833	1						
				.025					1		
		1	2	.03125							
				.041667	2	1					
			3	.046875							
				.05					2	1	
	1	2	4	.0625	3						
				.075					3		
			5	.078125							
				.083333	4	2	1				
		3	6	.09375							
				.1					4	2	1
				.104167	5						
			7	.109375							
1	2	4	8	.125	6	3			5		
			9	.140625							
				.145833	7						
				.150					6	3	
		5	10	.15625							
				.166667	8	4	2	1			
			11	.171875							
				.175					7		
	3	6	12	.1875	9						
				.2=1-5					8	4	2
			13	.203125							
				.208333	10	5					
		7	14	.21875							
				.225					9		
				.229167	11						
			15	.234375							
2	4	8	16	.25=¼	12	6	3		10	5	
			17	.265625							
				.270833	13						
				.275					11		
		9	18	.28125							
				.291667	14	7					
			19	.296875							
				.3					12	6	3
	5	10	20	.3125	15						
				.325					13		
			21	.328125							
				.333=⅓	16	8	4	2			
		11	22	.34375							
				.35					14	7	
				.354167	17						
			23	.359375							
3	6	12	24	.375	18	9			15		
			25	.390625							
				.395833	19						
				.4=2-5					16	8	4
		13	26	.40625							
				.416667	20	10	5				
			27	.421875							
				.425					17		
	7	14	28	.4375	21						
				.45					18	9	
			29	.453125							
				.458333	22	11					
		15	30	.46875							
				.475					19		
				.479167	23						
			31	.484375							
4	8	16	32	.5=½	24	12	6	3	20	10	5

8ths.	16ths.	32ds.	64ths.	Decimals.	48ths.	24ths.	12ths.	6ths.	40ths.	20ths.	10ths.
			33	.515625							
				.520833	25						
				.525					21		
		17	34	.53125							
				.541667	26	13					
			35	.546825							
				.55					22	11	
	9	18	36	.5625	27						
				.575					23		
			37	.578125							
				.583333	28	14	7				
		19	38	.59375							
				.6=3-5					24	12	6
				.604167	29						
			39	.609375							
5	10	20	40	.625	30	15			25		
			41	.640625							
				.645833	31						
				.65					26	13	
		21	42	.65625							
				.6667=⅔	32	16	8	4			
			43	.671875							
				.675					27		
	11	22	44	.6875	33						
				.7					28	14	7
			45	.703125							
				.708333	34	17					
		23	46	.71875							
				.725					29		
				.729167	35						
			47	.734375							
6	12	24	48	.75=¾	36	18	9		30	15	
			49	.765625							
				.770833	37						
				.775					31		
		25	50	.78125							
				.791667	38	19					
			51	.796875							
				.8=4 5					32	16	8
	13	26	52	.8125	39						
				.825					33		
			53	.828125							
				.833333	40	20	10	5			
		27	54	.84375							
				.85					34	17	
				.854167	41						
			55	.859375							
7	14	28	56	.875	42	21			35		
			57	.890625							
				.895833	43						
				.9					36	18	9
		29	58	.90625							
				.916667	44	22	11				
			59	.921875							
				.925					37		
	15	30	60	.9375	45						
				.95					38	19	
			61	.953125							
				.958333	46	23					
		31	62	.96875							
				.975					39		
				.979167	47						
			63	.984375							
8	16	32	64	1.=one	48	24	12	6	40	20	10

In this number we reproduce, by request, two articles that have appeared in the Locomotive previously. The article on *Correcting Thermometers* first appeared in August, 1884, and *Comparison of Decimal and other Scales* in September, 1883.

The Locomotive.

HARTFORD, DECEMBER, 1888.

J. M. ALLEN, *Editor.*

H. F. SMITH, A. D. RISTEEN, } *Associate Editors.*

THE LOCOMOTIVE *can be obtained free by calling at any of the company's agencies.*
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MR. THOMAS PRAY, Jr., has issued a new edition of his *Twenty Years with the Indicator*, the two parts being bound together instead of separately as in former editions. We have already spoken a good word for this book, in the LOCOMOTIVE, and it gives us pleasure to speak another. Mr. Pray's style is easy, so that his work is both instructive and pleasing; and his large experience with the indicator gives weight to what he says. The book is fully illustrated with diagrams taken from actual practice, and the comments and explanations are easily understood. The price has been reduced to $2.50. Address John Wiley & Sons, 15 Astor Place, New York.

IN Sheffield, Eng., the citizens seem to be troubled with smoke. We take the following from *Engineering* (London): "Steps have been taken by the authorities to abate the smoke nuisance, if it is possible to do so. Offending parties have pleaded before the Sheffield bench that there are no systems known by which smoke consumption can be combined with economy; in fact, that smoke consumption means the lowering of the steam productive power of the furnaces. It is suggested that 'more boiler room' is the only way by which the smoke nuisance, so far as users of steam power are concerned, can be prevented. Mr. Sayer, the deputy town clerk of Sheffield, is rather incredulous on the point, and the manufacturers who have been summoned this week for disregarding the smoke by-laws, as well as himself, would possibly be happy to have a few words of advice from experts on the subject. Some of the manufacturers of the town have gone so far as to plead that smoke consuming apparatus are, as a rule, failures." The best smoke preventing apparatus that we know of, is a good fireman. He is never a failure.

IT is commonly believed that boilers carrying very low pressures, for heating purposes, do not need to be insured: but this belief is not borne out by statistics. Note, for instance, the explosion at Troy, N. Y., on Dec. 22. Here no less than seven persons were seriously injured by a heater put in only three weeks before, and supposed to be perfectly safe.

Another notable heater explosion occurred in Massachusetts in the early part of October. In this case a fire had just been started under the boiler, and the owner had left the basement but a few minutes when he was startled by a report, and on looking toward the house he saw the piazza and the front section of the building torn off and rent in pieces. The boiler was shattered completely, and the basement, after the explosion, "looked as though an express train had run through it." The loss on the house was not less than $1,500, and about $7,000 worth of furniture and *bric-a-brac* were destroyed.

It is evident that heaters need to be inspected and insured, as well as other boilers.

The Efficiency of Engines.

Every little while we see an article somewhere about the efficiency of steam engines and the supposed failure of the formula $\frac{T_1 - T_2}{T_1 + 461^\circ}$ where T_1 is the temperature of the boiler and T_2 that of the condenser, if there is one, or of the air, if the exhaust is into that.

Although this formula is generally called Carnot's, it was first stated we believe by Clausius, who was too modest to claim it as his own. It is of such importance in the theory of heat engines that we are going to explain it a little; and we will begin by saying that no engine that ever was built, or that ever will be built, can have an efficiency as great as that given by this formula.

When we say that the level of the ocean is higher than that of the Dead Sea, all we mean is that water would flow from the ocean into the Dead Sea if the two were connected. Similarly, when we say that a certain piece of brass is hotter than a certain piece of iron, all we mean is that heat would pass from the brass to the iron if the two were brought together. Now, if those two bodies of water were connected by a pipe, water would rush through it very rapidly, but no useful work would be done unless a suitable water wheel or hydraulic engine were placed on it somewhere. Similarly, if the pieces of brass and iron were brought near one another, heat would pass from the brass to the iron; but no useful work would be done unless that heat were made to pass through a suitable heat engine.

Now let us suppose that we have a water wheel in the one case and an air engine in the other; and let us further suppose that the supplies of water and heat are just sufficient to make each of the motors exert one horse-power for one hour. Then the water wheel is perfect, *provided* the water that has run through it can all be pumped back by the same wheel into the original reservoir by the exertion, from some external source, of one-horse power for one hour; for it is evident that this cannot be done if there is any leakage, or waste of any kind. The heat motor is perfect, too, provided all the heat that has passed into it can be restored to the original source, so that the machine comes back to its original state, by the exertion of one horse-power for one hour from some external source; for it would then be proved, as in the case of the water wheel, that there had been no leakage or waste of heat.

Up to this point the parallel between the water wheel and the heat engine has been very perfect; but here it ceases. The efficiency of a water wheel such as we have described would be one hundred per cent.; but the efficiency of the heat engine would be less than that by an amount that would depend on the temperatures of the hot and cold bodies. The science of thermodynamics has shown that if these temperatures are represented by T_1 and T_2 respectively, the efficiency of the perfect engine would be equal to $\frac{T_1 - T_2}{T_1 + 461^\circ}$.

Now an engine in which there is radiation, or waste of heat from any other cause, cannot have as high an efficiency as the engine we have been considering; and it appears, then, that the formula under consideration gives us the *greatest* efficiency that is possible for any engine to have, running under the given conditions. For example, let us suppose that an engine runs under a pressure of fifty-five pounds of steam, the temperature of boiler and condenser being, say, 307° and 100° respectively. The calculation is as follows: $307^\circ - 100^\circ = 207^\circ$. $307^\circ + 461^\circ = 768^\circ$. $207^\circ \div 768^\circ = 0.27$. This is not the *actual* efficiency that we may expect to find, but the *greatest* efficiency that it would be possible to attain with perfect apparatus.

The question whether air is more efficient than steam, or not, does not enter the calculation. Let the inventor puzzle over that problem, and invent and plan until he has found a medium better than either, and devices for using it far superior to those now known. When he has completed his labors, the engine he has produced will still have an efficiency not greater than 27 per cent. when working between these temperatures.

It is often asked whether it is worth while to carry the heavy pressures to which modern engineers are tending, and Carnot's formula is not infrequently resorted to as a test. Now what the formula says about it is of very slight importance. Suppose, for example, that we work at 150 pounds pressure, or say between 366° and 100°. In this case the formula gives 32 per cent. as the limiting efficiency. But no one believes that the difference between this and the previous figure is all that is gained by a triple expansion engine at 150 pounds over a single expansion at 55 pounds. The real gain is due, not to the extension of the limit of possible efficiency, but to other causes that must be considered separately and on their own merits. In the first of the preceding examples (in which the steam pressure was 55 pounds), the smallest coal consumption with which it is possible to work any kind of an engine between the temperatures given, is two-thirds of a pound per horse-power per hour. A comparison of this with the actual results in such cases will show what we still have to expect from further improvements in boilers, and further studies of cylinder condensation and other such points; but the fact that we want to emphasize specially in this article is that Carnot's formula does not give the *actual* efficiency at all, but merely gives the limit that it is not possible to go beyond.

Correcting Thermometers.

The extent to which thermometers are used or should be used by engineers, renders it desirable some notice should be taken of the errors to which they are liable, and the methods usually adopted for their correction. If these errors were very small, say a fraction of one degree Fahr., they would be of little consequence in ordinary steam engineering work, but it is no uncommon thing to buy two ordinary thermometers made by the same man and apparently just alike, and find that their readings at ordinary temperatures differ by some degrees. This is too great an error to be disregarded, and may be easily rectified by almost any person who is possessed of a little patience. Aside from the fact that it is always best to have working thermometers measurably correct, we find the operation of correcting them very interesting work.

In buying thermometers to use for any important work we should always get the oldest ones we can find, that is, those that have been made the longest ; the reason for this being the fact that the glass-tubes always undergo a change after they are newly made and filled with mercury, which change is quite rapid at first, but after the lapse of some months becomes much slower. This change consists of a contraction of the bulb, and is indicated by a *rise* of the freezing point as fixed by the maker. For ordinary purposes, the change may be considered complete at the end of a year, though in most cases, a very slow change probably goes on for several years. Thus, Mr. Joule of Manchester, England, so well-known for his experimental determination of the mechanical equivalent of heat, found that the freezing point of one of his delicate thermometers continued to rise for many years. In 1870, at the end of twenty-six years, the change was still going on, though very slowly. A temporary change is also produced in the freezing point every time the thermometer is heated to a high temperature. The effect of this change nearly all passes off in a few days.

The first operation is to determine the freezing point. To do this, immerse the thermometer in melting snow, or ice, if it be the summer season. If it is desired to work with great accuracy, the thermometer should be kept at this temperature for several days, more especially if it has been recently heated to the boiling point of water. The reading of the mercury may then be marked on the tube, and the freezing point is determined. The freezing point thus found is called the *permanent* freezing point, and will be found usually to differ about three-fourths of a degree Fahr. from that obtained by the same means just after the thermometer has been heated to a high temperature, which is called the *temporary* freezing point, and is the one to be used when a thermometer is to be used for taking observations of high and low temperature alternately at short intervals of time.

The next operation is to determine the boiling point. This is attended with more difficulty than the determination of the freezing point, and for scientific accuracy requires the use of a standard barometer and thermometer, and an accurate knowledge of the latitude of the place of observation, and its height above the sea level. Scientific accuracy, however, is only obtainable by trained observers, and is not necessary in ordinary work, such as we are now considering, and we will dispense with every thing but the barometer. This, however, is absolutely necessary for even ordinary accuracy, and the corrections are very easily made.

For the determination of the boiling point, we need a tin vessel in which water may be boiled, which may be closed with a cork or wooden stopper provided with a hole, through which the thermometer-tube may be slid up and down until the boiling-point shall come just above the top outside, while the bulb is just above the surface of the water, *not* immersed in it. An opening should also be provided for the steam generated to pass off freely, so that *no pressure* is produced in the vessel. A little ingenuity will enable any one to improvise an excellent apparatus for the determination of the boiling point out of an old tin teapot, or other similar vessel.

Everything being in readiness, we bring the water in our apparatus to boiling, and when the mercury has risen and becomes stationary, we make a mark at the top of the column. If the barometer at the time happens to stand at 29.922 inches, we mark the point thus found 212° F., or 100° Centigrade, no correction being necessary. If however, as will probably be the case, the barometer stands somewhat above or below 29.922 inches, we make our mark for 212° F. either below or above the point just found. The correction amounts to 1 degree F. for every $\frac{581}{1000}$ of an inch, or 1 degree C. for every $1\frac{47}{1000}$ inch variation in height of the barometrical column from 29.922 inches. Thus, if the barometer indicated 30.503 inches, the temperature indicated by the vapor of the boiling water would be 213° F., and we would make our mark on the tube for the true boiling point 212°, just $\frac{1}{181}$ part of the distance from that point down to the freezing point below. Thus suppose the distance from the actual boiling point, which we found as above to be just $4\frac{1}{2}$ inches above the freezing point previously found, then because our freezing point is marked 32° on the Farenheit scale, we shall have $213 - 32 = 181$ degrees between the two points, to find our true boiling point for mean pressure, 212°, we divide $4\frac{1}{2}$ by 181, which gives $\frac{25}{1000}$, or $\frac{1}{40}$ of an inch, as the length of one degree. A second mark $\frac{1}{40}$ of an inch below the actual boiling point evidently indicates the temperature 212°.

Having found and marked on our tube two definite points, the freezing and boiling, the next step is to divide the interval between them into $212 - 32 = 180$ parts. If the tube had a bore of uniform diameter from end to end, this would be a very simple matter, but no thermometer-tube will be found to possess this very desirable feature. We must, therefore, divide our scale so that each degree shall represent an equal volume of mercury, as the expansion of mercury for equal increments of heat between 32° and 212° is practically constant. To make this division of the scale requires some patience and tolerably accurate measuring.

(*To be continued.*)

Eleven persons were killed and 175 injured by the explosion of a boiler at Kineshma, Central Russia, on Nov. 28th.