# The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XXIII. HARTFORD, CONN., JANUARY, 1902. No. 1.

## On Pipes and Pipe Threads.

Five years ago (in the issue of THE LOCOMOTIVE for September, 1896), we printed an illustrated article on standard sizes of wrought-iron pipe for steam, water, and gas, giving a table of the proportions that the threads on such piping should have, as well as cuts showing the length of standard thread, and the number of perfect and imperfect

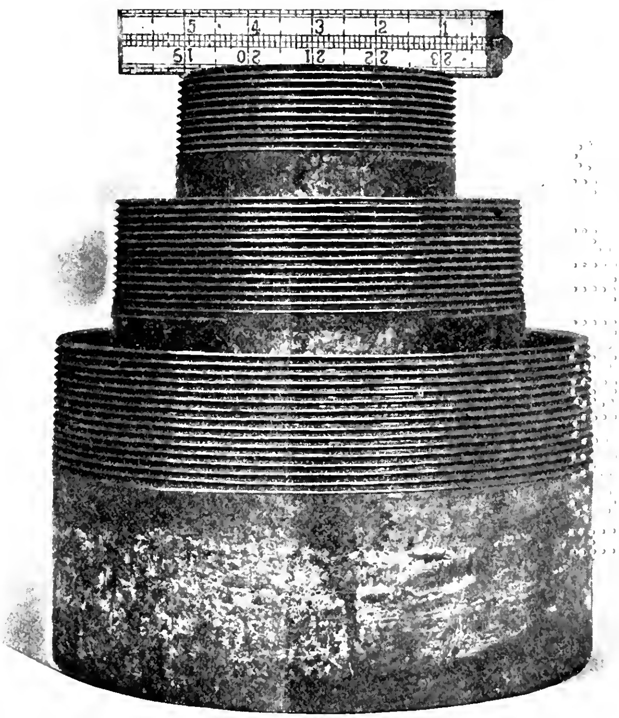

FIG. 1. — FOUR-INCH, SIX-INCH, AND EIGHT-INCH PIPE, WITH STANDARD THREADS.

threads, for two-inch, three-inch, four-inch, five-inch, and six-inch pipe. The dimensions and proportions there shown, having been formally adopted, as we then explained, by the Manufacturers of Wrought Iron Pipe and Boiler Tubes, and also by the Manufacturers' Association of Brass and Iron, Steam, Gas, and Water Work, may be regarded as a national standard, and all pipe that is threaded at the mills of the manufacturers is supposed to be threaded according to this standard.

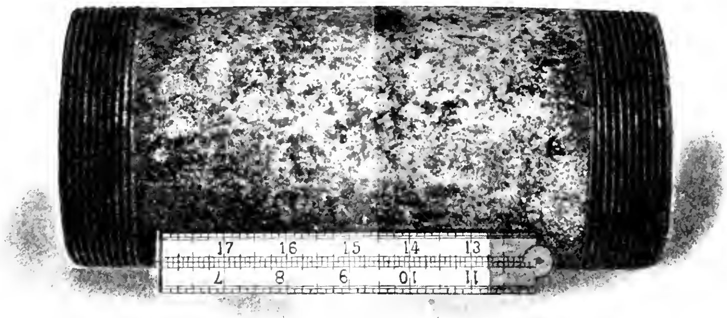

FIG. 2. — FOUR-INCH PIPE, STANDARD AT ONE END AND NOT STANDARD AT THE OTHER.

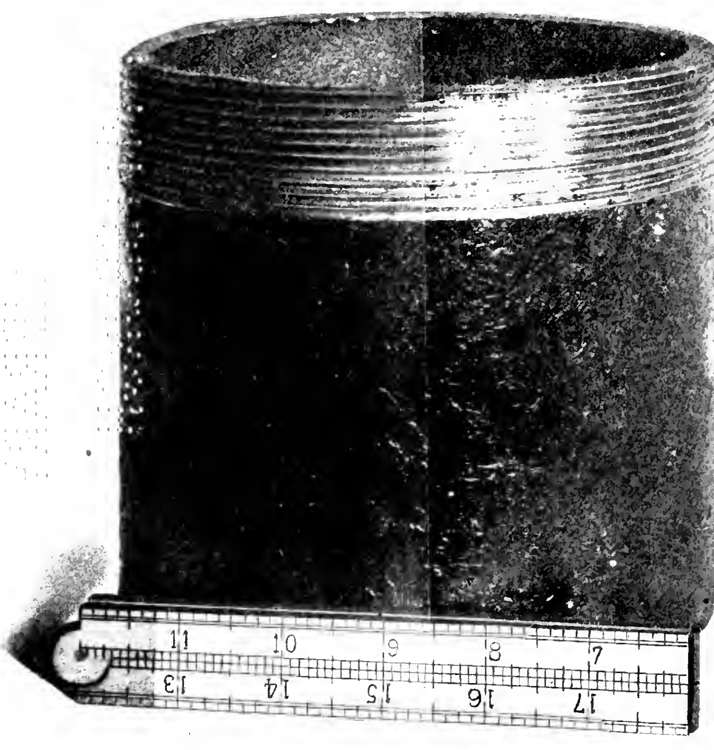

FIG. 3. — SIX-INCH PIPE; THREAD NOT STANDARD.

But in the shops where the pipe is cut into commercial lengths, in installing new systems of piping or in repairing old ones, the standard proportions of thread are not always followed. This, in fact, is but a very mild and temperate way of stating the case; for we often find that the threads that are cut in such shops are so far from the standard of the fittings that they have to enter, that it is impossible to make a good joint in erecting the pipe; and the result is that many lines of pipe that are now running under heavy pressure are in a condition that can be fairly described as positively dangerous. The justice of this statement is abundantly proved by the failures that are constantly occurring at threaded joints; and if further evidence were required, a mere

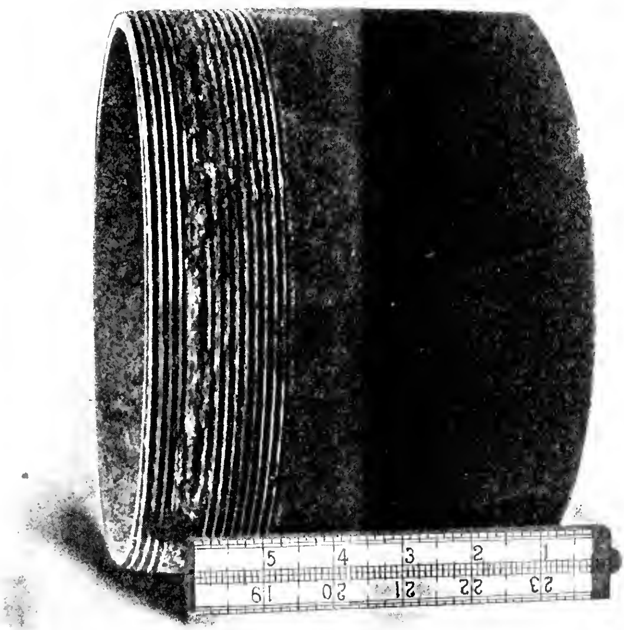

Fig. 4.—Eight-inch Pipe, which could be Made up only Three Threads.

inspection of some of the threads that are to be found on pipes that are being made ready in these shops to go into important work, or that are taken out of such work in the course of repairs, would furnish it abundantly enough to satisfy the most incredulous.

As an example of the kind of thing that may be expected to occur, let us consider a medium size of pipe,—say a four-inch one. The standard calls for eight perfect threads, then two that are perfect at the bottom and slightly flat on the top, and then four that are imperfect on both the top and the bottom; the total length that is scored by the die on the pipe being 1.80″. This is what the standard calls for, as we have said; but when we come to look at the threads that are actually turned out in the shops, we find, not uncommonly, that the total length of thread on a four-inch pipe is only 1.25″, and often this is all the thread there is even on a *six-inch* pipe, where the stand-

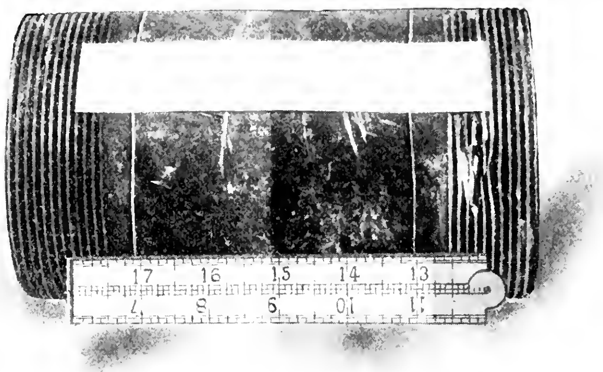


FIG. 5. — FOUR-INCH PIPE; MADE UP ONLY FOUR THREADS AND A HALF ON ONE END.

ard calls for a total length of 2.01″. Now when a pipe is threaded in such a careless manner as that, it cannot possibly be made up into a standard fitting to the full number of threads that are called for in this system, and which are essential in order to secure the requisite strength of the joint; and we regret to say that we are constantly finding pipe connections to boilers made with only two, three, or four threads properly made up. We cannot speak too strongly against such a practice, for it shows an indifference to the safety of life and the security of property that is little short of criminal. There is no excuse for it whatever, for it is easy to tell, upon looking at a pipe before the joint is made up, whether the thread upon it conforms to the standard for that size or not; and

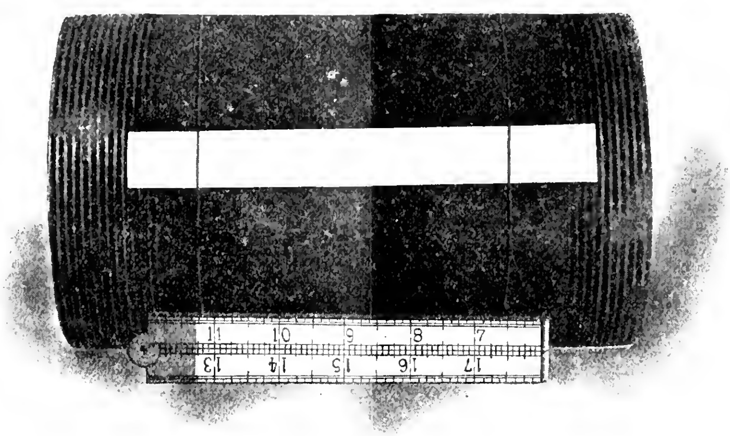


FIG. 6. — FIVE INCH PIPE; STANDARD (OR NEARLY SO) AT ONE END, BUT NOT AT THE OTHER.

no pipe ought to be accepted that does not so conform. If a pipe has been threaded short, and then made up snug against the fitting, it is often difficult to tell, in the finished job, whether it was threaded to standard or not; but the man who puts it in has every chance to inspect it before it is made up, and there can be no excuse whatever for his passing it if it is not right.

In order to illustrate as clearly as possible the points that we are making with regard to piping, we present, herewith, a number of half-tone engravings that were made from photographs, which will show how real are the dangers to which we refer.

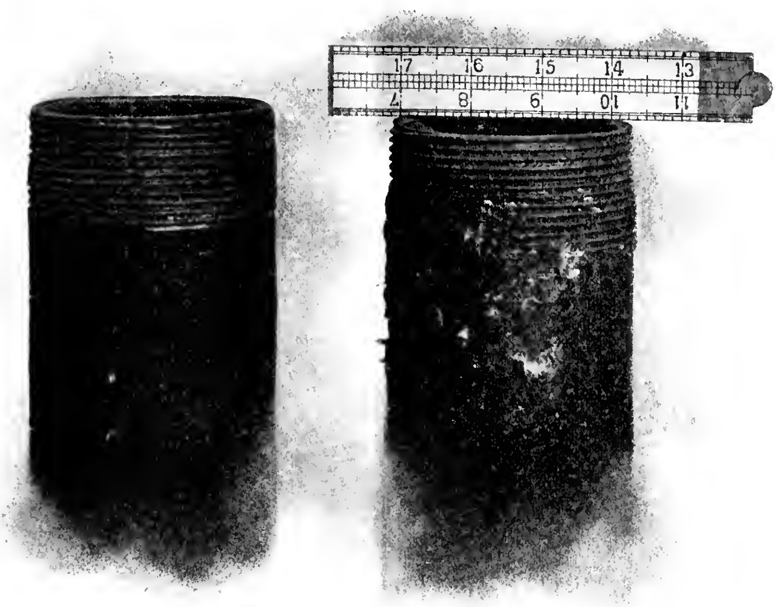

FIG. 7. — THREE-INCH PIPES. (THE ONE ON THE RIGHT COULD BE MADE UP ONLY SIX THREADS. THE OTHER WAS STANDARD, OR NEARLY SO.)

Fig. 1 shows the ends of four-inch, six-inch, and eight-inch pipes, as cut from pipe just received from the mills of the manufacturer. These threads are not absolutely correct, but they are so nearly in conformity with the standard that they would make up all right, and give a good job. They are strictly standard so far as the number and shape of the perfect threads are concerned, and where they depart from the standard they do so only by the omission of a couple of the imperfect threads. The perfect threads, and the two that are slightly flat on top, are correct in each case. We may say that we have not tried to select specimens, for any of these illustrations, that would represent extreme cases, either of conformity to the standard, or of departure from it;

because we have thought that it would be much more useful and instructive to take specimens that would fairly represent what would be found in actual practice.

For comparison with what may be expected from the mills, we present Figs. 2, 3, and 4, which show specimens of four-inch, six-inch, and eight-inch pipe, respectively, as selected at random from shops where the pipe had just been made ready to go into a new job, or had just been taken out from an old one. As will be evident from the engravings themselves, Figs. 2 and 4 represent pipe that has been taken out, and Fig. 3 represents a piece of new pipe that has just been threaded for use. The piece shown in

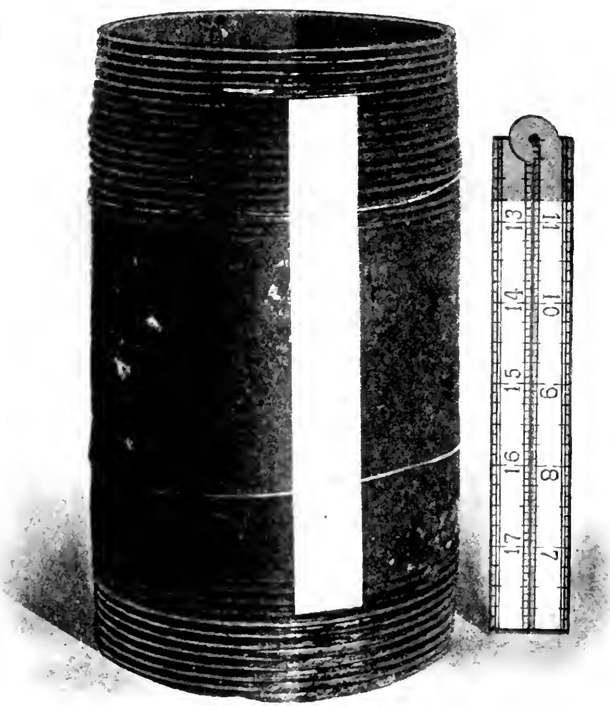

FIG. 8. — FOUR-INCH PIPE. THREAD WITHOUT SUFFICIENT TAPER; MADE UP ONLY FOUR THREADS.

Fig. 2 was threaded correctly on the right-hand end, except that some of the imperfect threads were omitted. Otherwise it was standard, at this end, and would make a good joint. At the left-hand end, however, it was not standard, but was short by several perfect threads. The thread on the piece shown in Fig. 3 was only $1\frac{1}{4}''$ long, over all; whereas the standard, for this size of pipe, calls for a total threaded length of $2.01''$, so that the thread on the actual specimen was fully three-quarters of an inch short. In the specimen shown in Fig. 4, the threads were not clean and sharp, and, moreover, were not of standard shape. In making up this piece of pipe, it had been found impossible to force it into the fitting more than about three threads: and it had been in use, for how long or under what pressure we do not know, with only these three threads to take the entire strain.

Other specimens of piping that have done service, while departing materially from the standard, are shown in Figs. 5, 6, 7, and 8. It is almost impossible to preserve, in a photo-engraving, all the little indications that tell the story, to the eye, of what the

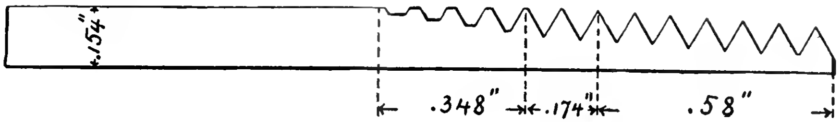


Fig. 9. — Section through a Two-inch Pipe.

pipe is, and how it has been threaded; and to assist the reader somewhat in judging of the character of the threads that we have here shown, we have secured slips of paper to the pipes before photographing them, these slips being so adjusted that their ends show the distance to which the various specimens had been made up into their fittings. The case shown in Fig. 8 is perhaps of special interest, because this pipe was threaded, at its upper end, for a length of $2\frac{1}{4}''$, when the standard only calls for a total length of

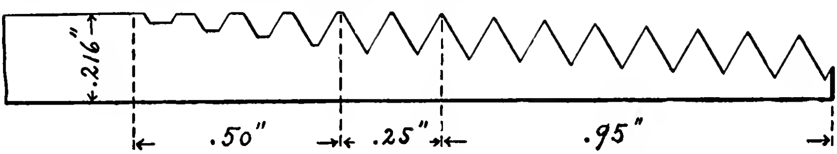


Fig. 10. — Section through a Three-inch Pipe.

thread, over all, of 1.80"; yet, notwithstanding the great length of the thread, it had been found impossible to make the pipe into the fitting to a greater distance than four threads, because the thread was almost perfectly straight, and had hardly any sensible taper, at all.

When the specimens that we have illustrated are examined at first hand, they show almost every kind of a departure from the standard that they are supposed to conform to. Some are threaded too short, some do not have clean threads at all, some have threads that are wrong in shape, and some do not have the proper taper. The fact that the specimens that we have shown and described are not extreme cases in any sense, but

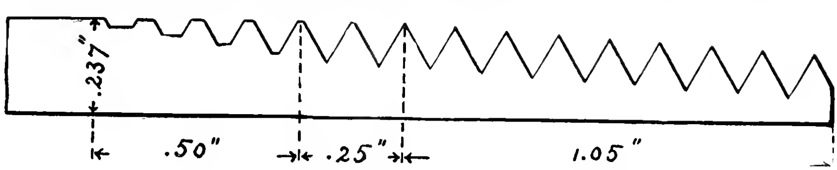


Fig. 11. — Section through a Four-inch Pipe.

were selected almost at random from pipe shops, shows how grave this matter is; and we want to say again, that we can hardly find words strong enough to express our condemnation of pipe work that is done in any such bungling and reckless fashion. Too much care cannot be exercised in making pipe connections, particularly in steam pipe and boiler work, when failure is liable to cause loss of life. There is no reason whatever why a workman cannot determine at once, in fitting up piping, whether or not a joint is properly put together, and whether or not it is of the strength intended for standard fittings and pipe. Some of the specimens here illustrated show evidence that calking has been resorted to, in order to make them tight. This is all wrong, for if the joint is properly made up, calking will not be necessary. Calking to obtain tight work is proof of an imperfect joint.

We reproduce, in addition to the half-tone engravings, the diagrams that were used in our earlier article on this subject, to illustrate the correct proportions of standard threads on several common sizes of pipes.

All pipe that is to be used in steam, water, and gas fitting should be of standard size, standard thickness, and standard thread, and should be round and straight. All fittings should be of heavy gray iron castings, with heavy beads, and with clean, full

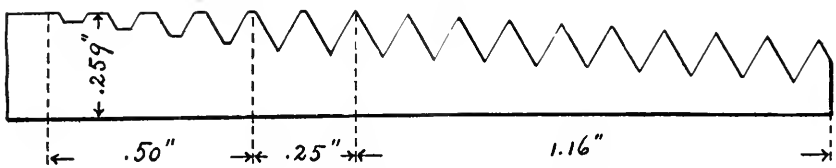


FIG. 12.—SECTION THROUGH A FIVE-INCH PIPE.

threads, tapped to standard gauge; and for high pressure service (100 pounds and over), the fittings should be extra heavy high pressure fittings.

In handling large, heavy pipe, the threads sometimes become bruised so as to prevent the proper making up of the joint; and for this reason the precaution of examining both the fitting and the pipe before making the joint, should never be neglected. In the best practice a thread guard is used in shipping and handling heavy pipe, and we are glad to say that this practice is now followed by a considerable and increasing number of contractors.

Often, in connecting to boilers and tanks, no re-enforcing piece is used; and we have often found that the opening in the shell of a boiler, where the blow-off is re-en-

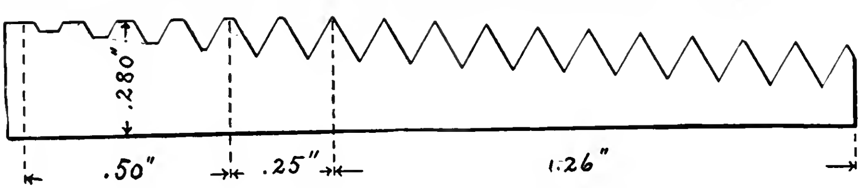


FIG. 13.—SECTION THROUGH A SIX-INCH PIPE.

forced, is cut large, so that only the re-enforcing piece is threaded. This is all wrong. To obtain a proper strength or holding power, both the re-enforcing piece and the shell should be threaded.

In conclusion we desire to say a word about what we consider to be a bad practice among manufacturers of pipe. At the present time, when there are so many pipe attachments to boilers, carrying full boiler pressure and perhaps subjected to an intense heat also, and endangered, often by corrosion, it appears to us just and proper that manufacturers of such pipe should brand their products in the same way that boiler plates are branded, giving the name of the manufacturer, the quality of the material, and the pressure to which the pipe has been tested, as a guarantee of good faith. In the present state of affairs we have to take these things on trust, for there is no certain way of demonstrating from what plant a given sample of pipe came, unless the plant is known within a limited number of places. In this latter case the character of the marks left by the welding clamps will sometimes serve to determine from which plant it came; but it should not be necessary to trust to such an uncertain and often inapplicable method of identifying the source from which it came. There is nothing unreasonable about this suggestion, and we should think that all well-intentioned makers of pipe would be glad to adopt such a plan, in order to protect themselves from unjust suspicion, when an inferior piece of pipe, from some less scrupulous maker, comes to light.

## Dangers of Electrical Roads.

There is a clamor among unthinking persons for the immediate substitution of electricity for steam as a motive power in the tunnel of the New York Central railroad, and on the elevated roads in New York. Now the substitution of electricity for horse power on the surface roads has largely increased the loss of life, and the discomfort of passengers, who are worse crowded than before and thrown about by the sudden starts and jerks of the motive power, and the average time of transit through the crowded city is no better than it used to be. The profit of the change has been to the company and not to the public. The elevated roads have carried more passengers with less loss of life and a nearer approach to rapid transit than any system that New York has had. Boston is establishing elevated roads in place of the noisy and disagreeable underground roads, upon which New York is now spending millions without any assurance of their success. Changes are not always improvements. The following from an English paper illustrates one of the dangers of electrical roads:

"An alarming accident, attended by the loss of six lives, took place at the Dingle Station of the Liverpool Electrical Overhead railway on Monday afternoon. As the train was in the tunnel between the Herculaneum Dock Station and the Dingle terminus — quite close to the latter — one of the motors fused, and set fire to the train, the platform, and a stock of creosoted sleepers, and a second train standing in the tunnel. Unluckily a gale from the westward was blowing at the time through the tunnel, which converted it into a chimney, and though all the passengers but two got safely out of the station, four of the station staff lost their lives while attempting to put out the flames. The gale undoubtedly aggravated the disaster, but none the less the catastrophe has revealed the possibility of a serious danger in connection with railways worked by electricity — a danger, be it noted, inherent in the mode of propulsion, and not due, as in the case of the Abergle disaster, to collision with extraneous inflammable matter."

Mr. George Westinghouse, president of the Westinghouse Electric and Manufacturing Company of Pittsburg, directs attention to this accident and enforces the dangers of electricity, in a letter to the *New York Times* of January 11th, as follows:

"It may prove useful at this moment to direct the attention of the press to certain features incident to the use of electricity for the operation of trains or cars. From the comments which have already been made in regard to the accident which is now uppermost in our minds, it seems to be assumed that such accident would in all probability not have occurred if the colliding trains had been propelled by electricity, and also that the absence of steam would have lessened the risk to the occupants of the telescoped cars. As a matter of fact, with an electrically operated train the risk of accident will, judging by experience, be increased rather than diminished because of the presence of the heavy electrical machinery which it is proposed to attach to several cars of each train. Already there have been many serious collisions with great loss of life between electric cars, while there have been numerous cases in New York and other places in which cars have been quickly destroyed by fires which have resulted from some derangement of the electrical apparatus or circuits, and in some instances so quickly that passengers have had scarcely time to escape to the street.

"It should be borne in mind that the electric energy required to operate a heavy train is sufficient to melt a considerable bar of iron, or to start a dangerous fire, if anything goes wrong upon a car of ordinary combustible construction, much more readily than the car stove, the use of which has been abolished by law. Therefore, if a collision were to occur between two electrically-fitted trains, each having several combustible cars thereof fitted with electrical apparatus and carrying electrical circuits throughout, there could be an accident of so serious a character as to start an agitation having for its purpose the abolition of the use of electricity altogether, or, at least, to compel the railway companies to abandon the use of combustible cars fitted with electric motors.

"The destruction by fire of a car or train upon a street or upon a level is one thing, but such an occurrence upon an elevated railway or in a tunnel can have consequences the contemplation of which should lead to wise regulations governing the construction and use of electrically propelled trains and thereby insure to the public the rapid development of electric traction."

The directors of the New York Central railroad should not be influenced by popular clamor to make changes which are simply experimental, and which may involve even greater horrors than have yet been endured in connection with rapid and frequent travel. — *New York Observer.*

## "Also a Pig."

Under the heading of profit and loss in the Standard Oil Company's books there is an entry "1 bulldog," followed by some details. The dog is catalogued on the loss side of the balance. It is said that he is the only dog ever owned by that powerful combination, and after its experience with him the company is not likely to invest in any more of his kind. He became a Standard Oil dog in this way:

One of the company's stations near Charleston, W. Va., had suffered the loss of many empty barrels from the depredation of thieves, who found them useful as firewood. After trying in vain to capture or get a shot at the thieves, Blake Stewart, who had charge of the office, sent a requisition to the division office in Baltimore for one large and savage bulldog. In the course of time, after some fluctuations of red tape, the division office notified Mr. Stewart that it possessed no facilities for the purchase or manipulation of savage bulldogs, but that if he thought he could obtain one locally, of a sufficient degree of ferocity, for $10, that sum was at his disposal. Two days later a negro delivered to Mr. Stewart a brindle bulldog chained to the end of a pole. The negro explained to Mr. Stewart that the reason he used the pole instead of a rope was that its stiffness was of advantage in keeping the beast at a proper and respectful distance. The dog was duly established in the barrel yard, and went on record as an employee of the Standard Oil Company, with an allowance for maintenance.

The office force then set about making the acquaintance of the new acquisition. Mr. Stewart conducted his advances from the top of a shed, which, being an agile and athletic person, he had gained just before the dog got to him.

The head clerk tried the power of his hypnotic eye on the beast, and, though normally a dignified and slow-moving person, he cleared the fence by a vault that was the admiration of all beholders. Several other employees tried to establish friendly relations, and those that got away intact were the lucky ones.

They named the dog Fury, and employed a trainer from Charleston to come down and train him. Three minutes after his introduction to Fury the trainer gave up his job, together with a considerable portion of his raiment, and went home. Thereafter Fury ruled the roost. There were no more barrels stolen, for his reputation went abroad in the land; but there were other difficulties. When a stock of barrels was acquired, however, it took the major part of the office force, armed with clubs, to drive Fury to cover while the workmen got the stock out.

In the course of time Fury became a little more peaceable and would allow a few favored acquaintances around the place; but no stranger ever got so much as one foot inside the inclosure without hastening to take it out again before the dog could fasten to it. Fury earned his salary.

One day a wandering pig came nosing around the inclosure, found a loose place in the fence, and made his way in. Now the West Virginian breed of pig is not the fat, lazy, and inert porker of the farmyard. He is a lean, razor-backed, sinewy animal who has had to make his own way in the world for so long that he is thoroughly equipped to take care of himself. The only thing he considers it worth while to get out of the way of is a railroad train, and he sometimes contests the right of way with that, under which circumstances both train and pig commonly leave the track together. Either Fury didn't understand the nature of the invader, or his lordly career had puffed him up with an undue sense of his own abilities. With a snarl of concentrated rage he made for the trespasser, and launched his powerful body like a thunderbolt straight at piggy's throat.

There was a wild clamor of grunts, squeals, growls, and howls that brought Mr. Stewart and the rest out in haste. All they could see was a mad whirl of dust and writhing bodies. Then a streak emerged from the whirl. It was Fury. Away he went, yelling murder at every leap, and the pig after him. After two circuits of the yard, Fury noted the hole in the fence, and with a yelp of mingled joy and shame started through it. It was more of a squeeze for piggy, but he got through, too. There was no doubt about his intentions; he meant murder. Fury realized it. He took to the railroad track and headed eastward. When the curve, half a mile up the road, hid him from view, the pursuer was running head down and tail up, with a vigor which suggested that obstinacy of pursuit for which his kind is proverbial.

At the Standard Oil office they waited until closing time, expecting to gloat over the return of a chastened and drooping Fury. But he came not; neither that day nor the next, nor the next. Then Mr. Stewart, following his instructions to notify the company of any loss of property, wired the division office at Baltimore as follows:

"Company's bulldog last seen headed for Baltimore. Look out for him. Details follow; also a pig."

The office got the details later, by mail; but they haven't yet seen the bulldog or the pig.— *New York Sun.*

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The article on page 9 of this issue, entitled "Dangers of Electrical Roads," was inspired by the recent horror in the tunnel of the New York Central & Hudson River railroad, in New York city. We are inclined to think that most persons who have had experience with New York's horse cars and also with her electric cars will feel that the case against the electric cars is put too strongly. We think few would prefer to return to horses. Yet there is much sense in the article, and Mr. Westinghouse's words are specially worthy of attention, as he is an authority on safety in railway travel.

# The Locomotive.

HARTFORD, JANUARY 15, 1902.

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

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## Boiler Explosions.

OCTOBER, 1901.

(289.) — The boiler of a threshing machine outfit exploded, on September 13th, at Colfax, Wash. Charles W. Rich was killed. [This account was received too late for insertion in the regular September list.]

(290.) — On October 1st the boiler of a traction engine exploded on the White farm, at Fleming, some six miles south of Auburn, N. Y. Charles White was instantly killed, and his brother, Edward White, was injured so badly that it was thought that he could not recover. Later advices, however, indicate that his injuries were not fatal.

(291.) — On October 1st a boiler exploded at the Nickel Plate mine of the Brazil Coal Company, at Ehrmanndale, near Terre Haute, Ind. The air was filled with bricks, timbers, and fragments of the boiler, yet nobody was injured, although a number of men were standing about the shaft at the time. We have seen no estimate of the property loss, but it is said that it will amount to several thousand dollars.

(292.) — The boiler of a cotton gin exploded, on October 3d, on Luster Babb's plantation, near Laurens, S. C. Stewart Babb was hurt so badly that he died soon afterwards. W. C. Deck, Luster Babb, Guy Babb, William Boland, Thomas Boland, and Henry Meekins were also injured to a lesser extent.

(293.) — A boiler exploded, on October 4th, on the tug-boat *Elmer Wood*, at New Orleans, La. William E. White, Andrew Brown, Samuel Bland, and John Marsh were seriously injured, but it is believed that all will recover. It is said that the damage to the tug will amount to several thousand dollars.

(294.) — On October 5th a boiler used for steaming oysters exploded in the oyster house of James Stevens, at Georgetown, D. C. Charles H. Dove and Mrs. Mary Stevens and her two children, Fred and Helen, were seriously injured.

(295.) — On October 6th the boiler of a threshing machine outfit exploded at Brampton, near Forman, N. D. Edward Ashley, who was one of the owners of the machine and also its engineer, was struck in the head by a piece of iron, and instantly killed. Three other men were fatally injured, and several received minor injuries.

(296.) — A boiler exploded, on October 7th, in Rickert's rice mill, New Orleans, La. John Hausch, Martin Trier, and Emile Pfeffer were severely scalded and bruised. It is said that the explosion consisted in the safety-valve blowing bodily off of the boiler.

(297.) — A boiler exploded, on October 8th, in R. S. Myers' sawmill, on the Sunflower river, near Rolling Fork, Miss. Mr. R. E. Maxwell and one other man, whose name we have not learned, were killed, and several other persons were injured. The mill was wrecked.

(298.) — On October 9th a boiler exploded in Davis & Couch's laundry, at Italy, Tex. Claude Powell, Clyde Wolaver, Thomas Robinson, and William Davis were severely injured, and it is doubtful if Powell can recover. The laundry was a new one, and the boiler had just been fired up to test the machinery.

(299.) — On October 9th a boiler exploded in the Hays Manufacturing Company's plant, in the rear of the Hotel Liebel, at Erie, Pa. Nobody was killed, but Ella Dolan, Frances Levenduski, Annie Schimagua, May Bentley, John Davidson, and Charles Whandon were injured. A three-story brass foundry, a three-story annex to the Hotel Liebel, a warehouse belonging to a hardware store, and the café of the hotel were totally demolished, and the property loss was in the neighborhood of $30,000. (An illustrated account of this explosion was given in the issue of The Locomotive for October, 1901.)

(300.) — A boiler exploded, on October 10th, at Inez, Ky. Brown Salmons was killed, and four other men, whose names we have not learned, were injured.

(301.) — A boiler exploded in the Lone Star Salt Company's plant, at Grand Saline, Tex., on October 10th. Fireman Edward Clay was killed, and J. W. Wilson, John Smith, and William Price were severely injured. Parts of the boiler were thrown several hundred feet. The property loss will amount to several thousand dollars, according to the accounts that we have received.

(302.) — On October 10th a boiler exploded at the New Pittsburg Coal Company's plant, at Blatchford, near New Pittsburg, Ohio. Fireman Luke Hamilton was killed, and several other men were injured.

(303.) — A boiler exploded, on October 10th, in Rennie Butterworth & Co.'s sawmill, at Dewitt, Va. Albert G. Smith was killed, and Norman Smith, Norman Wright, and several other men were injured. The mill was wrecked, and the property loss was large.

(304.) — An explosion occured, on October 11th, in the boiler room of the Howe factory, at Peru, Ind., scalding A. B. Ulrich fatally, and badly injuring Joseph Kyle and W. H. Folger. We have not learned the exact nature of the explosion, except that it consisted in the failure of some part of the boiler.

(305.) — On October 12th a boiler exploded at Grand Junction, Colo. Nobody was injured, although the engineer had a very narrow escape. The boiler belonged to Samuel Cox.

(306.) — A terrible boiler explosion occurred, on October 13th, in the plant of the Detroit Copper Company, at Clifton, Ariz. W. W. Hogan and F. A. Adamitz were instantly killed, and Harry Davidson, José Antiveras, and several other men were severely injured. The smelting plant of the Detroit Company is one of the largest in Arizona.

(307.) — On October 14th the boiler of a locomotive on the Mexican International Railroad exploded at Sabinas, near Eagle Pass, Tex. The engineer, the fireman, and a little girl, daughter of the pumper at Aure, were killed.

(308.) — The boiler of Frank Mattechek's threshing outfit exploded, on October 18th, at Webster, S. D., badly wrecking the outfit. It fortuately happened that none of the crew was in the immediate vicinity of the machine at the time, so that no one was injured.

(309.) — On October 19th a boiler used in making chewing gum exploded in the Novelty Candy Company's works, on Grant Street, Pittsburg, Pa. Vincenzo Canduni was injured so badly that he died two hours later. We have not learned further particulars.

(310.) — On October 21st the boiler of Isaac Jennings' portable sawmill exploded near Berea, Ohio. Charles Weeder was killed, and Edwin Irving was fatally injured. John Seebold, William Simmons, and one other man, whose name we do not know, were also injured to a lesser extent.

(311.) — On October 21st a boiler exploded on the Elk lease, at Spurgeon, some fourteen miles south of Joplin, Mo. Lewis Oliver, Milton Oliver, and Herbert Hays were severely injured, and at last accounts one of the men was not expected to recover. The boiler room was completely wrecked.

(312.) — On October 21st the boiler of a threshing-machine outfit exploded between Clyde and Lockport, N. Y. Frank Lee was instantly killed. One report states that "the crown sheet of the engine fell into the fire pot, causing an explosion."

(313.) — A boiler exploded, on October 22nd, at Whitehouse, near Ashland, Ky. A man named Simmons was injured so badly that he died two days later. Several other persons were about the mill, but none of them was hurt. The boiler belonged to Mr. Newton Music.

(314.) — On October 21st a boiler exploded in the Fleetwood-Jackson Lumber Company's mill, at Hertford, N. C. Three men were injured, and the property loss was probably $5,000. Most of the estimates that we have seen place it at $20,000, but we are of the opinion that $5,000 is nearer to the truth.

(315.) — Mr. W. H. Wofford was instantly killed, on October 24th, by the explosion of a boiler in Mr. E. S. Smith's cotton gin, at Glenn Springs, near Spartanburg, S. C. We have seen no estimate of the property loss.

(316.) — On October 24th the boiler of locomotive No. 710, on the Wabash Railroad, exploded two miles north of Boody, Ill. Thomas Evers and Thomas Holland were killed; Engineer F. M. Donnelly was injured. (George Anthony, a tramp, had his leg blown off; ut as the leg was a wooden one, we do not count this an injury!)

(317.) — On October 24th a boiler exploded at the Carrie furnaces of the Carnegie Steel Company, at Rankin, Pa. Michael McAllister and two other men, whose names we do not know, were very badly injured, and Harry Elby received minor injuries. It is said that the loss to the Carnegie Steel Company, on buildings and machinery, and on damage to the furnace, amounted to something like $100,000.

(318.) — A boiler exploded, on October 25th, in George W. Bragg's grist mill, at Laurel Creek, near Hinton, W. Va. Mr. Bragg was the only person who was injured. He was severely scalded by escaping steam.

(319.) — On October 26th a boiler exploded in Andrew Meadows' stave mill, at Mahan Station, near Williamsburg, Ky. Frank Meadows was killed, and James Meadows was fatally injured.

(320.) — A boiler exploded, on October 28th, in John Sewell's sawmill, about seven miles south of Texarkana, Tex. Engineer W. P. Martin was instantly killed, and J. H. Sewell (the owner of the mill), Columbus Nolan, and Flippin McKeehan were seriously injured, and it is feared that Sewell may die. The boiler was thrown to a distance of 300 feet, and the mill was destroyed.

(321.) — A boiler exploded, on October 28th, at King's cider mill, at Pittsford, near Rochester, N. Y. George Snyder was seriously injured.

(322.) — On October 29th a boiler exploded in James Gillis' sawmill at Neva, nine miles north of Antigo, Wis. The fireman was scalded.

(323.) — A boiler exploded, on October 29th, in the Atkinson Cistern Company's plant at Toledo, Ohio. C. H. Atkinson was scalded and burned so badly that he died later in the day.

(324.) — The crown sheet of locomotive No. 171, on the Illinois Central Railroad, blew down, on October 29th, at Chicago, Ill. Engineer John Normile and Fireman James S. Marlowe were thrown from the cab and badly scalded and bruised. It is thought probable that both men will die.

(325.) — On October 30th a safety boiler exploded in the Baldwin Locomotive Works, at Philadelphia, Pa. Edward Gaughan and Frank Colvin were instantly killed, and James Dawson was injured so badly that he afterwards died.

(326.) — On October 30th a boiler exploded near Elyria, Ohio. One man was killed, and another injured. We have not been able to learn further particulars of this explosion.

(327.) — A boiler exploded, on October 31st, in Leiper's quarry, at Leiperville, near Chester, Pa. A large section of the boiler was thrown into Fields Bros.' brick yard a quarter of a mile away, striking a bench at which twenty men had just been at work. A boy saw the huge projectile, apparently dropping from the sky, and uttered a cry of warning, at which the men scattered, just in time to escape being struck. It was thought, for a few moments, that a meteor had fallen.

(328.) — A heating boiler exploded, on October 31st, in the basement of the Homer block, at Helena, Mont. No great damage was done.

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An important feature of the steam turbine, not always considered, is the freedom from great or sudden angular variations in speed. This defect in reciprocating engines is of constantly increasing importance. With its high rotative speed and entire absence of reciprocating parts, it is practically impossible for any appreciable variation in speed to occur in the course of a single revolution of the turbine, the speed changes necessarily extending over a number of revolutions, and being gradual in their nature; while, with the use of properly-designed governors, even these gradual variations in speed may be kept within very narrow limits.

A modern "turbo" plant of 1,500 kilowatt capacity will stand on a floor space of 728 square feet, and will have its own condensing plant at that. No foundations are needed for its reception, and no oil is necessary for the lubrication of the rotating parts that are acted on by steam. In both these items it will be seen, at once, that large economies will be effected. The absence of oil in the steam does away with one of the great sources of trouble that ordinarily have to be carefully guarded against, in using the water of condensation in the boilers again. The machine, when delivered, can be assembled on its particular portion of the engine room floor, and no vibration will take place while the plant is in motion. The appearance of the engine room will also be greatly improved, because the "turbo" sets occupy little head room, and consequently will cut off little or no light from the windows. The small vertical space needed also does much to decrease the cost of buildings, as well as the steam and exhaust piping.

That the early types of turbine were extravagant in steam is well known; but this fault was due to the comparative scarcity of data in the design of such engines, as well as to the fact that very small units were required for electric supply purposes. — *The Engineering Magazine.*

# The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XXIII. HARTFORD, CONN., FEBRUARY, 1902. No. 2.


## The Standardization of Flanges.

It used to be the custom, to a certain extent, among manufacturers of machines and other mechanical articles, for each maker to have a "standard" of his own for every part entering into the construction of the thing he sold. This was not altogether because no concerted action had been taken to secure the adoption of a universal standard; for many manufacturers deliberately departed from sizes that had become almost universal, for the express purpose of obliging the purchaser to buy, from the original maker, any parts, however simple, that might be required in making repairs. This was carried to such an extreme that in some cases the manufacturers even adopted odd threads on the machine screws that they used.

All this has practically passed away, now, in the United States, for it has been recognized that one of the strongest arguments that can be offered to a prospective purchaser is that if he needs repairs, he can buy the necessary supplies anywhere, and so be saved the delay that is involved in sending to the original maker for them. In conformity with this principle, the tendency has been towards the universal standardization of everything that can be so standardized.

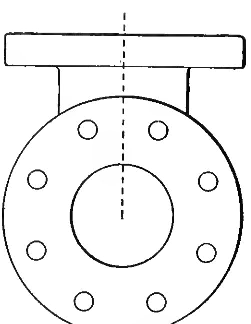
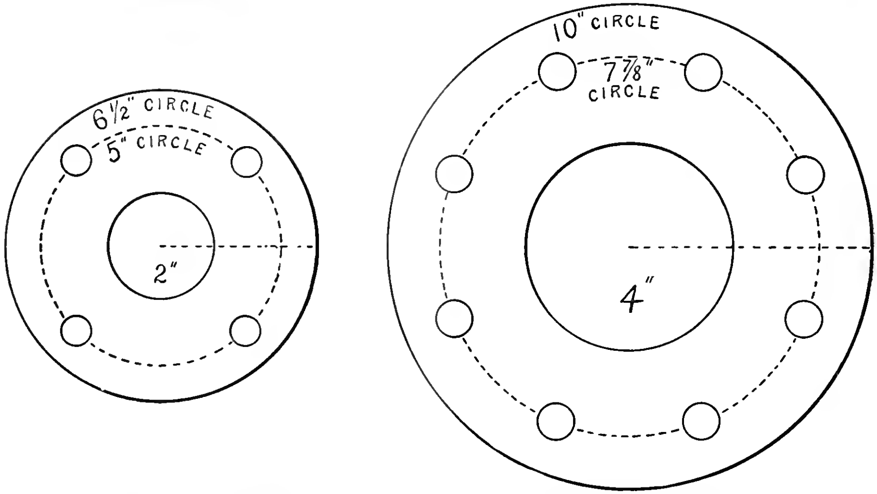


FIG. 1. — ILLUSTRATING THE "VERTICAL AXIS."

Of course a manufacturer of engines or other large machines cannot be expected to carry a stock of parts of other makers' engines, and standardization cannot be attempted in such cases as this; but where the thing in question is of the nature of a general commodity, like boiler tubes, sheet metal, and piping, that are carried in stock by dealers everywhere, the argument in favor of a universal standard is overwhelming.

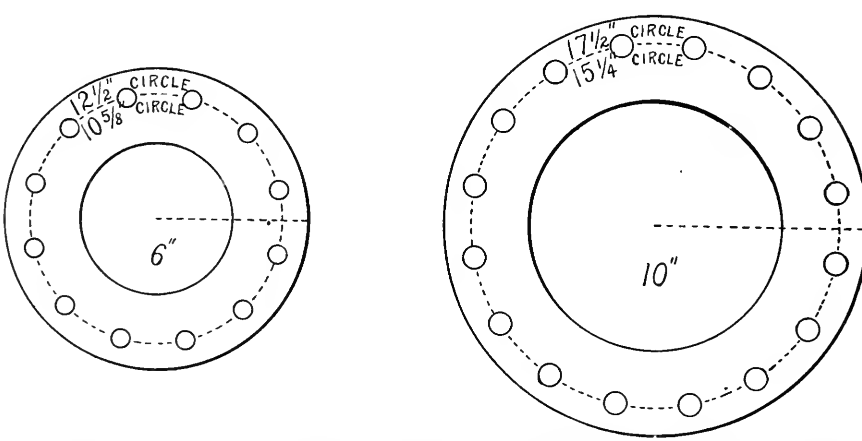
Piping for steam, hot water, and gas was standardized some fifteen years ago, as were also pipe threads and fittings; but no concerted attempt was made to standardize flanges until quite recently. On July 18, 1894, committees of the Master Steam and Hot Water Fitters' Association and of the American Society of Mechanical Engineers, and representatives of the leading valve and fitting manufacturers of the United States adopted a schedule of standard flanges, which is given in Table I, but although, as has been said, this schedule was adopted in 1894, yet only about five valve and fitting manufacturers had put it into force up to the year 1900, at which date the number of manufacturers using it increased to twelve. Today, most of the manufacturers of valves and fittings are using the schedule given in Table I for their standard work.

Up to a dozen years ago, or so, pressures exceeding 100 or 125 pounds per square inch were not at all common in engineering practice; but since that time the tendency has




FIGS. 2 AND 3. — EXTRA HEAVY FLANGES FOR TWO-INCH AND FOUR-INCH PIPES. (ONE-FOURTH ACTUAL SIZE.)

been continuously in the direction of higher pressures, until now they range as high as 200 or 250 pounds. To handle these high pressures safely, extra heavy pipe and fittings are necessary; and the flanges described in Table I can no longer be used. It has therefore become desirable to adopt a second standard for these extra heavy flanges; and the manufacturers of valves and fittings, appreciating these facts, appointed delegates to a convention which was held in New York City in June, 1901. The subject of extra heavy flanges was there threshed out at considerable length, and after each size had been carefully considered, the dimensions given in Table II were adopted for extra heavy work. This new schedule, for extra heavy flanges, was adopted on June 28, 1901, and went into effect on January 1, 1902. The manufacturers who have adopted this standard




FIGS. 4 AND 5. — EXTRA HEAVY FLANGES FOR SIX-INCH AND TEN-INCH PIPES. (ONE-EIGHTH ACTUAL SIZE.)

represent upwards of 95 per cent. of all the valves and fittings and flanges that are made in the United States. This gives the standard a truly national character, and makes its ultimate universal adoption certain, because the other manufacturers will eventually be forced to conform to it. Indeed, several have already expressed their readiness to furnish flanges to this standard, when desired to do so by their customers.

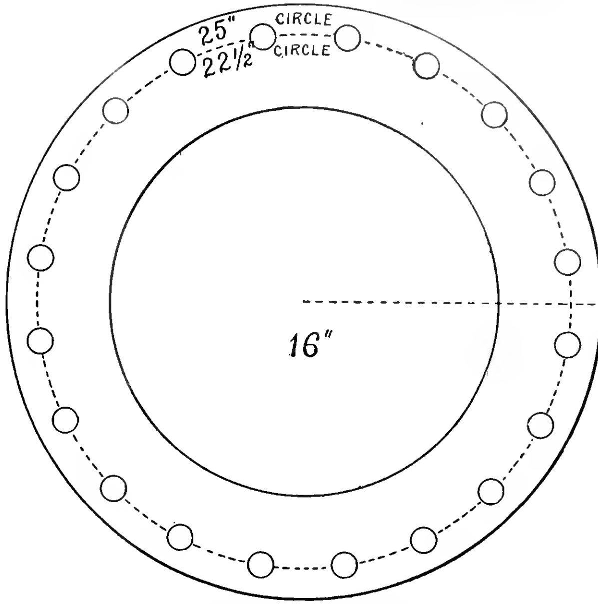
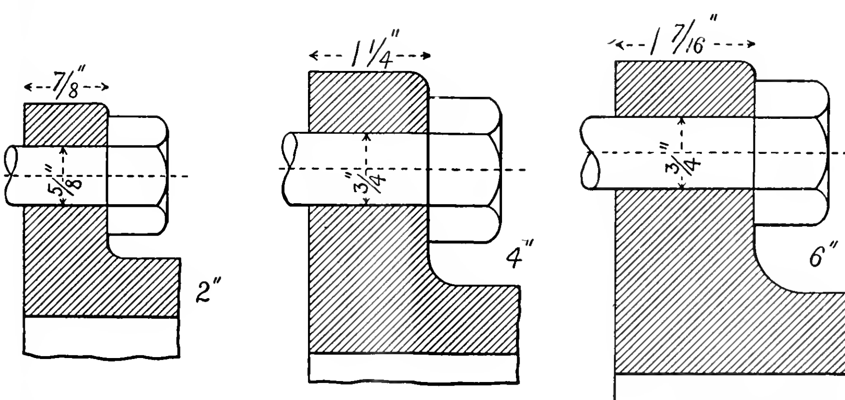



Fig. 6. — Extra Heavy Flange for Sixteen-Inch Pipe. (One-Eighth Actual Size.)

A few words may be added, with regard to the tables. The flanges are all drilled, it will be seen, in multiples of four; so that the number of bolts is either 4, 8, 12, 16, 20, 24, or 28, in every case. In the accompanying diagrams we have shown flanges for two-inch, four-inch, six-inch, ten-inch, and sixteen-inch pipes, to illustrate this feature of the arrangement of the bolts. In Fig. 2 the words "6½" circle" relate to the outside diameter of the flange, while the words "5" circle" refer to the bolt circle; and the corresponding inscriptions on the other diagrams are to be understood in the same way.

One of the most important features of these standards (both for ordinary flanges and for the extra heavy ones) is, that the bolt holes must "straddle the vertical axis." All




Figs. 7, 8, and 9. — Sections of Extra Heavy Flanges. (One-Half Actual Size.)

TABLE I. — SCHEDULE OF STANDARD FLANGES.

(Adopted, July 18, 1894.)

| | Pipe size. | Diameter of flange. | Diameter of bolt circle. | Number of bolts. | Diameter of bolts. Pressure under 80 lbs. | Diameter of bolts. Pressure 80 lbs. or over | Length of bolts (under head). | Flange thickness at hub for iron pipe. | Flange thickness at edge. | Width of flange face. |
|---|---|---|---|---|---|---|---|---|---|---|
| Inside diameter of pipe | 2″ | 6″ | $4\frac{3}{4}$″ | 4 | $\frac{1}{2}$″ | $\frac{5}{8}$″ | 2″ | 1″ | $\frac{5}{8}$″ | 2″ |
| | $2\frac{1}{2}$ | 7 | $5\frac{1}{2}$ | 4 | $\frac{1}{2}$ | $\frac{5}{8}$ | $2\frac{1}{4}$ | $1\frac{1}{8}$ | $\frac{11}{16}$ | $2\frac{1}{4}$ |
| | 3 | $7\frac{1}{2}$ | 6 | 4 | $\frac{1}{2}$ | $\frac{5}{8}$ | $2\frac{1}{2}$ | $1\frac{1}{4}$ | $\frac{3}{4}$ | $2\frac{1}{4}$ |
| | $3\frac{1}{2}$ | $8\frac{1}{2}$ | 7 | 4 | $\frac{1}{2}$ | $\frac{5}{8}$ | $2\frac{1}{2}$ | $1\frac{1}{4}$ | $\frac{13}{16}$ | $2\frac{1}{2}$ |
| | 4 | 9 | $7\frac{1}{2}$ | 4 | $\frac{5}{8}$ | $\frac{3}{4}$ | $2\frac{3}{4}$ | $1\frac{3}{8}$ | $\frac{15}{16}$ | $2\frac{1}{2}$ |
| | $4\frac{1}{2}$ | $9\frac{3}{4}$ | $7\frac{3}{4}$ | 8 | $\frac{5}{8}$ | $\frac{3}{4}$ | 3 | $1\frac{3}{8}$ | $\frac{15}{16}$ | $2\frac{3}{8}$ |
| | 5 | 10 | $8\frac{1}{2}$ | 8 | $\frac{5}{8}$ | $\frac{3}{4}$ | 3 | $1\frac{1}{2}$ | $\frac{15}{16}$ | $2\frac{1}{2}$ |
| | 6 | 11 | $9\frac{1}{2}$ | 8 | $\frac{5}{8}$ | $\frac{3}{4}$ | 3 | $1\frac{1}{2}$ | 1 | $2\frac{1}{2}$ |
| | 7 | $12\frac{1}{2}$ | $10\frac{3}{4}$ | 8 | $\frac{5}{8}$ | $\frac{3}{4}$ | $3\frac{1}{4}$ | $1\frac{1}{2}$ | $1\frac{1}{16}$ | $2\frac{3}{4}$ |
| | 8 | $13\frac{1}{2}$ | $11\frac{3}{4}$ | 8 | $\frac{5}{8}$ | $\frac{3}{4}$ | $3\frac{1}{2}$ | $1\frac{3}{4}$ | $1\frac{1}{8}$ | $2\frac{3}{4}$ |
| | 9 | 15 | $13\frac{1}{4}$ | 12 | $\frac{5}{8}$ | $\frac{3}{4}$ | $3\frac{1}{2}$ | $1\frac{3}{4}$ | $1\frac{1}{8}$ | 3 |
| | 10 | 16 | $14\frac{1}{4}$ | 12 | $\frac{3}{4}$ | $\frac{7}{8}$ | $3\frac{5}{8}$ | 2 | $1\frac{3}{16}$ | 3 |
| | 12 | 19 | 17 | 12 | $\frac{3}{4}$ | $\frac{7}{8}$ | $3\frac{3}{4}$ | 2 | $1\frac{1}{4}$ | $3\frac{1}{2}$ |
| Outside diameter. | 14 | 21 | $18\frac{3}{4}$ | 12 | $\frac{7}{8}$ | 1 | $4\frac{1}{4}$ | 2 | $1\frac{3}{8}$ | $3\frac{1}{2}$ |
| | 15 | $22\frac{1}{4}$ | 20 | 16 | $\frac{7}{8}$ | 1 | $4\frac{1}{4}$ | 2 | $1\frac{3}{8}$ | $3\frac{5}{8}$ |
| | 16 | $23\frac{1}{2}$ | $21\frac{1}{4}$ | 16 | $\frac{7}{8}$ | 1 | $4\frac{1}{4}$ | $2\frac{1}{4}$ | $1\frac{7}{16}$ | $3\frac{3}{4}$ |
| | 18 | 25 | $22\frac{3}{4}$ | 16 | 1 | $1\frac{1}{8}$ | $4\frac{3}{4}$ | .. | $1\frac{9}{16}$ | $3\frac{1}{2}$ |
| | 20 | $27\frac{1}{2}$ | 25 | 20 | 1 | $1\frac{1}{8}$ | 5 | .. | $1\frac{11}{16}$ | $3\frac{3}{4}$ |

Drilling should straddle vertical axis.

pipers will know what this phrase means, but it will be well to explain it at some length, in order to avoid any misunderstanding. In Fig. 1, which represents an elbow, the dotted line shows what is known as the "vertical axis"; and it was the intention of the committee to recommend that in assembling pipe, the flanges are to be so arranged that the vertical line through the center of the flange shall pass half way between the two nearest bolt holes, as shown. This is recommended in all cases, as it is considered to be the best practice. It is not as important, however, when the flanges merely serve as a union, to join two lengths of straight pipe, as it is when elbows, tees, and other fittings are concerned. In all such cases, the bolt holes are made to "straddle" the axis of the fitting, as is shown by the dotted line in Fig. 1. It happens that the "vertical axis" and the "axis of the fitting" are one and the same thing in Fig. 1; but if this elbow turned horizontally instead of upwards, the "axis of the fitting" would then be horizontal, while the "vertical axis" would, of course, be the vertical line through the center of the flange; so that in the new position of the elbow, the "vertical axis" and the "axis of the fitting" would be at right angles to each other. Each of these two axes would still be "straddled" by the bolt holes, however, because all the holes are drilled in multiples of four. One object of the committee's recommendation is to ensure the easy insertion of the bolts, on tees, elbows, and valves. The idea of the bolt holes straddling the axis is suggested in the other diagrams by radial dotted lines.

TABLE II. — STANDARD OF FLANGES FOR EXTRA HEAVY IRON PIPE, FITTINGS, AND VALVES.

(Adopted, June 28, 1901; in force, January 1, 1902.)

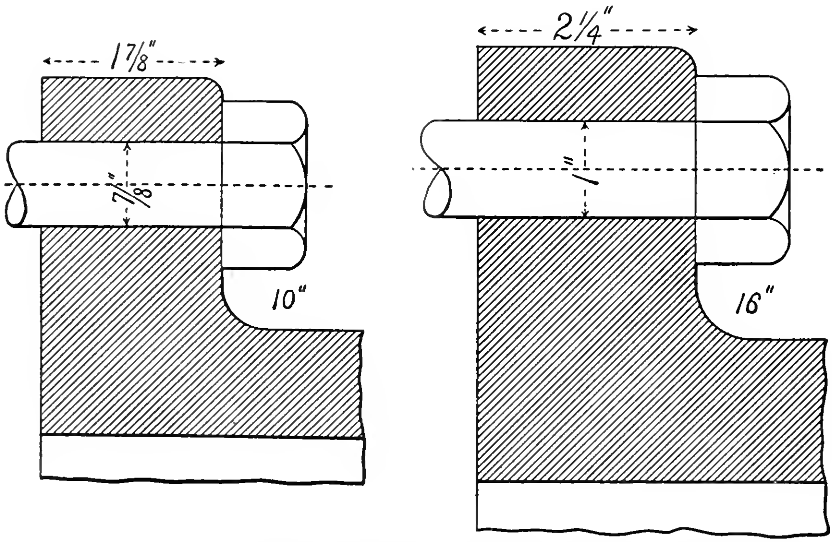
| | Pipe size. | Diameter of flange. | Thickness of flange. | Diameter of bolt circle. | Number of bolts. | Diameter of bolts. |
|---|---|---|---|---|---|---|
| Inside diameter of pipe. | 2″ | 6½″ | ⅞″ | 5″ | 4 | ⅝″ |
| | 2½ | 7½ | 1 | 5¾ | 4 | ¾ |
| | 3 | 8¼ | 1⅛ | 6⅝ | 8 | ⅝ |
| | 3½ | 9 | 1 3/16 | 7¼ | 8 | ⅝ |
| | 4 | 10 | 1¼ | 7⅞ | 8 | ¾ |
| | 4½ | 10½ | 1 5/16 | 8½ | 8 | ¾ |
| | 5 | 11 | 1⅜ | 9¼ | 8 | ¾ |
| | 6 | 12½ | 1 7/16 | 10⅝ | 12 | ¾ |
| | 7 | 14 | 1½ | 11⅞ | 12 | ⅞ |
| | 8 | 15 | 1⅝ | 13 | 12 | ⅞ |
| | 9 | 16 | 1¾ | 14 | 12 | ⅞ |
| | 10 | 17½ | 1⅞ | 15¼ | 16 | ⅞ |
| | 12 | 20 | 2 | 17¾ | 16 | ⅞ |
| Outside diameter. | 14 | 22½ | 2⅛ | 20 | 20 | ⅞ |
| | 15 | 23½ | 2 3/16 | 21 | 20 | 1 |
| | 16 | 25 | 2¼ | 22½ | 20 | 1 |
| | 18 | 27 | 2⅜ | 24½ | 24 | 1 |
| | 20 | 29½ | 2½ | 26¾ | 24 | 1⅛ |
| | 22 | 31½ | 2⅝ | 28¾ | 28 | 1⅛ |
| | 24 | 34 | 2¾ | 31¼ | 28 | 1⅛ |

Drilling should straddle vertical axis.

The bolt-circle diameters given in Table II will allow the use of a calking recess on pipe flanges, when it is desired to use this device.

In Figs. 7 to 11, inclusive, we present sectional views of the flanges that are shown in the preceding diagrams. These sectional views hardly call for any description, as their significance will be evident.

Attention should be directed to the fact that the pipe sizes from 2″ to 12″ inclusive, are based on the *inside* diameter of the pipe, while those from 14″ up are based on the outside diameter of the pipe. Pipe of ordinary weight, for steam, hot water, and gas, is supposed to be made to a standard that is fully explained in the issue of THE LOCOMOTIVE for September, 1896. In this standard, the actual dimensions of each size of pipe are given and, with certain exceptions that are most marked in the smallest sizes, the trade "size" of a pipe is supposed to correspond approximately to the actual diameter that the standard prescribes for the *inside* of the pipe. The intention of the manufacturers is, to have such pipe come as nearly as possible to the standard in all respects; but of course, special care is taken to have the *outside* diameter as exact as it can commercially be made to be, for it is only with the outside diameter that we are concerned, in threading and fitting it. So, although such pipe is rated according to its inside diameter (up to the 12″ size, inclusive), it is the outside diameter that is guaranteed to be exact, and nothing is guaranteed as to the inside diameter, except that it is as near to the standard as it is feasible to make it, consistently with the outside diameter being exact. Extra heavy pipe (up to the 12″ size inclusive, as before) is made with the same outside diameter as the corresponding size of ordinary pipe, in order that the same dies can be used in threading it; and its extra thickness is added on the *inside*, in such a way as to diminish its actual discharge area. A 6-inch extra heavy pipe is therefore a pipe that has the same *external* diameter as an ordinary weight pipe that has an *internal* diameter of approximately six inches (the standard internal diameter of an ordinary pipe that is rated as "six-inch" is 6.065″ instead of exactly 6″, and that is why we say "approxi-




FIGS. 10 AND 11.—SECTIONS OF EXTRA HEAVY FLANGES. (ONE-HALF ACTUAL SIZE.)

mately six inches"). The same is true up to the 12″ size, inclusive; but when we pass to higher sizes, the pipe is rated by its external diameter directly, and there is no such complication of ideas as is implied in the explanation just given for the smaller sizes. The words "inside diameter of pipe" in the tables are not to be understood as meaning that the actual internal diameter of the pipe referred to is given under the heading, "pipe size," but are given merely as a reminder of the fact that the system of estimating pipe sizes changes at the black line across the table.

Mr. J. F. O'Brien, Secretary of the Pratt & Cady Company of Hartford, Conn., was one of the most ardent and active advocates of the new standard for heavy flanges; and while he is in no wise responsible for any error of facts or figures that this article may contain, we wish to express our indebtedness to him for the advice and assistance that he cheerfully extended to us in its preparation.

---

WE desire to acknowledge a copy of the *Memorandum* of the chief engineer of the Manchester (England) Steam Users' Association, as presented at the annual meeting held on June 18, 1901. It contains a considerable amount of suggestive matter on steam engineering topics,—notably a brief report on fifteen water-softening devices of various kinds.

# The Locomotive.

HARTFORD, FEBRUARY 15, 1902.

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

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

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

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


THE *Index* for THE LOCOMOTIVE for the year 1901 is now ready.

WE desire to acknowledge a copy of the Eddy Valve Company's catalogue of valves. It is very creditably gotten up, and is full of useful information concerning valves of all kinds.

THE *Engineering Magazine* comes to us, this month, printed entirely upon heavy plate paper, in order to emphasize the great quantity of matter that it contains. The quality of the matter needs no emphasis, because this magazine is universally admitted to be one of the best technical publications in existence. The present issue is really impressive in size, and we can certify (having tested the point) that it weighs nearly two pounds and a half. The articles that go to make up this issue are of the same high grade that everyone has come to expect of the *Engineering Magazine*, as a perfectly natural thing. In fact, one of the discouraging things about running a first-class technical journal is that nobody thinks of praising it when it is ideally excellent, because that is taken as a matter of course; and it is only when some little slip occurs that the public speaks up.

## Inspectors' Reports.

AUGUST, 1901.

During this month our inspectors made 12,218 inspection trips, visited 23,298 boilers, inspected 9,472 both internally and externally, and subjected 1,018 to hydrostatic pressure. The whole number of defects reported reached 18,458, of which 1,171 were considered dangerous; 80 boilers were regarded unsafe for further use. Our usual summary is given below:

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment, | 1,352 | 55 |
| Cases of incrustation and scale, | 3,172 | 101 |
| Cases of internal grooving, | 240 | 13 |
| Cases of internal corrosion, | 1,165 | 40 |
| Cases of external corrosion, | 937 | 54 |
| Broken or loose braces and stays, | 160 | 38 |
| Settings defective, | 525 | 21 |
| Furnaces out of shape, | 629 | 22 |
| Fractured plates, | 277 | 52 |
| Burned plates, | 438 | 32 |

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Blistered plates, | 119 | 4 |
| Cases of defective riveting, | 3,208 | 166 |
| Defective heads, | 134 | 11 |
| Serious leakage around tube ends, | 3,213 | 293 |
| Serious leakage at seams, | 544 | 9 |
| Defective water-gauges, | 398 | 57 |
| Defective blow-offs, | 270 | 78 |
| Cases of deficiency of water, | 33 | 13 |
| Safety-valves overloaded, | 109 | 30 |
| Safety-valves defective in construction, | 95 | 32 |
| Pressure-gauges defective, | 532 | 31 |
| Boilers without pressure-gauges, | 18 | 18 |
| Unclassified defects, | 890 | 1 |
| Total, | 18,458 | 1,171 |

September, 1901.

During this month our inspectors made 10,659 inspection trips, visited 20,207 boilers, inspected 8,286 both internally and externally, and subjected 998 to hydrostatic pressure. The whole number of defects reported reached 14,634, of which 852 were considered dangerous; 47 boilers were regarded unsafe for further use. Our usual summary is given below:

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment, | 1,011 | 68 |
| Cases of incrustation and scale, | 2,573 | 81 |
| Cases of internal grooving, | 130 | 7 |
| Cases of internal corrosion, | 630 | 32 |
| Cases of external corrosion, | 568 | 38 |
| Broken and loose braces and stays, | 149 | 34 |
| Settings defective, | 364 | 24 |
| Furnaces out of shape, | 374 | 12 |
| Fractured plates, | 278 | 40 |
| Burned plates, | 338 | 59 |
| Blistered plates, | 86 | 3 |
| Cases of defective riveting, | 2,936 | 18 |
| Defective heads, | 54 | 10 |
| Serious leakage around tube ends, | 2,743 | 178 |
| Serious leakage at seams, | 329 | 19 |
| Defective water-gauges, | 266 | 43 |
| Defective blow-offs, | 221 | 61 |
| Cases of deficiency of water, | 16 | 6 |
| Safety-valves overloaded, | 85 | 51 |
| Safety-valves defective in construction, | 112 | 30 |
| Pressure-gauges defective, | 361 | 27 |
| Boilers without pressure-gauges, | 7 | 7 |
| Unclassified defects, | 1,003 | 4 |
| Total, | 14,634 | 852 |

## October, 1901.

During this month our inspectors made 12,150 inspection trips, visited 23,112 boilers, inspected 7,832 both internally and externally, and subjected 1,086 to hydrostatic pressure. The whole number of defects reported reached 15,754, of which 1,088 were considered dangerous; 69 boilers were regarded unsafe for further use. Our usual summary is given below:

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment, | 1,156 | 81 |
| Cases of incrustation and scale, | 2,786 | 79 |
| Cases of internal grooving, | 131 | 11 |
| Cases of internal corrosion, | 801 | 37 |
| Cases of external corrosion, | 678 | 42 |
| Broken and loose braces and stays, | 186 | 22 |
| Settings defective, | 396 | 18 |
| Furnaces out of shape, | 441 | 15 |
| Fractured plates, | 328 | 66 |
| Burned plates, | 392 | 31 |
| Blistered plates, | 116 | 5 |
| Cases of defective riveting, | 3,087 | 81 |
| Defective heads, | 84 | 10 |
| Serious leakage around tube ends, | 2,607 | 319 |
| Serious leakage at seams, | 469 | 20 |
| Defective water-gauges, | 300 | 67 |
| Defective blow-offs, | 231 | 76 |
| Cases of deficiency of water, | 27 | 12 |
| Safety-valves overloaded, | 89 | 47 |
| Safety-valves defective in construction, | 66 | 21 |
| Pressure-gauges defective, | 385 | 19 |
| Boilers without pressure-gauges, | 9 | 9 |
| Unclassified defects, | 989 | 0 |
| Total, | 15,754 | 1,088 |

## November, 1901.

During this month our inspectors made 10,720 inspection trips, visited 20,386 boilers, inspected 7,527 both internally and externally, and subjected 912 to hydrostatic pressure. The whole number of defects reported reached 14,297, of which 942 were considered dangerous; 63 boilers were regarded unsafe for further use. Our usual summary is given below:

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment, | 1,062 | 53 |
| Cases of incrustation and scale, | 2,878 | 97 |
| Cases of internal grooving, | 145 | 9 |
| Cases of internal corrosion, | 674 | 42 |
| Cases of external corrosion, | 598 | 50 |
| Broken and loose braces and stays, | 178 | 27 |
| Settings defective, | 346 | 24 |

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Furnaces out of shape, | 364 | 6 |
| Fractured plates, | 294 | 49 |
| Burned plates, | 382 | 38 |
| Blistered plates, | 112 | 1 |
| Cases of defective riveting, | 3,140 | 47 |
| Defective heads, | 99 | 22 |
| Serious leakage around tube ends, | 2,211 | 221 |
| Serious leakage at seams, | 390 | 11 |
| Defective water-gauges, | 233 | 47 |
| Defective blow-offs, | 207 | 58 |
| Cases of deficiency of water, | 25 | 6 |
| Safety-valves overloaded, | 94 | 35 |
| Safety-valves defective in construction, | 83 | 32 |
| Pressure-gauges defective, | 416 | 36 |
| Boilers without pressure-gauges, | 13 | 13 |
| Unclassified defects, | 353 | 18 |
| Total, | 14,297 | 942 |

DECEMBER, 1901.

During this month our inspectors made 10,590 inspection trips, visited 20,208 boilers, inspected 8,048 both internally and externally, and subjected 986 to hydrostatic pressure. The whole number of defects reported reached 16,248, of which 1,174 were considered dangerous; 72 boilers were regarded unsafe for further use. Our usual summary is given below:

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment, | 1,112 | 51 |
| Cases of incrustation and scale, | 3,238 | 95 |
| Cases of internal grooving, | 181 | 19 |
| Cases of internal corrosion, | 823 | 37 |
| Cases of external corrosion, | 576 | 52 |
| Broken and loose braces and stays, | 143 | 32 |
| Settings defective, | 346 | 26 |
| Furnaces out of shape, | 411 | 21 |
| Fractured plates, | 385 | 45 |
| Burned plates, | 412 | 25 |
| Blistered plates, | 75 | 3 |
| Cases of defective riveting, | 3,050 | 30 |
| Defective heads, | 87 | 6 |
| Serious leakage around tube ends, | 3,177 | 490 |
| Serious leakage at seams, | 492 | 42 |
| Defective water-gauges, | 196 | 41 |
| Defective blow-offs, | 200 | 49 |
| Cases of deficiency of water, | 23 | 12 |
| Safety-valves overloaded, | 73 | 28 |
| Safety-valves defective in construction, | 68 | 21 |
| Pressure-gauges defective, | 360 | 24 |

| Number of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Boilers without pressure-gauges, | 6 | 6 |
| Unclassified defects, | 814 | 9 |
| Total, | 16,248 | 1,174 |

## Summary of Inspectors' Reports for the Year 1901.

During the year 1901 our inspectors made 134,027 visits of inspection, examined 254,927 boilers, inspected 99,885 boilers both internally and externally, subjected 11,507 to hydrostatic pressure, and found 950 unsafe for further use. The whole number of defects reported was 187,847, of which 12,614 were considered dangerous. A summary of the work by months is given below, and the usual classification by defects is likewise given:

Summary, by Defects, for the Year 1901.

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment, | 14,109 | 731 |
| Cases of incrustation and scale, | 36,137 | 986 |
| Cases of internal grooving, | 2,284 | 153 |
| Cases of internal corrosion, | 10,383 | 461 |
| Cases of external corrosion, | 8,135 | 532 |
| Defective braces and stays, | 3,035 | 680 |
| Settings defective, | 4,986 | 363 |
| Furnaces out of shape, | 5,512 | 249 |
| Fractured plates, | 3,802 | 632 |
| Burned plates, | 4,691 | 477 |
| Blistered plates, | 1,379 | 39 |
| Defective rivets, | 32,303 | 897 |
| Defective heads, | 998 | 147 |
| Leakage around tubes, | 31,925 | 3,171 |
| Leakage at seams, | 5,306 | 308 |
| Water-gauges defective, | 3,398 | 626 |
| Blow-offs defective, | 2,465 | 702 |
| Cases of deficiency of water, | 393 | 123 |
| Safety-valves overloaded, | 1,180 | 438 |
| Safety-valves defective, | 932 | 323 |
| Pressure-gauges defective, | 5,284 | 361 |
| Boilers without pressure-gauges, | 163 | 163 |
| Unclassified defects, | 9,047 | 52 |
| Total, | 187,847 | 12,614 |

Comparison of Inspectors' Work during the Years 1900 and 1901.

| | 1900. | 1901. |
|---|---|---|
| Visits of inspection made, | 122,811 | 134,027 |
| Whole number of boilers inspected, | 234,805 | 254,927 |
| Complete internal inspections, | 92,526 | 99,885 |
| Boilers tested by hydrostatic pressure, | 10,191 | 11,507 |
| Total number of defects discovered, | 177,113 | 187,847 |
| " " of dangerous defects, | 12,862 | 12,614 |
| " " of boilers condemned, | 782 | 950 |

We append also a summary of the work of the inspectors of this company from 1870 to 1901 inclusive. The years 1876 and 1878 are omitted, because the data that we have at hand for those years are not complete. The figures, so far as we have them, indicate that the work during those years was in good accordance with the general pro-

SUMMARY OF INSPECTORS' WORK SINCE 1870.

| Year. | Visits of inspection made. | Whole number of boilers inspected. | Complete internal inspections. | Boilers tested by hydrostatic pressure. | Total number of defects discovered. | Total number of dangerous defects discovered. | Boilers condemned. |
|---|---|---|---|---|---|---|---|
| 1870 | 5,439 | 10,569 | 2,585 | 882 | 4,686 | 485 | 45 |
| 1871 | 6,826 | 13,476 | 3,889 | 1,484 | 6,253 | 954 | 60 |
| 1872 | 10,447 | 21,066 | 6,533 | 2,102 | 11,176 | 2,260 | 155 |
| 1873 | 12,824 | 24,998 | 8,511 | 2,175 | 11,998 | 2,892 | 178 |
| 1874 | 14,368 | 29,200 | 9,451 | 2,078 | 14,256 | 3,486 | 163 |
| 1875 | 22,612 | 44,763 | 14,181 | 3,149 | 24,040 | 6,149 | 216 |
| 1877 | ....... | 32,975 | 11,629 | 2,367 | 15,964 | 3,690 | 133 |
| 1879 | 17,179 | 36,169 | 13,045 | 2,540 | 16,238 | 3,816 | 246 |
| 1880 | 20,939 | 41,166 | 16,010 | 3,490 | 21,033 | 5,444 | 377 |
| 1881 | 22,412 | 47,245 | 17,590 | 4,286 | 21,110 | 5,801 | 363 |
| 1882 | 25,742 | 55,679 | 21,428 | 4,564 | 33,690 | 6,867 | 478 |
| 1883 | 29,324 | 60,142 | 24,403 | 4,275 | 40,953 | 7,472 | 545 |
| 1884 | 34,048 | 66,695 | 24,855 | 4,180 | 44,900 | 7,449 | 493 |
| 1885 | 37,018 | 71,334 | 26,637 | 4,809 | 47,230 | 7,325 | 449 |
| 1886 | 39,777 | 77,275 | 30,868 | 5,252 | 71,983 | 9,960 | 509 |
| 1887 | 46,761 | 89,994 | 36,166 | 5,741 | 99,642 | 11,522 | 622 |
| 1888 | 51,483 | 102,314 | 40,240 | 6,536 | 91,567 | 8,967 | 426 |
| 1889 | 56,752 | 110,394 | 44,563 | 7,187 | 105,187 | 8,420 | 478 |
| 1890 | 61,750 | 118,098 | 49,983 | 7,207 | 115,821 | 9,387 | 402 |
| 1891 | 71,227 | 137,741 | 57,312 | 7,859 | 127,609 | 10,858 | 526 |
| 1892 | 74,830 | 148,603 | 59,883 | 7,585 | 120,659 | 11,705 | 681 |
| 1893 | 81,904 | 163,328 | 66,698 | 7,861 | 122,893 | 12,390 | 597 |
| 1894 | 94,982 | 191,932 | 79,000 | 7,686 | 135,021 | 13,753 | 595 |
| 1895 | 98,349 | 199,096 | 76,744 | 8,373 | 144,857 | 14,556 | 799 |
| 1896 | 102,911 | 205,957 | 78,118 | 8,187 | 143,217 | 12,988 | 663 |
| 1897 | 105,062 | 206,657 | 76,770 | 7,870 | 131,192 | 11,775 | 588 |
| 1898 | 106,128 | 208,990 | 78,349 | 8,713 | 130,743 | 11,727 | 603 |
| 1899 | 112,464 | 221,706 | 85,804 | 9,371 | 157,804 | 12,800 | 779 |
| 1900 | 122,811 | 234,805 | 92,526 | 10,191 | 177,113 | 12,862 | 782 |
| 1901 | 134,027 | 254,927 | 99,885 | 11,507 | 187,847 | 12,614 | 950 |

gression observable in other years. Previous to 1875 it was the custom of the company to publish its reports on the first of September, but in that year the custom was changed and the summaries were made out up to January 1st, so as to agree with the calendar year. The figures given opposite 1875, therefore, are for sixteen months, beginning September 1, 1874, and ending December 31, 1875.

### Summary by Months, for 1901.

| Month. | Visits of inspection. | Number of boilers examined. | No. inspected internally and externally. | No. tested hydrostatically. | No. condemned. | Number of defects found. | Number of dangerous defects found. |
|---|---|---|---|---|---|---|---|
| January, . . | 11,820 | 22,331 | 6,742 | 758 | 59 | 12,734 | 1,238 |
| February, . . | 10,308 | 19,479 | 5,672 | 730 | 57 | 11,523 | 764 |
| March, . . . | 11,109 | 21,155 | 7,854 | 873 | 79 | 16,405 | 1,082 |
| April, . . . | 10,570 | 20,105 | 8,756 | 959 | 144 | 15,890 | 1,063 |
| May, . . . . | 11,717 | 23,063 | 9,901 | 1,089 | 134 | 16,925 | 1,308 |
| June, . . . | 11,320 | 21,037 | 9,729 | 1,159 | 78 | 15,804 | 985 |
| July, . . . | 10,846 | 20,546 | 10,066 | 939 | 68 | 19,175 | 947 |
| August, . . | 12,218 | 23,298 | 9,472 | 1,018 | 80 | 18,458 | 1,171 |
| September, . | 10,659 | 20,207 | 8,286 | 998 | 47 | 14,634 | 852 |
| October, . . | 12,150 | 23,112 | 7,832 | 1,086 | 69 | 15,754 | 1,088 |
| November, . . | 10,720 | 20,386 | 7,527 | 912 | 63 | 14,297 | 942 |
| December, . . | 10,590 | 20,208 | 8,048 | 986 | 72 | 16,248 | 1,174 |
| Totals, . . | 134,027 | 254,927 | 99,885 | 11,507 | 950 | 187,847 | 12,614 |

The following table is also of interest. It shows that our inspectors have made over a million and a half visits of inspection, and that they have made more than three million inspections, of which more than a million and a quarter were complete internal inspections. The hydrostatic test has been applied in over one hundred and seventy thousand cases. Of defects, nearly two and a half millions have been discovered and pointed out to the owners of the boilers; and more than a quarter of a million of these defects were, in our opinion, dangerous. More than fourteen thousand boilers have been condemned as unsafe, good and sufficient reasons for the condemnation being given in each case.

### Grand Total of the Inspectors' Work Since the Company Began Business, to January 1, 1902.

| | |
|---|---|
| Visits of inspection made, - - - - - - - | 1,673,459 |
| Whole number of boilers inspected, - - - - - - | 3,304,130 |
| Complete internal inspections, - - - - - - - | 1,275,982 |
| Boilers tested by hydrostatic pressure, - - - - - | 174,093 |
| Total number of defects discovered, - - - - - - | 2,414,103 |
| " " of dangerous defects, - - - - - - | 257,824 |
| " " of boilers condemned, - - - - - - | 14,165 |

ON page 182. of the issue of THE LOCOMOTIVE for December, 1901, we printed an account of an explosion in the works of the American "E. C." and "Schultze" Gunpowder Co., of Oakland, N. J. It was represented to us to have been a compound explosion, beginning with a boiler explosion, and ending with the explosion of something like a thousand pounds of powder; and we therefore gave it as No. 272, in our regular list for the month of September, with the explanation that it was only the first explosion that could properly be counted as a boiler explosion. Every account that we had received agreed with the theory that a boiler exploded first, and we accordingly took it for granted that that was the case. We have now received a letter from the owners of the plant, in which the occurrence of a boiler explosion is denied; and we take pleasure in making the correction.

## The Carnegie Institution.

One of the most noteworthy events in the history of science was the bequest of James Smithson, an Englishman dying in Italy, in 1829, of about $500,000 to found at Washington "an establishment for the increase and diffusion of knowledge among men." Equally important is the gift of Mr. Andrew Carnegie of $10,000,000 to establish in Washington an institution for the encouragement of "investigation, research, and discovery." These two foundations represent more than an addition to the sum annually spent on scientific work. They stand for the spirit of science, not confined by place or buildings, titles or degrees. In foreign countries we are often called worshipers of wealth and ostentation; in reply we need only point to the Smithsonian and Carnegie institutions, situated in the National Capital, but extending throughout the country and beyond, quietly and powerfully representing the highest ideals of knowledge and research.

The Smithsonian Institution under Henry and Baird fostered science in many directions, having been more or less a factor in the establishment of the National Library, the Weather Bureau, the Geological and Coast Surveys, and the Fish Commission. It still has under its charge the National Museum, the Bureau of American Ethnology, and the Zoölogical Park. The Carnegie Institution, with twenty times the resources of the Smithsonian, will henceforth be a great influence for the advancement of knowledge. The founder states that the primary object is the promotion of research, and specifies several directions in which work will be undertaken. The Institution will probably supersede the Washington Memorial Institution in the function of utilizing for advanced work the resources of the Government at Washington and elsewhere. It will also aim to increase the efficiency of universities and other institutions by providing funds for investigations and for fellowships. It will assist in the publication of scientific work. It may give salaries and pensions to permit the continuous prosecution of research. Mr. Carnegie shows much insight in particularly specifying as one of its objects, "to discover the exceptional man in every department of study, whenever and wherever found, and enable him, by financial aid, to make the work for which he seems specially designed his life work."

This is, indeed, the great need of science — to find the men.

Given the man, there is no danger but that the research, the discovery, and the publication will follow. What is essential is to secure for research the men best fitted for it. Good men are needed for all kinds of useful work; but on the whole the business man, the lawyer, or the physician is less likely to contribute to the general welfare than the investigator. But the investigator is exactly the man whose profession is most insecure. He never depends on his scientific work for his support; he must earn his living by teaching, or by administrative work, or the like. A good novel or a good picture has market value; a good research has none. The author is not only unpaid, but is fortunate if his paper or book can be properly published without expense to himself.

The number and quality of men engaged in scientific work can apparently be increased best in two ways: by permitting a larger number of young men to carry on work long enough to be eligible for national selection, and by offering certain prizes for those who reach the highest efficiency. Our universities now provide a considerable number of scholarships and fellowships; they should be increased, but even more than these we need offices, such as the secretaryship of the Smithsonian Institution, that will attract young men to science as a profession and provide adequate rewards and the best opportunities for those whose work is most fruitful. A lawyer may become a judge, a clergyman a bishop, a business man a millionaire, and the like : but there are no similar rewards for a scientific man or a university professor. At a comparatively early age he receives the maximum salary of from three to five thousand dollars, and no further advancement is possible — unless he leaves scientific work to become an inventor or a college president.

The directorship of the Carnegie institution will be one prize, but its duties will be largely administrative. The trustees of the institution selected by Mr. Carnegie are men of tried administrative ability, but they are too busy and too widely scattered over the country to attend to the details of the scientific work of the institution. We should view with much satisfaction the establishment of a board of scientific directors who should at the same time be research professors, spending part of the year at Washington and part at their present universities or institutions, receiving ample salaries and having the best facilities for work. The honor of selection for this position and a salary comparable to that which may be earned in other professions would add great attractiveness to science as a profession and serve as a continual stimulus to scientific research.

There are, however, many ways by which the great resources of the Carnegie Institution can be utilized for the benefit of science, and the trustees are certainly competent to select the best methods. There is no doubt but that the institution will greatly aid in giving the United States a leading place among the nations that are contributing to the advancement of science, and will tend to make Washington one of the three or four chief scientific centers of the world.— *Popular Science Monthly.*

## Abstract of Statement.—January 1, 1902.

HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

ASSETS.

| | | |
|---|---|---|
| Cash in office and bank, | | $150,294.37 |
| Premiums in course of collection (net), | | 237,479.73 |
| Loaned on bond and mortgage, first liens, | | 510,345.00 |
| Bonds and stocks, market value, | | 1,929,115.00 |
| Real estate, | | 38,750.00 |
| Interest accrued, | | 14,742.34 |
| Total assets, | | $2,880,726.44 |

LIABILITIES.

| | | |
|---|---|---|
| Premium reserve, | | $1,645,476.92 |
| Losses in process of adjustment, | | 45,121.51 |
| Capital stock, | $500,000.00 | |
| Net surplus, | 690,128.01 | |
| Surplus as regards policy-holders, | $1,190,128.01 | 1,190,128.01 |
| Total liabilities, including capital and surplus, | | $2,880,726.44 |

(Many insurance authorities maintain that uncollected premiums should not be treated as a cash asset forming part of the surplus, because it has usually been found impossible to collect them in the cases in which companies have been obliged to go into liquidation. To modify the foregoing statement so as to make it harmonize with this view of the case, it is only necessary to subtract $237,479.73 from the total assets, and also from the surplus as regards policy-holders. This would make the total assets of the company on January 1st, 1902, $2,643,246.71, and the surplus as regards policy-holders on the same date $952,648.28. It therefore appears that, even when the most unfavorable assumptions are made, the Hartford's policy-holders are amply protected by a substantial cash surplus of $952,648.28.)

# The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XXIII. HARTFORD, CONN., MARCH, 1902. No. 3.

## Another Scamped Boiler Job.

We do not need to say that boilers are not always built as they should be; but the errors of construction can be divided into two classes, one of which may be regarded as pardonable, while the other certainly cannot be so regarded. In the first class come all those errors of construction which were made through misunderstanding, or through that mild form of ignorance on the part of the designer or builder which leads to the construction of a riveted joint, or a flat surface, or some other intrinsically weak structure, through failure to comprehend the necessities of the case. We are meeting errors of construction of this sort, in our inspection service, almost every day; and one of our most important duties is to call attention to them, and to point out how they can be remedied with the least expense and inconvenience to all concerned. In such cases

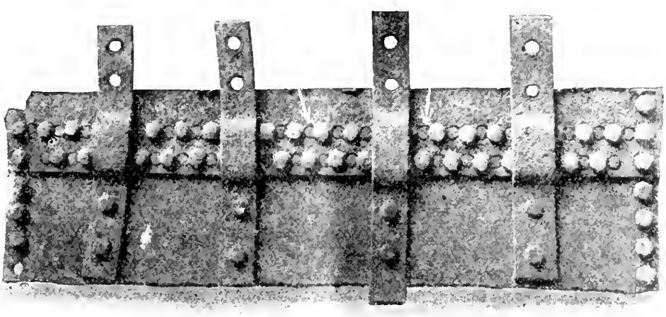


Fig. 1. — Showing the Buttons as Replaced.

there is almost invariably a disposition on the part of the person or persons who made the mistake, to rectify it at once, in the best manner possible. The other class of defects of construction embraces all those that were made knowingly, or that were concealed so far as possible after they had been made, and were allowed to remain in a boiler that was sold without proper representations concerning its true condition. In the issue of the Locomotive for June, 1894, we gave what we think is one of the worst cases of this sort that ever came to our attention. It consisted of a faulty joint, which had the strength of only a single-riveted joint, while it was made to have every appearance of a double-riveted joint, by means of a somewhat elaborate addition of a kind of putty that had been mixed up apparently of red lead, iron filings, and some other element that we could not identify. We are glad to say that cases as flagrant as this are not common; but other cases, betraying the same instincts on the part of the builders, are by no means uncommon. We illustrate, in this issue, a section of a longitudinal joint that was removed from a boiler that was recently offered to us for insurance. The joint was double riveted, as will be seen, the rivet holes being $\frac{13}{16}''$ in diameter, while the pitch was apparently intended to be $2\frac{1}{8}''$.

When the sheets were assembled it was found that a mistake had been made in punching three of the longitudinal seams, so that the holes did not match as they should, the holes in one of the laps coming opposite the solid metal in the other. Instead of discarding the plates, for use on some smaller job, the builder conceived the scheme of plugging up the holes that had been already punched (using, for this purpose, the buttons that had already been punched out of them), and punching the plate over again, with the holes in the right places. (The buttons that were so replaced are all visible in the engraving, Fig. 1, but in order to call attention to them more positively, two have been specially marked by arrows.) It goes without saying that this work was done on the inner lap, where it could not be seen unless the joint was examined from the inside. The result was, that the material was punched away for almost the entire length of the plate. The spacing of the rivets was a little irregular, but it is easily seen, from the data given above concerning the pitch and size of the holes, that the average width of the ligament between successive holes was only about $\frac{1}{4}''$ as indicated in Fig. 2.

When we first met with the boiler, four straps had been added to each joint, as shown in Fig. 1. These bridged across from one plate to the other, and were secured to the shell by two rivets at either end. We cannot say whether these straps were added by the builder before he let the job go out of his shop, or whether they were an afterthought, and were put in later, when the boiler showed signs of distress; but inasmuch as the builder was human, and therefore doubtless had something which he called a conscience, we shall take it for granted that he put the straps on as a safeguard, at the time he built the boiler.

The plate of which the boiler was built is $\frac{11}{32}''$ thick and, being of iron, probably has a tensile strength of about 45,000 pounds to the square inch. The straps were about 10″ apart, and were $\frac{1}{2}''$ thick and 3″ wide. The rivet holes in the straps were $\frac{15}{16}$ in diameter. If the joint were to fail, the straps would have to break, or else the rivets that secure them to the shell would have to shear. It is easily seen that the shearing strength of the rivets of the strap is greater than the tensile strength of the strap itself; for the area of a $\frac{15}{16}$ hole is 0.6903 square inches, and if we allow 38,000 pounds as the shearing strength of rivet iron, per square inch of sectional area, we find that the shearing strength of a rivet that just fills a $\frac{15}{16}''$ hole is $0.6903 \times 38{,}000 = 26{,}200$ pounds (in round numbers). The combined shearing strength of the two rivets that would have to be sheared in each strap is therefore $2 \times 26{,}200 = 52{,}400$ pounds.

Passing now to the tensile strength of the straps, it is plain that each strap is weakest across the section at which the rivet-hole is punched, for securing it to the shell. The net width of the strap at this point is $2\frac{1}{16}''$, and the thickness being $\frac{1}{2}''$, it is evident that the net sectional area of the strap, at its weakest section, is $1\frac{1}{32}$ square inches. The tensile strength of the strap being 45,000 pounds per square inch, it follows that the total resistance offered by the strap to fracture across the rivet hole is $1\frac{1}{32} \times 45{,}000 = 46{,}400$ pounds in round numbers. This is 6,000 pounds less than the shearing strength of the rivets that secure the strap to the shell; and therefore the strap may be expected to fail by fracture across the rivet holes.

It will be observed that we have allowed the straps the full strength that they would have if they were *straight*; whereas, as a matter of fact, they each had a small offset that would tend to cause them to yield somewhat before the full breaking stress came upon them. We have done this in order to favor, as much as possible, the construction that we are criticising.

Let us now consider the strength of the net section of the plate, across the line of rivet holes, at *AB* in Fig. 2. On account of the double punching, there was only a small ligament left between successive holes. We have seen, in fact, that the holes were so close together that the ligament of plate left between them was only $\frac{1}{4}''$ wide. The thickness of the plate being $\frac{11}{32}''$, or (which is the same thing), 0.344'', the area of cross section of one of these ligaments is 0.25 × 0.344 = 0.086 square inches; and if we allow a tensile strength to the material of the plate of 45,000 pounds per square inch, the strength of one of these ligaments is equal to 0.086 × 45,000 = 3,870 pounds. As there are two such ligaments to each unit of the joint, the total strength of the net section of the plate, per unit of the joint, is 2 × 3,870 = 7,740 pounds. The spacing of the straps was somewhat irregular, but it will be fair to say that there were about

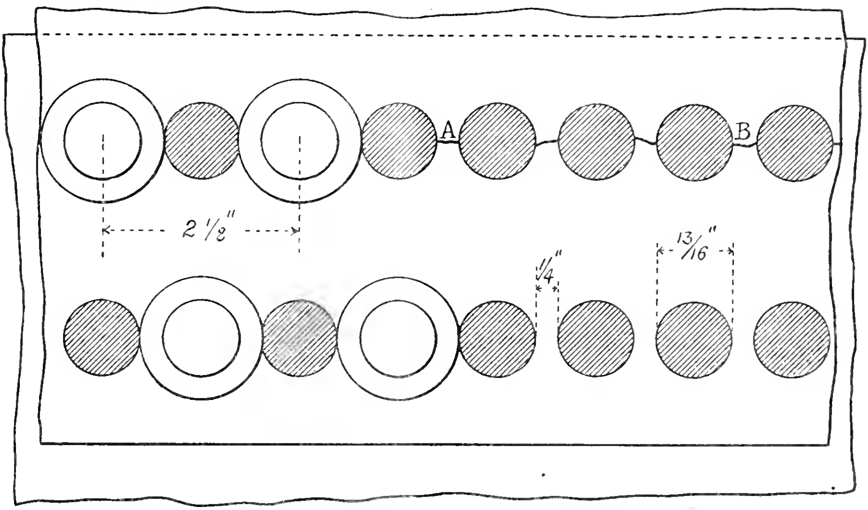



Fig. 2.—Diagram Giving Dimensions.

[Four rivet heads are shown in this cut, to illustrate the relation of the replaced buttons to the rivets. The other rivet heads are supposed to be removed, so that the ligaments left between the real and false rivet holes may be seen more clearly.]

$4\frac{1}{2}$ units of the joint allotted to each strap. The combined strength of all the ligaments in $4\frac{1}{2}$ units of the joint would evidently be equal to $4\frac{1}{2}$ × 7,740 = 34,830 pounds; and if we add to this the strength of one strap, as already calculated, we shall have 34,830 + 46,400 = 81,230 pounds, which is the total power of resistance to tension of a section of the joint as long as the distance between two successive straps.

Taking the distance from strap to strap as equal to $9\frac{9}{16}''$ (because we have already assumed it to be, on the average, equal to $4\frac{1}{2}$ units of the joint), the tensile strength of the solid plate, for a length of joint equal to the distance between two consecutive straps, is seen to be $9\frac{9}{16}$ × 11/32 × 45,000 = 147,900 pounds (in round numbers). The efficiency of the joint, as re-enforced by the straps, was therefore

$$81,230 \div 147,900 = 54.9 \text{ per cent.}$$

The joint, as re-enforced by the straps, was therefore weaker than a good single riveted joint ought to be, because it is quite possible to design a single riveted joint that would have an efficiency of (say) 56 per cent.

The double riveted joint that this boiler purported to have was poor enough, even if the work had been done right; for it is easily seen that the efficiency of a double riveted joint, with a pitch, a diameter of rivet hole, and a thickness of plate as given above, would be only about 61.8 per cent., even if the work were done in the best manner possible; whereas a properly designed double riveted joint should have an efficiency as high as (say) 70 per cent.

We do not wish to be understood as condemning the use of straps, such as are shown in the accompanying engraving, for increasing the efficiency of a joint, because there are occasions on which such straps can be used to good advantage. In fact, they were very serviceable indeed in this particular case, for the boiler could hardly have been run at all without them. The point that we wish to make is, that a boiler maker, when putting out a new boiler, does very wrongly to sell something that he knows is not made right, and which is essentially weaker than it ought to be, for the simple reason that he made a fool mistake, and does not wish to sacrifice a few pounds of plate as a penalty for his own blunder. It was not even necessary to sacrifice that much, for, as we have already said, the plates that had been punched wrongly could be held in stock, and later be cut down and used on some smaller job. The case we have here cited shows once more the advantage of having a boiler built by a reliable maker, who will do his work on honor, and make his own mistakes good, without cavil. It also illustrates the advantage of having boilers inspected by somebody besides the builder, before they are accepted and paid for. Even an honorable and well intentioned builder may make a mistake and honestly overlook it, till the inspector points it out.

## Steam Boiler Inspection.

It is only in the presence of a fatal and destructive explosion that the public fully appreciates the tragic possibilities that are wrapped up in every one of the two or three hundred thousand boilers that nestle among the teeming multitudes of our cities, or speed to and fro on steamboats and locomotives. Steam boiler explosions date from the very first use of steam under pressure, and the records of the early growth of steam engineering are punctuated with many a sad accident due to faults of material or design in the early boilers. With the increase of pressures which came at the time of the introduction of multiple expansion engines, there was a call for special care in the testing of the materials and in the construction of steam boilers, and there is no doubt that measured against other forms of constructive mechanical work the boiler of today will hold its own on any point of comparison.

If the security of the user depended solely upon the quality of his boiler, and there were no such thing as rapid depreciation due to neglect or unsuspected decay, there might have been relatively but little work for the steam boiler inspector, and no development of the great steam boiler insurance companies whose organization and operations mark them as among the most perfect insurance institutions in the world.

The absolute necessity of inspection is so fully realized that, in some States, the inspection of boilers is compulsory, and the State provides inspectors for this work. In such cases a fee is charged by the State for the service. In other States, there is no compulsion about inspections; and in all cases, if the boilers are inspected regularly by a boiler insurance company in good standing in the State in question, additional inspection by the State is not required.

In most States locomotives on railroads are expressly exempt from State inspection. It is presumed that the railroad owning the locomotive will provide a master mechanic or other expert, who will be competent to pass upon the fitness and safety of their locomotives. This presumption does not appear to be altogether realized in practice, for railroad locomotives constitute a class of boilers which explode almost as often as any other class that can be mentioned. Omitting city elevated railroads, the total number of railroad locomotives in the United States on December 31, 1900, was 38,065.

Steamboat boilers are inspected by the United States government, and are therefore exempt from inspection by the State, or by any other authority. For this service the United States government employs sixty-three inspectors of boilers. There are over 7,000 steamers in the deep sea, coastwise, and river service of the United States.

The total number of stationary boilers now in use in the United States was not ascertained in the last census. Neither are they enumerated in the census of 1890; but the census of 1880 shows that at that time there were 72,304 stationary boilers in this country. It was estimated by The Locomotive that on December 31, 1890, there were approximately 100,000 stationary boilers in the United States. The same authority estimates that at present there may be about 170,000 stationary boilers in the country that are used for power purposes.

The methods of inspection adopted by the various companies, though they vary in detail, are carried out upon the same general lines. We have been informed by Mr. J. M. Allen, president of the Hartford Steam Boiler and Inspection Company, that at the present writing this company has 83,907 boilers under insurance, and the system employed may be taken as representative of the best modern practice. The inspection, as such, is divided into three classs: (1) hydrostatic tests, (2) external inspections, and (3) internal inspections.

The hydrostatic test consists in applying a cold-water pressure to a boiler that is completely filled with water. The pressure is usually applied by a pump that the inspector carries with him. The usual test pressure that is applied, hydrostatically, is 50 per cent. greater than the working pressure at which the boiler is run. In Philadelphia, however, the law states that "a hydrostatic test of one-third greater than the boiler is rated to carry" will be considered sufficient.

When the boiler is under hydrostatic pressure, the inspector looks it carefully over, in all parts, to see if there are any signs of leakage, or of distress of any sort. This test is usually applied to new boilers, or to boilers upon which extensive repairs have recently been made, or upon boilers the interiors of which are not accessible, either because of their small size, or for any other reason. In some places, however (notably in the city of Philadelphia), a hydrostatic test is required by law on all boilers. Authorities differ about the advisability of applying the hydrostatic test, some maintaining that it is much better than the "hammer" test, to which we shall presently refer, because the actual pressure may develop a defect that the inspector, armed only with his hammer, might overlook. Other authorities claim that there is danger of straining the boiler by subjecting it to a test 50 per cent. greater than it will ever have to withstand in practice. The hydrostatic test is not considered to be injurious to the boiler, when it is applied by a man with good judgment, but the hammer test is preferable when that can be applied.

"External inspections" are those made by merely looking the boiler over from the outside, to make sure that the attendant is not running it at a higher pressure than is allowed; that he is carrying plenty of water in the boiler; that the safety-valve will blow off freely, and at the pressure that is allowed; that the water gauges are in good condition; that the boiler is not showing any signs of leakage, nor any bulges over the fire sheet, nor any signs of distress of any kind. Of course the attendant is not notified in advance when the company makes an inspection of that kind; for the object of the visit is, to see the boiler in the condition in which he usually runs it, without giving the attendant any opportunity to "fix up" for the inspector's benefit.

"Internal inspections," or hammer tests, as they are sometimes called, are made by the inspector entering the boiler through the manhole, and looking the interior over very carefully. He makes a similar examination, also, of the outside of the boiler, crawling into the furnace and all about, everywhere that he can go. Among the things that he has to look out for are these: Deposit of sediment or muddy matter, hard incrustation or scale on the tubes and plates, corrosion of any part of the boiler, both inside and outside, fractures of the plates, heads, headers, etc., leakage around the tube ends, seams, and all other places where such leakage is possible, defective bracing of the flat parts of the boiler, grooving of the plates or heads, burned or blistered parts, and defective accessories of all kinds; water gauges, feed pipes, blowpipes, safety-valves, pressure gauges, and everything else that can get out of order in any way whatever.

As an example of the magnitude and extent of the work of insurance and inspection it may be mentioned that the company above referred to employs a regular force of 198 inspectors, and in the year 1901 made 99,885 complete internal and external inspections (i. e. "hammer tests"), and in addition subjected 11,507 boilers to hydrostatic pressure; while from the beginning of the company's business down to January 1, 1902, 1,275,982 complete internal and external inspections were made, and enough external inspections to bring the total up to 3,304,130. Also 174,093 hydrostatic tests were made and 14,165 boilers were condemned as unsafe, good and sufficient reason for the condemnation being given to the owners in every case. During this time there were discovered and pointed out to the owners 2,414,103 defects of one sort and another, 257,824 of which were quoted as dangerous.

It is upon data of this sort that a steam boiler inspection company bases its claims to be considered as a great public safeguard. We have no way of knowing how many explosions work of this kind may have prevented, nor how many lives it may have saved, but the claim can fairly be made that the total number of lives saved has been great, and that the loss of property that has been prevented has been enormous. — *Scientific American.*

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It is stated, on good authority, that arrangements are progressing at the Portsmouth (England) dockyard for fitting the battleships *Mars* and *Hannibal* with oil-fuel burning apparatus in all their eight single-ended cylindrical boilers. The liquid fuel, however, will be used in its crude state, in combination with coal: — a process which has given the best results in an exhaustive series of trials in the torpedo boat *Surly.* The great advantage of the system is the reduction of labor on the part of the stokers. Success with oil fuel might enable the number of stokers to be reduced; but so far as efficiency is concerned, it is found that one pound of oil is equivalent, in evaporative power, to only about $1\frac{1}{4}$ pounds of coal, instead of 2 pounds, as is often stated. The greatest practical difficulty consists in providing for the proper combustion of large quantities of the oil in the confined space of the ordinary marine boiler furnace, oil requiring a greater volume of air than coal, in order that the combustion may be complete.— *The Iron Age.*

[We have taken liberties with the figures as given by the *Iron Age*, because we are of the opinion that our esteemed contemporary had them a little twisted.— EDITOR.]

# The Locomotive.

HARTFORD, MARCH 15, 1902.

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

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

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THE tremendous influence that the Baldwin Locomotive Works (Messrs. Burnham, Williams & Co.) have had upon the railroad interests of the world is emphatically illustrated by the fact that on February 27th this firm celebrated its seventieth anniversary, and, coincidently, the completion of its 20,000th locomotive, by a banquet at the Union League Club, Philadelphia. Some 250 guests were present. Mr. John H. Converse, of the Baldwin Locomotive Works, presided, Mr. Burnham being unable to be present on account of illness. Mr. Converse said, among other things: "We celebrate today the completion of 20,000 locomotives. When I remind you that statistics show that there are, on all American railroads, probably about 44,000 locomotives, we feel a pardonable pride in the share that we have had in contributing to the number built. One other bit of statistics may interest you, and that is, that our foreign trade has amounted, in these seventy years, to nearly one-fourth of our product. We have exported, in that time, 4,457 locomotives out of the 20,000 that have been built."

## The Isthmian Canal.

There is so much controversy about the isthmian canal, that it is exceedingly difficult to find any one thing upon which all engineers are agreed. In fact, the only thing upon which there appears to be *absolute* unanimity of opinion is, that if ships are to get from the Atlantic to the Pacific by a short cut, they must either pass through a canal, or be drawn across on a ship railway! But even this affords some basis for discussion, because there are only a limited number of places at which either a canal or a ship railway can be constructed. If we look over the various suggestions that have been made by engineers we shall find that only four routes have been seriously proposed. The most obvious of these, of course, is the isthmus of Panama, which is in the province of Panama, and owned by the Colombian government. As is well known, there is already a railroad across the isthmus at this place. A little south of Panama there is another narrow place known as the isthmus of Darien, which also is in the province of Panama, and which was one of the first candidates for a canal. Further north, mostly within the territory of Nicaragua but close to the boundary separating that country from Costa Rica, there is another possible route known as the Nicaragua route. All of the three routes thus far mentioned have been proposed as *canal* routes; but still further north, in the territory of Mexico, there is another candidate for our attention known as the Tehuantepec route, over which Eads proposed to run a ship railway, which should transfer ships bodily, on cars, between the Gulf of Mexico and the Pacific Ocean.

We should not like to say that a ship railway of length sufficient to cross the isthmus of Tehuantepec (which is about 160 miles wide) would be impracticable; but as it would involve engineering problems which would have to be solved here for the first time in the history of man, on the grand scale, the construction of a canal instead of such a railway would show much sounder judgment, provided any of the other three routes that have been proposed for canals do not involve difficulties of like magnitude and novelty. This has been the conclusion that almost all engineers have reached, and we now hear very little of a ship railway across Tehuantepec, or any other place; and whatever its merits may be, it is quite plain, from the course that events have taken, that no such railway is at all likely to be built.

There remain, therefore, three possible canal routes: the Darien route, the Panama route, and the Nicaragua route.

For some years the Darien route appeared to be well worth attention; but further exploration of the region through which it would pass has shown that we can no longer consider it as feasible. Three possible courses, and only three, were suggested at Darien, and it has been found that one of these is absolutely out of the question on account of the practically insuperable difficulties that it offers. Both of the remaining routes across the Darien isthmus call for the construction of a gigantic ship *tunnel* big enough to allow the passage of any ship that sails. It must be remembered that the great backbone of the western hemisphere passes along the narrow strip of land that unites North and South America, joining the Rocky Mountains on the north with the Andes on the south. At Darien, although the isthmus is narrow, the mountains are high; and it would be utterly impracticable to make a "cut" through them that could be traversed by means of locks. It would be necessary to *tunnel through* the mountain range, as has been said; and a ship tunnel through a mountain range is a proposition from which the boldest engineer would shrink, especially in a country more or less liable to earthquakes. We may therefore regard the Darien route as out of the question, as much as the Tehuantepec ship railway.

It will be seen that the only routes that are admitted to be fair possibilities are the Panama route and the Nicaragua route.

Having reached this conclusion, we come to the real nub of the matter; for we find that the engineers that have surveyed the two routes are divided into two hostile camps, one favoring the Nicaragua route with great earnestness, and the other favoring the Panama route with equal fervor, and each declaring the other's route to be out of the question. It is distinctly a case in which the doctors disagree.

The truth of the matter appears to be, that there are problems of the gravest kind to be solved along either route; and an engineer who happens to know more about the solution of the problems that occur on the Panama route will naturally favor that route in preference to the other one, which involves problems concerning whose solution he is not so well informed. At any rate, if this is not the case, it is hard to understand how it comes to pass that nothing approaching an agreement has been reached among the experts that have considered the canal question.

In a general way it may be said that the problems involved in the whole question can be divided into five classes. They are, namely: (1) Political, (2) Sanitary, (3) Engineering, (4) Commercial, and (5) Fiscal. The political and sanitary questions that are involved are not entirely distinct, and hence it may be well to take them up together.

It will be remembered that England has manifested a disposition to insist upon being taken into a sort of partnership with the United States in the construction of the canal, her claims to recognition of this sort being based upon the old and well-known Clayton-Bulwer treaty, of half a century ago. We hardly think it likely that the United States will consent to anything like joint ownership or joint control of the canal. Numerous eminent American jurists have declared that the Clayton-Bulwer treaty can no longer be considered binding on the United States, for the reason that England, in the past, has violated some of its most important clauses. However that may be, we are confident that a way will be found out of this difficulty, and that if a canal is constructed at all it will be under the sole ownership and control of the United States. The only other questions of international politics that enter as fundamental considerations are those that must be decided between the United States and the country through which the canal is to pass. What rights, we may fairly ask, are Colombia on the one hand, and Nicaragua and Costa Rica on the other, prepared to grant to us? The United States would hardly care to construct a canal through territory in which it could not land troops, if necessary to protect the interests of the canal, without that act being construed as an act of war. Such a course would not be wise in any country; but it would be the height of folly in Central America, where the political conditions are so unstable that we are prone to consider the governments there as machines making so many revolutions per minute. In Nicaragua this part of the problem promises to be very simple, for the Nicaraguans have practically agreed to give us what amounts to sovereignty over a strip of land on either side of the canal, some miles in width. It is true that this promise was recently withdrawn, but we have been assured that this was done for reasons of state, and that the desired concession will be made, to our entire satisfaction, when the time comes for us to ask it. Is Colombia, on the other hand, equally willing to grant a concession of this kind? Frankly, we do not know, and we do not believe that anybody else does, with any certainty. The Nicaragua route is not complicated by any private concessions already made, while the Panama route *is* so complicated. Professor Emory R. Johnson, who served on the Isthmian Canal Commission, puts the matter thus: "The differences of the two routes are most pronounced in the matter of concessions. In the case of the Nicaragua line there are no private corporations holding any concessions at present valid, and the United States is free to treat directly with Nicaragua and Costa Rica, both of which governments have, on several occasions, expressed their willingness to treat with us on the canal question. The Panama Canal Company controls, absolutely, the situation at Panama. It has a concession that is certainly valid until 1904, and which the company considers valid until 1910. Furthermore, the Panama Railroad [which follows the line of the projected canal very closely] is owned by the Panama Canal Company, and the concession under which this road was constructed has fifty years to run. By its terms no canal can be built in the neighborhood of the railroad without arrangements being made with the owners of the concession. It thus becomes necessary for the United States to buy out the Panama Canal Company before negotiations with the Colombian government can be consummated."

This matter of concessions demands the most careful attention before we make any final decision, for it is not to be supposed that the company that now holds the concessions to which we have just referred will relinquish everything without attempting to get every last cent out of the United States government that can be had. The Panama Canal Company has had a rough and stormy existence, and this is its last chance to recoup.

The sanitary problems connected with the canal question are of two kinds, namely, those that relate to the construction of the canal, and those that relate to its subsequent operation. It is well known that the death rate among the laborers on the Panama Railroad was very heavy, and it is to be expected that the death rate among the laborers on either canal will also be large, although there is reason to hope that it will not be so heavy as it was on the railroad construction. The Panama route has an apparent advantage in this particular, because the surface soil has already been removed over a great part of the route. General Henry L. Abbot puts the case very clearly in an article written by him for the *Engineering Magazine:* "Experience both on the Panama Railroad and on the canal has shown that when the virgin soil is first disturbed much sickness is caused by the malaria thus generated; but when excavation has gone below this level, to the deeper subsoil, far less occurs. The hospital records of the Panama Canal Company during the past twenty years demonstrate this fact, and the progress already made in the excavations (about two-fifths of the entire volume required) makes it evident that there is no reason for apprehending serious trouble from sickness." General Abbot also points out that along the Panama route there is a clearly defined dry season of about four months in the year, which would be available for specially difficult work; while he asserts that there is no sensible dry season at the gulf end of the Nicaragua route, where the heaviest excavations would have to be made.

When it comes to the operation of the completed canal, there does not appear to be any vast difference in the probable healthfulness of the two routes, although what difference there is appears to us to be rather in favor of the Nicaragua route. Neither canal attains any great altitude, the Panama and Nicaragua routes having their highest levels at 85 and 107 feet above the sea, respectively. But what appears to be a serious drawback to the Panama route is the fact that one of its terminals is a city (Panama) of some size. We do not know what the yellow fever record of Panama has been in the past, but we have no reason for assuming that it has been different from that of other Spanish-American cities in similar latitudes. We should certainly be assured, in some way, that the sanitary condition of any city along the route of the isthmian canal will be perpetually attended to, in the best manner possible. It is hard to see how that can be arranged, unless such cities are placed under the care of the United States government. We shall not deny that the healthfulness of a Central American city *can* be properly attended to by the government to which the city now belongs; but neither will any one else deny, we think, that in the past this has not been done, and we can hardly feel assured that the future will be any great improvement, in this respect, upon the past. We are therefore of the opinion that it will be found highly desirable and perhaps imperative to our interests, for the United States to control the sanitation of the terminals of the canal. Now the terminals of the Nicaragua route are at Brito and Greytown, respectively; and, while we do not know the size of Brito, we know that Greytown, which is much larger, has a population, at present, of only about 1,500. Colon, on the other hand, has a population of 3,000, and the present population of the city of Panama is about 25,000. Plainly the sanitary problem should be easier on the Nicaragua route so far as insuring the healthfulness of the terminals is concerned. Panama is the capital of the province of Panama, and the prospect of the Colombians giving us any kind of control over it is very poor indeed. If the canal is put through from Greytown to Brito, it cannot be doubted that both these towns will grow to a considerable size; but yet the present prospect of getting control of the sanitation of these cities is much better than the corresponding prospect in the case of the city of Panama.

Passing now to the matter of the engineering difficulties to be overcome, let us note, first, that, although the engineers who advocate the Panama route insist that the Nicaragua route is out of the question, the Panama Canal Company itself did not regard it so; for although they demanded, at first, $109,000,000 for their present rights and for their property in general, that amount was reduced to $40,000,000 within ten days of the time that it became apparent that the United States was seriously considering the Nicaragua route. If there were any insuperable engineering difficulties connected with the Nicaragua route, or any difficulties of any other sort that could not be overcome by a reasonable use of brains and money, the Panama Company would very likely know of them, and would hardly make such an enormous reduction in price on so short a notice; because the probability would be that the United States would soon discover the said difficulties, and be ready to pay the larger price in order to avoid them.

In each case the canal would follow the general course of a river, the San Juan river in Nicaragua, and the Chagres river in Panama. The San Juan river is bad enough to control, it is true, but the Chagres has always been a sort of thorn in the flesh of the advocates of the Panama route. According to the figures of General Abbot, who is a warm advocate of the Panama route, the Chagres river behaves itself very well during the dry season. covering the four months from January to April, inclusive. At this time (at Bohio, for which place the figures that we now quote are given, and at which a vast dam will have to be built) it has a discharge of some 750 cubic feet per second. In the wet season, the discharge of the river is 5,400 cubic feet per second, with sudden bursts of fury in which it discharges 25,000 to 30,000 cubic feet per second, for an hour or two. In November, 1879, a flood occurred in which the river discharged no less than 112,000 cubic feet per second, or 150 times the quantity that it discharges in times of peace. General Abbot does not see any reason why such a river as that cannot be controlled with certainty, so that it will not do the canal any damage; but some of us, who are not trying to prove anything in particular, would be inclined to doubt the practicability of such control. It is true that an elaborate plan has been worked out by the engineers who are interested in the Panama route, which makes the control of the Chagres river look feasible; but no such eccentric river as we have described can be regarded as certain to do anything in particular. It is full of interesting possibilities.

The chief engineering difficulties of the Panama route may be summarized as follows: (1) There is the difficulty of controlling the erratic Chagres, which looks much more serious to an outsider who reads every week or so of the unexpected and disastrous failure of engineering works of this character that were supposed to be safe than it does to the advocates of the Panama route. Then (2) there is the construction and maintenance of the big dam at Bohio, which is to hold back an artificial lake of Chagres water nearly 13 miles long, this lake being a part of the canal. According to the plans that we have seen, it is proposed to erect this dam, which is to be 75 feet high and a quarter of a mile long, upon a foundation of clay. That does not strike us as being an ideal engineering proposition; and yet a rock foundation cannot be had "that does not involve masonry work at a depth of 128 feet below the level of the sea; and no foundation has yet been sunk to that depth." (3) There is the matter of the famous Culebra cut, where the Panama canal pierces the continental divide. A considerable amount of digging has been done already in this cut, but there still remain something like 43,000,000 cubic yards of rock to be removed. So far as the quantity of material to be taken out is concerned, this is equivalent to digging a trench, one yard wide and one yard deep, through solid rock, for a distance equal to the entire circumference of the globe at the equator. It is plain that the job in prospect is a big one. In order to be perfectly fair, however, it is proper to say that the difficulty of executing the great cut at Culebra, on the Panama route, is not so great as it appeared to be some years ago. More has been learned about the nature of the rock through which it must pass, and the outlook for success is far better than it was. Formerly it was doubted if the rock would keep its form after the excavation was completed; and we used to hear prophecies made that the sides of the cut would flow down and fill the canal, either in avalanches of rock or by gradual plastic yield, like that which might be expected in a great mass of dough. We will quote what General Abbot has to say on this point:

"The deep cut at Culebra has now quite lost the ancient terrors that hung over it in the closing days of the old [DeLesseps] company. The cutting at that date was in disintegrated materials near the surface, and serious caving and sliding had occurred, partly from natural causes, and partly from neglect to secure proper drainage. The old company had made numerous borings, and they have been mu'tiplied by the new company, with deep pits permitting the material to be inspected to the full depth adopted for the bottom of the canal; six million cubic yards have actually been removed since the resumption of the work, so placed as to secure depth rather than width, and thus to throw light on future conditions; and lastly, a tunnel 2,100 feet long and 20 feet by 13 feet in cross section has been driven at a low level without difficulty, at the point where the worst sliding had occurred. All the evidence thus secured concurs in establishing the fact that the dangerous material has already been passed, and that future deep cutting will lie chiefly in an indurated argillaceous schist which stands well, even on steep slopes, and in which caving is not to be feared."

Having now spoken of the *disadvantages* of the Panama route from an engineering standpoint, let us present a few of its more notable *advantages*. The advantages, so far as the magnitude of the necessary operations is concerned, are certainly on the side of Nicaragua; but in the matter of curves and locks the Panama route is preferable. Only five locks will be required on the Panama route against eight on the Nicaragua route. It is impossible to build either canal without curves, but the alignment of the Panama route is much the better. The *Engineering News* summarizes this feature as follows: "Except for one curve of 3,280 feet radius at the entrance to Colon harbor, where the bottom width is from 500 to 800 feet, there are no curves on the Panama canal with a smaller radius than 6,200 feet, and only three with radii shorter than 8,260 feet; while on the Nicaragua route there are 10 curves of less than 5,000 feet radius, and 23 of from 5,000 to 6,C00 feet." In the matter of harbors too, the Panama route has the advantage. Elaborate harbor facilities have been planned for the Nicaragua route, and the commission considers that the two routes would not be widely different in respect to harbors when all the work is completed; but the shifting nature of the ocean bottom at Greytown (one of the Nicaragua termini) makes it probable that in the matter of maintenance the Panama route would have the advantage. The lower summit elevation at Panama has already been referred to, although the difference in this respect is not very great.

So far as the engineering problems are concerned, therefore, we may say that the Panama route has the advantage (1) in the matter of harbors; (2) in the matter of curves; (3) in the matter of locks; and to these we may add the important items (4) that a railroad exists along the Panama route, so that the transportation of men and materials would be greatly facilitated in the work of construction; and (5) that there are quarters now ready for some 15,000 laborers, and that a considerable quantity of machinery is already on the ground, although some of it has been damaged by long exposure to the weather.

The Nicaragua route, on the other hand, has the advantages (1) that it does not involve any single engineering problem as great as those that must be solved for the Panama route; and (2) the related advantage that, notwithstanding the fact that a great deal of work has already been done at Panama, the Nicaragua canal can be completed sooner by some two years. The Canal Commission estimated that the Nicaragua canal could be completed in 8 years and the Panama canal in 10 years.

If we now pass to the commercial question, we are faced at the outset by the fact that the Panama canal would be only 49 miles long, against 183 miles at Nicaragua. It has often been said that this would mean a considerable advantage in favor of Panama, because it would mean that the time of transit for a deep-draft vessel would be about $11\frac{1}{4}$ hours by the Panama route, and 33 hours by the Nicaragua route, so that there would be an advantage, in this respect, in favor of Panama of something like 22 hours. But this way of looking at the case is very misleading. What is really important to the vessels using the canal, so far as the time element is concerned, is the *total* duration of their passage, between the ports which form the beginning and end of their voyage. A canal across South America at Rio de Janeiro, for instance, even if the passage through it could be effected in one minute, could not be compared, from a commercial point of view, with a canal across any of the isthmus routes, on account of the time that it would take to get down to the canal in the one ocean, and back from it again in the other. Now Panama is a considerable distance further south than Nicaragua, and the time necessary to reach it and get back again is well worth consideration. On this point the Canal Commission says: "Except for the items of risks and delays, the time required to make the transit through the canals needs to be taken into account only as an element in the time taken by the vessels to make their passage between terminal ports. Compared on this basis, the Nicaragua route is the more advantageous for all trans-isthmian commerce except that originating or ending on the west coast of South America. For the commerce in which the United States is more interested, that between our Pacific and Atlantic ports, European and American, the Nicaragua route is shorter by about one day. The same advantage exists between our Atlantic ports and the Orient. For our gulf ports the advantage of the Nicaragua route is nearly two days. For the commerce between north Atlantic ports and the west coast of South America the Panama route is shorter by about two days. Between gulf ports and the west coast of South America, the saving is about one day. The Nicaragua route would be the more favorable one for sailing vessels, because of the uncertain winds in the Bay of Panama."

Turning now to the fiscal question, we have first to consider the cost of constructing the Nicaragua canal, and the cost of completing the Panama canal. The estimates made by the Canal Commission on these points are as follows:

| | |
|---|---|
| Cost of constructing the Nicaragua canal, . . . . | $189,860,000 |
| Cost of completing the Panama canal, . . . . . | 144,200,000 |

There is therefore a difference, in this respect, of about $45,000,000 in favor of Panama. But we do not yet own the Panama canal, and to the estimate here given we therefore have to add whatever the Panama Canal Company would charge us for the work they have already done, and for their appliances and good will. At first they were disposed to charge $109,000,000; but as that would make the total cost of the Panama canal something like $60,000,000 greater than that of the Nicaragua canal, it was not considered, by our Canal Commission, to be a good business proposition. The Panama Canal Company's president, M. Hutin, subsequently resigned, and after a stormy meeting the stockholders of the company reduced the price to $40,000,000. This would make the estimated cost of construction approximately the same on both canals.

It is considered probable that the cost of maintaining the canals would be about $2,000,000 per annum at Panama, and about $3,300,000 at Nicaragua. This difference of $1,300,000 per annum is, of course, well worth consideration; but we do not feel sure that it might not, in time, be overbalanced by the advantage due to the shorter time of total passage by way of the Nicaragua route. So far as the probable revenues of the canal are concerned, Professor Johnson (whom we have already quoted) says that a careful calculation of the probable traffic, guided by the experience of the Suez canal management, indicates that at the end of ten years of service the travel through our isthmian canal would probably amount to about 10,500,000 tons per annum, net register. At the time of completion of the canal the travel would probably be only about 7,000,000 tons. "A toll of about one dollar per ton of net register," continues Professor Johnson, "could be levied upon the commerce using the isthmian canal, without much restricting the amount of traffic through that waterway. This charge is about one-half of that now paid for the use of the Suez canal. A toll considerably higher than one dollar per ton net register would probably yield a larger maximum revenue than would a toll of one dollar; but in fixing the charges for the use of an isthmian canal, owned and operated by the United States government, the principle of maximum revenue could not wisely be followed. The function of the canal as a toil gate will be a minor one as compared with its service in promoting the industrial and commercial progress and general welfare of the United States. The language of the final report of the commission on this point is that 'An annual traffic of 7,000,000 tons at one dollar a ton will produce a revenue of $7,000,000. The expenses of operating and maintaining the Panama canal are estimated at about $2,000,000 per annum, and those of the Nicaragua canal at about $3,200,000. Upon this basis the net revenue by either route would not be sufficient, at the opening of the canal, to pay interest upon the capital invested and compensate a private corporation for the risks involved. It is the opinion of the commission, however, that there are other considerations more important than revenue. It may even be expedient for the United States to reduce the tolls to an amount that will barely cover the expense of operation and maintenance. A large increase of traffic in the future is probable, and the revenue-producing power of the canal would then be proportionately greater.'"

Looking over the whole ground, we may regard certain things as fairly evident:

(1) In cost of construction, the two canals will not differ widely, if we take account of the price that must be paid for the Panama canal in its present state.

(2) The cost of maintenance is greater, by about $1,300,000 per annum, for the Nicaragua route; but, as the Commission has well said, the matter of revenue ought not to be made the *primary* consideration. If the Nicaragua route is preferable on other grounds, it should be selected; though of course it is desirable that the canal should pay its own expenses, if that is possible without sacrificing more important things.

(3) The traffic at the end of ten years of service will probably be 10,000,000 net tons, by either route; and there is every reason to suppose that it will increase continuously thereafter. When it has increased to 11,000,000 net tons per annum, the income, from a transit charge of $1 a ton, will suffice to pay the cost of maintenance of the Nicaragua canal, together with four per cent. interest on the cost of the whole undertaking.

(4) There is some difference in favor of the Nicaragua route so far as the date of completion is concerned. If work were begun at once, the Nicaragua canal could be completed by 1910, and the Panama canal by 1912. There is not enough difference between these to decide us in making a choice, because we can do without the canal for another two years very well, if there is anything material to be gained by waiting that length of time.

(5) Although the Nicaragua route has been very thoroughly surveyed, it cannot be denied that we are *surer* of the difficulties that will be encountered on the Panama route, because much digging has been done there already, and actual work of this kind is much more trustworthy as a means of judging the character of the operations of the future,

than any number of sample borings can be. In Panama we have the borings and the digging too. In Nicaragua we have only the borings.

(6) The Greytown harbor, on the Nicaragua route, offers peculiar difficulties, that promise to require ceaseless attention, even after the completion of the canal.

(7) So far as the commerce that we are interested in is concerned, we know that the time of passage, from port to port, will average from one to two days shorter by the Nicaragua route than by the Panama route.

(8) The Chagres river, on the Panama route, is as difficult a river to control, for its size, as any in the world. It runs beside the canal for some distance, and any failure to control it would mean disaster.

(9) The Panama canal being shorter, there is less likelihood of accident to a vessel during transit. Storms are less likely to come up in twelve hours than in thirty-three hours, and the passage could often be made at Panama during the daylight hours of a single day.

(10) We know that we can get adequate concessions from Nicaragua and Costa Rica. We do not know just what we can get at Panama. On this point, the importance of which can hardly be overestimated, the editor of the *Engineering News* says: "There is one advantage on the side of Nicaragua which will yet, we believe, prove the determining factor — the fact that the United States can secure there a clear concession, incumbered by no past claims or obligations. This is far from being the case at Panama. It is hastily assumed that, as the new Panama Canal Company has now offered to sell all it has to the United States for $10,000,000, the way is now open for the immediate closing of the deal. Unfortunately for those who have sunk their money in the Panama canal, this is far from being the case. Before making any such purchase the United States would have to satisfy itself that the officers of the new Panama Canal Company have the legal power to make such a transfer. It is still open to doubt whether the stockholders of the old Panama Canal Campany would not have the power at least to cloud the title given by such a transfer. Moreover, even if the Panama Canal Company disappears, the question of a concession from Colombia is yet to be met, and the difficulty of making any satisfactory and binding agreement with the Colombian government at the present time is too obvious to require comment."

In conclusion let us say that the problem, to our minds, resolves itself into just this: If the Chagres river can be demonstrably controlled, and proper concessions can be had from the Colombian government, then the Panama route appears to be the better. Otherwise the Nicaragua route appears preferable. We have already admitted that the advocates of the Panama route have prepared plans that make the control of the Chagres look feasible, and if the consensus of opinion among disinterested engineers of large experience in such matters is that these plans will be really effective, then we might take chances on the control of the Chagres, and the only remaining questions are those that relate to the validity of a transfer by the Panama Canal Company, and to the matter of concessions. These are questions for lawyers and statesmen, and we cannot do more than point them out, and call attention to their paramount importance.

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MR. W. H. WAKEMAN, of 64 Henry St., New Haven, Conn., announces that the second edition of his *Engineering Practice and Theory* is now ready for delivery.

# The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XXIII. HARTFORD, CONN., APRIL, 1902. No. 4.

## Failure of a Blowoff Pipe.

In the issue of The Locomotive for January of this year we presented an article on pipes and pipe threads, in which we called attention to the fact that pipers are often entirely too careless about the kind of thread that they cut on pipes that are to carry considerable pressures. In the course of the article we said: "When the specimens that we have illustrated are examined at first hand, they show almost every kind of a departure from the standard that they are supposed to conform to. Some are threaded too short, some do not have clean threads at all, some have threads that are wrong in shape, and some do not have the proper taper. The fact that the specimens that we have shown and described are not extreme cases in any sense, but were selected almost at random from pipe shops, shows how grave this matter is; and we want to say again, that we can hardly find words strong enough to express our condemnation of pipe work that is done in any such bungling and reckless fashion. Too much care cannot be

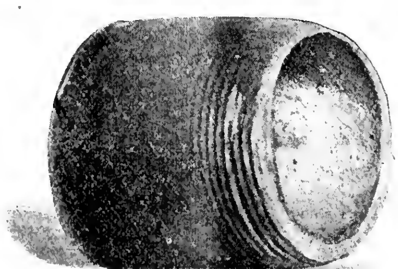

Fig. 1.

exercised in making pipe connections, particularly in steam pipe and boiler work, when failure is liable to cause loss of life. There is no reason whatever why a workman cannot determine at once, in fitting up piping, whether or not a joint is properly put together, and whether or not it is of the strength intended for standard fittings and pipe."

Some of our correspondents have thought that this general condemnation of pipe jobs is too strong, and in spite of our disclaimer, they have found it hard to believe that the specimens that we illustrated were not selected carefully, as "terrible examples," out of a great number of pipes. This is a natural enough view to take of the case, but if the doubting Thomases will only take the trouble to look into the matter for themselves, the crying need of reform in pipe threads will very quickly prove itself.

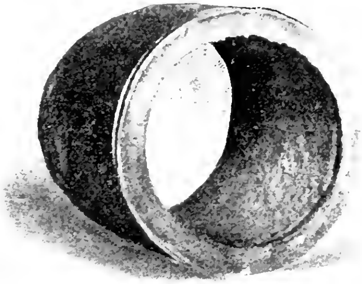

FIG. 2.

It is particularly hard to believe that any workman would allow a joint to pass, for use with high pressure steam, with the nipples made up into the fittings by only a few threads. It is scarcely credible that any piper could be so indifferent to prospective loss of life and injury to his fellow men as to pass such a job. Yet we are finding the thing done all the time.

The engravings accompanying this article represent the threaded end of a blowoff pipe that failed from just this very cause, since our previous article was printed. The boiler to which this pipe was attached was run under a pressure of 120 pounds per square inch, and the blowoff pipe was very properly made of extra heavy stock, as will be seen from Fig. 2, which shows the full thickness of the material. The thread on this pipe was so far from standard, however, that the piper found it impossible to make it up into the fitting by more than three threads. Instead of removing it and seeing that it was threaded properly, so that it could be made up into the fitting as it should be, he was content to leave it, exposed to a working pressure of 120 pounds per square inch, and with only three threads caught in the fitting.

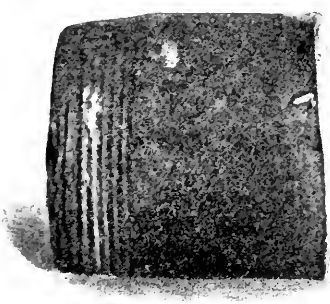

FIG. 3.

Not long after the pipe was put into service, a leak developed around the defective thread, and the constant escape of the contents of the pipe, impelled by the pressure of 120 pounds, wore the threads away until the pipe became perfectly smooth on one side, as may be seen in Figs. 1 and 4. The three threads that had held the pipe in the fitting at first were now cut entirely away for nearly one-half of the circumference of the pipe, and the result was that one day, after the boiler had been in service only about six months (if we recollect rightly), the blowoff gave way, and the attendants had very narrow escapes from being burned and scalded to death.

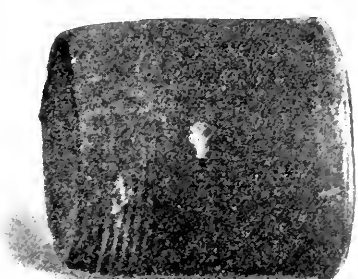

FIG. 4.

The fitting at which failure took place was buried in soot, at the bottom of the combustion chamber, below the back end of the boiler; and for this reason the sound of the escaping steam was not noted, and the explosion itself was the first intimation that the attendants had that anything was wrong. The strong scouring action that steam and water have, when escaping through a leak at high pressure, can hardly be appreciated by those who have not had experience with such matters. It will be seen, in Fig. 1, that the extra heavy pipe was thinned down, on one side, so that it was reduced, at one place, to an actual edge.

## Boiler Explosions.

November, 1900.

(329.) — On October 31st a boiler belonging to Perry J. Naylor exploded at Windfall, near Tipton, Ind. Nobody was injured. [Received too late for insertion in the regular October list.]

(330.) — The boiler of locomotive No. 767 of the Lake Shore & Michigan Southern Railroad exploded on November 1st at Shannopin Station, Pa., on the Pittsburg & Lake Erie railroad. Engineer Herman Walters was killed, and fireman John Sullivan and brakeman W. H. Porter were badly injured. Sullivan may die.

(331.) — On November 2d a boiler exploded on the Jenner oil lease, near Cannonsburg, in Union township, near Findlay, Ohio. Max B. Brugman was slightly scalded, but otherwise nobody was injured. The lease was operated by Reinsmith, Rohweder & Co.

(332.) — Two boilers exploded on November 3d in the power house of the Oakland, San Leandro & Hayward's division of the Oakland Transit Company's system at Elmhurst, near Oakland, Cal. The power house was demolished, and John Allenson, Michael Victor, and William Ford were injured. It is said that the property loss due to the explosion will amount to $20,000.

(333.) — On November 4th a boiler used in drilling the famous Hartselle oil well exploded near Hartselle, Ala. It is reported that the fireman was slightly scalded, but otherwise there were no personal injuries. The well is owned by the Moulton Valley Oil Company. The shock of the explosion was felt five miles away.

(334.) — A boiler exploded November 4th in Carroll Grayson's sawmill, at Hill City, near Chattanooga, Tenn. Kelly Grayson, a son of the owner of the mill, was fearfully scalded and bruised, and it is doubtful if he can recover. Carroll Grayson and one of his employés also received minor injuries. The mill was badly damaged.

(335.) — On November 7th a hot-water boiler exploded in the basement of the house-furnishing store of H. H. Lampe & Co., of Altoona, Pa. The basement of the building, which is used for storage purposes, was considerably damaged. Frank McNulty was slightly scalded.

(336.) — A slight boiler explosion occurred, on November 7th, in the Garver Ice company's plant, Indianapolis, Ind. The building was damaged somewhat, but nobody was injured.

(337.) — A boiler exploded, on November 7th, in the Tanglewood cotton gin, at Clayton Station, La., some twenty-five miles from Vidalia, on the New Orleans & Northwestern railroad. The gin, which belonged to J. L. & R. W. Clayton, was wrecked. Alexander Ford, Walter Valentine, and Thomas Harper was instantly killed. Robert

W. Clayton, one of the owners of the gin, was badly bruised, and two employees were scalded.

(338.) — On November 8th a traction engine boiler belonging to H. C. Horton exploded at Winder, Ga. Mr. Horton and Lewis Cane were instantly killed, and John Taylor was seriously scalded.

(339.) — An upright boiler exploded, on November 8th, in the Penobscot Chemical Fiber company's plant, at Great Works Station, Oldtown, Me., the explosion being due to the tubes pulling out of the lower tube sheet. Frederick Willett was killed, and Walter Pomeroy was severely injured.

(340.) — On November 8th a boiler belonging to Louis Just & Co., contractors, exploded in the Central Stock Yards, at Louisville, Ky. Engineer George Fusting was instantly killed, and Louis Just, Jacob Young, and John Douk were injured.

(341.) — An upright boiler, used to operate steam drills in connection with the Framingham aqueduct, exploded at Framingham Center, Mass., on November 9th. William Wheeler, the engineer, was severely injured, but will recover.

(342.) — A flue failed, on November 11th, in a boiler at one of the rolling mill furnaces at Greenville, Pa. Richard Fitzgerald was severely scalded about the arms and face, but it is thought that he will recover.

(343.) — A small boiler exploded, on November 11th, in smelter No. 3, Monterey, Mexico. Several of the workmen were injured.

(344.) — On November 12th a small boiler, used in refining oil, exploded at Dallas, Texas, in a building on Elm street, owned by Stephen Laval. No great damage was done.

(345.) — On November 12th a boiler exploded in the Norwood Cheese and Butter factory, at Norwood, near Peterborough, Ont. Thomas Moffat was injured so badly that he died about three hours later. Daniel Oakley, the owner of the factory, was also injured to a lesser extent. The walls of the building were blown completely away, and the roof fell in upon the wreckage. The dome of the boiler and a portion of the shell were thrown to a distance of about three hundred yards, carrying away the chimney of a house in their course.

(346.) — On November 13th a threshing machine boiler exploded on the Arne Kittelson farm, at Esmond, near Devil's Lake, N. D. Engineer George Saunderson and Fireman Joseph Miller were killed. The threshing outfit belonged to Albert Barstad and Hans Fjone.

(347.) — A slight boiler explosion occurred, on November 13th, in the electric light plant at Harrisburg, Ill. We are not aware that any personal injuries resulted, nor that any great damage was done to property; but the city of Harrisburg was in darkness for about a week.

(348.) — Two men were killed and six were injured, on November 14th, by a boiler explosion at Paducah, Ky. We have not learned further particulars.

(349.) — A boiler owned by J. E. Buddington of New Haven, and used in connection with a pile-driver at Weatogue, near Tariffville, Conn., exploded on November 14th. The boiler was blown to fragments, and the smokestack was thrown to a distance of 200 feet. Eight laborers were working near by at the time, but fortunately none of them were injured.

(350.) — A boiler exploded, on November 14th, in the Sturgis Milling Company's plant, at Sturgis, Ky., completely wrecking the place. Engineer George Quirey was killed, and Harry Somers was injured. The property loss is said to be about $10,000.

(351.) — On November 16th a boiler exploded in Dr. S. E. Churchill's sawmill, at Sexsmith Lake, near Davenport, N. Y. Fortunately the men were all at dinner at the time, and there are no personal injuries to record. The building in which the boiler stood was totally wrecked, but the main building was not greatly damaged.

(352.) — A heating boiler exploded, on November 16th, in the Sunlight Hotel, at Cannelton, Ind. The heating plant had been in operation only about a week. No great damage was done, and nobody was hurt.

(353.) — A boiler exploded, on November 19th, on one of the pump boats at the Monongahela coal fleet, on the Mississippi River, about ten miles above Baton Rouge, La. The boat was sunk, but nobody was hurt, as the man in charge was at supper. The steam pressure was not high at the time of the explosion.

(354.) — On November 20th a boiler exploded in John Well's sawmill, at Cana, near Seymour, Ind. Engineer Charles Slagers was killed.

(355.) — On November 21st a boiler exploded in Wolfe & Co.'s sawmill, some four miles from Vanceburg, Ky., badly scalding several employees.

(356.) — On November 21st the boiler of an agricultural engine exploded on S. G. Connell's farm, at Wellsville, near Lisbon, Ohio. Hunter Connell was slightly scalded.

(357.) — A boiler exploded, on November 25th, in W. A. Turner's sawmill, at Tatumville, some nine miles east of Dyersburg, Tenn. Dallas Wagster, John Nutt, and a man named Case were instantly killed, and Homer Cowley, Joseph Dozier, and William Turner injured. It is thought that Turner (who was a son of the owner of the mill) cannot recover.

(358.) — The boiler of locomotive No. 57, on the C., L. & W. Railroad, exploded, on November 25th, at Lorain, Ohio. Fireman Harris was badly injured.

(359.) — A boiler exploded, on November 25th, during the course of a fire at the sugarhouse on T. P. Himel's Ida plantation, near Napoleonville, La.

(360.) — On November 25th a boiler belonging to the Benedum Company exploded on the David Bonar farm, at Adaline, near Moundsville, W. Va. Nobody was injured. We have no further particulars.

(361.) — A boiler exploded on November 25th in the electric light plant at Brooklyn, Mich. Engineer William Stimm was blown into the street and his head was badly cut. The building occupied by the plant was blown almost to atoms. The boiler struck the Masonic Hall 150 feet away, tearing out a large part of the side and roof of the building. Bricks and stones were thrown through buildings nearly a quarter of a mile away.

(362.) — On November 26th a boiler exploded in the shops of the Penberthy Injector Company at Detroit, Mich. About 150 men and women were at work in the plant at the time. Half of them or so were in the part of the building fronting on Abbott street, and these escaped without injury, except for slight cuts or bruises received in making a hurried escape. But the rest of the three-story brick plant was thrown down into a shapeless mass of débris, carrying the other employees down with it. Maimed and dead alike were imprisoned in the masses of brick and mortar, machinery, and iron beams. We cannot give any adequate idea of the horror of the explosion. Absolutely without warning, while the employees of the factory were at their daily labor, the shock came, the floors sank, the walls fell in, and everything was ruin and desolation. Twenty-eight persons were killed, and about thirty others were severely injured. The killed were: Louis A. Henning, Patrick Malloy, Charles Marvin, Jacob Koebel, Charles A. Lydy, A. E. Miller, A. E. Hoffman, Edward Burtch, Eugene Bertram, Stephen Kriss, Bernard Miotke, George Schoener, Christopher Waldman, Robert Creer, Joseph P. Coffey, John Frey, George Downs, Adolph Knapp, Joseph Kosack, Walter Ide, Richard Bryan, John Schaibel, William Eggers, Douglass Dickson, Peter Doll, Ignătius Brock, Thomas J. Mullane, and an unidentified man. For some time there was no sign of fire in the ruins. Then, from a dozen places, tiny jets of smoke began to rise. They grew larger, and soon the gallant rescuers were driven from the ruins by flames that crackled and leaped into the air. A dozen fire engines were soon at work, while firemen, armed with long pikes and sharp axes, strove to break their way under the mass of wreckage to the imprisoned men, or to tear away openings through which streams of water might be advantageously played upon the blaze. Charred timbers and masses of twisted iron and steel blocked the way, and it was hours before the rescuers could get to the places where the sufferers were supposed to be. We have seen no accurate estimate of the property loss, but it is thought to have been in the neighborhood of $180,000.

(363.) — A boiler exploded on November 28th at the Ida D. mine, at East Hollow, near Joplin, Mo. A. D. Robert and John Hill were instantly killed. The property loss was about $3,000. The wrecked plant belonged to E. V. Wyssbrod.

(364.) — A boiler exploded on November 28th at Frazier Bros.' oil well, on the Ingram farm, at Waverly, near Parkersburg, W. Va. The boiler and engine house was badly wrecked, but nobody was hurt.

(365.) — On November 29th a boiler used in the construction of a sewer exploded at Kingston, N. Y. Engineer Robert Murphy received slight bruises, but otherwise nobody was hurt.

(366.) — A boiler exploded on November 29th in the portable sawmill of William H. Brewer at Antioch, some ten miles south of Decatur, Ala. Lloyd Garth, Walter Johnson, James Brown, and two other men whose names we have not learned, were killed.

(367.) — Earle O'Neil and Albert Halter were instantly killed on November 29th by the explosion of a boiler on the Elias Price farm, in Liberty township, five miles west of Findlay, Ohio. The men were employed by E. V. Wyssbrod & Co., who own the oil lease on the farm, and were endeavoring to get up steam when the boiler gave way. (We do not know whether the Mr. Wyssbrod mentioned in this account is the same as the one mentioned in explosion No. 363 or not; but we presume it is the same man.)

(368.) — On November 29th a slight boiler explosion occurred at the University of California, Berkeley, Cal. Nobody was injured, and the damage was very small; but a good deal of annoyance resulted, because the boiler was used to furnish light for the building, and the accident occurred during the Junior promenade, while the Harmon Gymnasium was filled with dancers. Candles were hunted up, and the dance proceeded under difficulties, with the illumination of our grandfathers, in the place of the rays from the hundreds of miniature electric lights that had been prettily arranged for the occasion.

# The Locomotive.

HARTFORD, APRIL 15, 1902.

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

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

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


## Sailing on the Land.

The camel has long been known as the original and only "ship of the desert"; but while it may still claim the proud title of being the "original," it can no longer be admitted to be the "only" such ship. We recall that Mr. Phileas Fogg, in Jules Verne's story, "Around the World in Eighty Days," made an exciting trip across a certain section of our western country in a wheeled vehicle that was fitted with sails, and we have an idea that M. Verne must have known of something of that sort being actually tried. We have a dim recollection that we have heard of "prairie schooners," too, but we have always suspected that those prairie "schooners," instead of assisting navigation, tended to impede it, or at least to make it erratic. However, that may be, *The Strand Magazine* presents a photo-engraving of a boat on wheels, which, its correspondent asserts, is regularly in commission on the great Mojave Desert, in southern California. It is sloop rigged, and runs on four wheels, sometimes at great speed.

"A fast ride on the *Desert Queen*," says Mr. Von Blon, who describes the vessel, "amid surroundings more desolate than the lonely sea itself, is a thrilling and exciting experience. You go dodging between the dots of greasewood and cacti as you leave the camp for the solitude when the wind rises. Here and there grotesque yucca trees stand like sentinels, with gaunt arms outstretched to reach you; horned toads scurry away over the hot sands, and lizards dart, looking like blue streaks, for the shelter, but not always quickly enough, for the *Queen's* wheels have crushed many before they could move; jackrabbits go skittering through the brush, and little ash-colored desert chipmunks scatter the sand about in their frenzied haste to get into their retreats; now and then a coyote, long and gray and lean — the picture of starved want — rises upon his scraggy hind legs and sniffs; occasionally you will run over a deadly 'sidewinder' (rattlesnake) and hear the whirring of the rattles, or pass the bleaching bones of some poor creature that suffered the horrors of starvation and probably sucked the blood from its own parched tongue before the end came.

"These are familiar scenes, and at first you notice them. Then the wind grows stronger and the pace madder. You tie a string to your hat and anchor it to your suspender; your handkerchief is whipped from your neck and goes sailing and writhing up and away—away out of sight almost before you realize that it is gone. The wind here is different from any that ever blew in any other part of the world. The *Queen* is fairly flying now, and but little sail is up. The air is filled with sand and pebbles as large as buckshot, and they pelt you hard; all around towering spirals of dust — small end of the spiral down — go springing across the plain, whirling up sand to feed the terrible storm that is sweeping from the Sierra Madre Mountains to Death Valley.

Wilder becomes the speed, and you hang on frantically with both hands and find it hard to catch your breath. The man at the helm and the man hauling in canvass are too busy to see you gasp and shiver, but at last the sails are all lowered and the wonderful voyage is ended. But then it has not begun to blow yet on the Mojave Desert! Thirty minutes later, unless you had a post to cling to, you could not stand anywhere on the ground over which you have passed."

## The Metric System.

We note, with much interest, that the metric system is receiving a constantly increasing share of attention from the people of the United States and England. We do not wish to be considered rabid advocates of the system, because we are very well aware that its introduction would be attended by many grave inconveniences, and, in some lines of business, with considerable expense. Some of the arguments that have been used against it, however, appear to us to be without any very great weight. For example, it is common to hear the remark made, that the division of the units into tenths, hundredths, and other finer decimal submultiples, will be far inferior to a subdivision into halves, quarters, etc. We also hear the question frequently asked, why it will not do as well to subdivide our familiar foot into decimal parts, and so "get all the advantages of the metric system," without the manifold inconveniences attending the introduction of an entirely new unit.

Of course the reply to these objections is, that the decimal feature of the metric system is the very smallest of its advantages, even if it be admitted to be an advantage at all. But it might be admitted to be a positive and insuperable disadvantage, without thereby weakening the argument in favor of the metric system to any great extent. The decimal subdivision might be dispensed with almost entirely, and the meter be divided into halves and quarters and eighths and so on, and yet there would be a pretty good argument left, in favor of the introduction of the new system.

For the main points of advantage of the metric system are two in number. (1) Practically all the nations (except England) whose competition we feel, or are likely to feel, to any great extent, now use the metric system; and (2) the units of bulk, weight, and length are related to one another in such a simple manner that the comparatively rough calculations that enter into the affairs of our everyday life are greatly facilitated.

No man is going to buy things that are made to size according to some unfamiliar unit, if he can get the same thing, equally cheap and good, but made in conformity with a standard with which he is familiar. If we are going to sell machinery and other articles that are made to dimensions, to countries where the metric system is the standard, and compete with Germany (for example) where the metric system is also the standard, we must expect to conform to the metric system ourselves.

The second main point in favor of the metric system, namely, that in it the units of volume and weight (or mass) are related in a simple manner, has been discussed so many times, in these pages and elsewhere, that we shall not take it up again at this time. Our main desire, just at present, is to call attention to the increased interest that is taken in the system, and the continually increasing probability that some radical action, looking to the adoption of the system in the United States and England, will shortly be taken.

The general history of the metric system in this country is given very clearly in the *Journal of the Franklin Institute* for February, 1902, in an article by Samuel W. Stratton, Director, entitled "The National Bureau of Standards." A brief epitome of the article in question may be of interest.

"From the beginning of this republic," says Mr. Stratton, "many of the foremost statesmen and scientists have worked assiduously to bring our system of weights and measures to a more satisfactory condition. Washington repeatedly urged upon Congress the necessity for uniform and reliable standards, and in his third message to Congress states that 'an improvement in the weights and measures of the country is among the important objects submitted to you by the Constitution, and if it can be derived from standards at once invariable and universal, may be not less honorable to the public councils than conducive to the public convenience.' Thomas Jefferson, then Secretary of State, was directed by Congress to report upon this subject and, after a most careful consideration, he submitted a report in which he outlined two alternative plans, one based upon the retention of the then existing standards, fixing them, however, by some invariable standard, and the other a decimal system based upon the length of a pendulum beating seconds. President Madison, in 1817, reminded Congress that nothing had been accomplished in reforming and unifying the system, whereupon the whole subject was referred to John Quincy Adams, then Secretary of State. Mr. Adams gave four years of historical research and mathematical study to the matter, and then prepared a report which has become a classic in metrology, but which advised delay until the time when nations had agreed on a universal standard, or until the subject of a universal standard had received more attention. Notwithstanding these efforts and the reports of various individuals and committees, Congress has never exercised the power delegated to it by the Constitution, with the exception of an Act of May 19, 1828, relative to the adoption of a troy pound as a standard to be used in the coinage of money." Previously to this, by an act passed in 1799, provision was made for testing the weights and measures that were used at ports of entry, for ascertaining duties; but this act was not inforced, probably because no standard had been adopted by Congress, or by the Treasury Department. On May 29, 1830, the Senate passed a resolution directing the Secretary of the Treasury to have an examination made of the weights and measures used at the principal custom houses. The work was entrusted to Mr. F. R. Hassler, Superintendent of the Coast and Geodetic Survey, who reported on January 27, 1832, that he had found large discrepancies among the weights and measures in use. He was thereupon directed to secure apparatus and provide means for making copies of certain standards adopted by the Treasury Department, for distribution to the various custom houses. In June, 1838, Congress passed a resolution requiring the Secretary of the Treasury to prepare a complete set of all the standard weights and measures for each state of the Union, in addition to those intended for the use of the custom houses. On July 27, 1866, the Secretary of the Treasury was directed to furnish to each state "one set of standard weights and measures of the metric system, for the use of the states respectively." The Secretary of the Treasury, in carrying out this last resolution, procured from abroad copies of the original metric standards. "In 1866 the metric system, while not adopted by Congress, was made lawful throughout the United States; but the standards of this system were not yet satisfactory, and in 1875, more than half a century after Adams had recommended a conference between nations for the purpose of establishing world-wide uniformity in standards, such a conference was held, and, as a result, there was established in Paris a permanent international bureau of weights and measures. Many of the great scientists of the world were engaged for several years in perfecting prototypes of metric standards, and in 1899 these were ready for distribution among the seventeen nations represented in the International Conference. The bringing of the standard meter and kilogram to the United States was considered to be such an important matter that the Treasury Department sent special commissioners to Paris for them. When the standards reached Washington, they were opened in the presence of the President, the Secretary of State, and a distinguished company of scholars invited to the White House for that occasion; and they were then placed in the custody of the office of Standard Weights and Measures. There is at the present time no satisfactory standard yard in the possession of the Government. Pound weights submitted for inspection are tested by comparison with metric weights, or with auxiliary standards that have been derived from the standard kilogram. That is to say, the standard meter and kilogram are so well constructed that more accurate standards in our own common system may be produced from them, than can be produced by comparison with any standard pound or yard in existence." Mr. Stratton also says: "In some States the standards have been destroyed or lost track of, . . . and an investigation carried on last summer by a Government official disclosed a condition of affairs, in regard to the common weights and measures of the country, that would hardly bear publication." It is evident, we think, that something ought to be done immediately, in the way of improving our system of weights and measures, whether we adopt the metric system or not; and we are very glad indeed to say that there is a good prospect that our metrology will soon be placed upon a far sounder basis, under the direction of the National Bureau of Standards, which was established by Act of Congress on March 3, 1901, of which Mr. Stratton himself is Director.

The following resolutions, which were adopted by the special committee appointed by the Franklin Institute to consider the feasibility and advisability of adopting the metric system in the United States, were submitted to the Institute on February 19, 1902, and have led to a general discussion of the whole subject, once more, in the technical press:

"Whereas, It is desirable to obtain an international standard of weights and measures, also to simplify and regulate some of our existing standards; and

"Whereas, The metric system is commendable, not only as a suitable international standard, but also for facility of computation, convenience of memorizing, and simplicity of enumeration;

"*Resolved*, That the Franklin Institute approves of any movement which will promote the universal introduction of the metric system with the least confusion and expense.

"*Resolved*, That the national Government should enact such laws as will ensure the adoption of the metric system of weights and measures as the sole standard in its various departments as rapidly as may be consistent with the public service."

The committee that presented this report consisted of ten members, of whom five are engaged in mechanical engineering, or allied industries.

At a meeting of a sub-committee, held on January 17, the following questions were discussed, and the answers that follow them were adopted:

(1) Assuming the desirability of an international standard, could we expect nations using the metric system to abandon that and adopt our system? Answer, No.

(2) Can we not concede the advantages of the metric system for purposes of computation, and also as being readily memorized and the relations between weights and measures borne in mind without much effort? Answer, Yes.

(3) Have any valid objections against the metric system been effectively urged, excepting that the numeration cannot be continuously subdivided by two? Answer, No.

(4) Is not this similar objection to our decimal currency overcome by the advantages of the system? Answer, Yes.

(5) For convenient minimum units of hand rules, is not the millimeter better than either $\frac{1}{16}''$ or $\frac{1}{32}''$, the latter being rather a fine subdivision for ordinary rough measurements? Answer, The millimeter is equally as convenient.

(6) Assuming that the change in our system could be effected without serious expense or confusion, could we recommend this change as desirable? Answer, Yes.

(7) Could not such a change be fairly initiated if the National Government would adopt the system in all its departments where no serious confusion would occur from an early change, gradually extending the system to other departments, when people became accustomed to its use, and tools were accumulated which conformed to the new standard? Answer, Yes.

(8) In the workshops, could not a large proportion of existing tools and gauges be retained until they were gradually superseded, merely designating their nominal dimensions in the nearest convenient metric units? Answer, We anticipate no prolonged serious confusion.

(9) If, in the course of a term of years, the system came into universal use in the service of the Government, is it probable that its adoption would follow elsewhere within a reasonable time? Answer, Yes.

(10) Would it appear to be practicable to inaugurate the adoption of the metric standards for weights or for liquid measures in advance of linear measures, as the former would not involve the abandonment of such numerous and costly tools as would the latter? Answer, No.

The report of the committee was followed by a discussion which was opened by Mr. George M. Bond, of The Pratt & Whitney Company, who opposed it. Eventually, however, the report was adopted by a decisive majority. The *Journal of the Franklin Institute* promises to publish, shortly, the discussion, and such of the correspondence as appears to be important.

On the same date as the adoption of the foregoing report by the Franklin Institute the Committee of the American Society of Mechanical Engineers (of which Mr. Bond was a member) issued the following report to the Society:

"PHILADELPHIA, U. S. A., Feb. 19, 1902.

*To the Council of the American Society of Mechanical Engineers, New York City:*

"GENTLEMEN:—The committee of your society to whom has been referred the consideration of the metric system in comparison with the system in use in the United States, at a meeting held in Philadelphia today, at which were present the subscribers in person or by letter, begs to report as follows:

"An attempt is being made through the Committee on Coinage, Weights, and Measures of the Fifty-seventh Congress in reference to H. R. Bill No. 2054, supplemented by H. R. Bill No. 123, to compel the adoption of the (French) metric system of weights and measures, in all departments of the government, in all its workshops, and in all matters connected with construction or commercial operations other than those relating to public lands and surveying. In this bill, on lines 9, 10, and 11, it will be seen that after fixing a date for its compulsory use, it states that the metric (French) system of weights and measures shall be *the* legal standard of weights and measures recognized in the United States. The word *the* on the tenth line must be considered as meaning the *only legal* standard, for the reason that the French metric system of weights and measures is now, and has been for many years, legalized by act of Congress, and is as free to be used and as legal in the use as are the pounds and tons or yards, feet and inches heretofore and at present commonly used in this country. If this bill is passed, it will make what we are now using to such good advantage illegal. The attention of the members of this society is therefore called to the proposed legislation, and it is earnestly urged by the committee that all the members should address their respective representatives in Congress, protesting against the passage of H. R. Bills No. 2054 and No. 123, expressing in the strongest terms their opposition to a measure involving changes that will inconvenience and hinder trade and manufacturing, and requiring an expenditure of time and money that cannot be expressed in figures, sweeping away as it does the advantages accruing from the numerous established standards now recognized and universally adopted throughout the country."

The *American Machinist* takes the view (rightly, we think,) that the American Society's committee has given too much significance to the word "the." "We note," says that paper, "that several very intelligent men who have read and studied the bill deny that it is intended to make the use of the metric system compulsory, so far as concerns transactions between private individuals. But our strongest reason for believing that it is not intended to attempt by a bill of Congress to force the exclusive use of an unfamiliar system of weights and measures upon the people of this country is that we consider it well nigh impossible to conceive that any member of Congress could for one moment imagine that any such bill would or could be enforced. It would be a dead letter from the beginning. We . . . think the committee has been needlessly alarmed. Bills of Congress intended to force the people of the United States to use the metric system, or any other system that they do not wish to use, will retard rather than advance the use of such a system."

In reply to this point, Attorney-General Knox addressed a letter to the Chairman of the Committee on Coinage, Weights, and Measures, from which we make the following extract: "The purpose and effect of each of these bills is to establish the metric system as the legal standard of weights and measures in the United States, and to require all government departments to use only that system, except in completing the survey of the public lands. This comes far short of attempting to compel the people to use only that system, or prohibiting to them the use of any other, or making invalid contracts expressed in other terms. Indeed, as each bill prohibits to the departments the use of any other system, by a familiar rule of construction this will be taken as the only prohibition intended, and it will end there. But a negative answer to your question does not depend upon a mere rule of interpretation, but is based upon much broader grounds. The result referred to, — the making of contracts illegal for this cause, — can be accomplished, if at all, only by clear provision to that effect, and there is nothing of that kind in either of these bills, which, as to this, merely declare that a system different from that now in common use shall be the legal standard. This by no means declares that no other system shall be legal or shall be used. It is both elementary and fundamental that a thing which is legal and innocent in itself is not made otherwise by making something else, even its opposite, legal, unless, indeed, there be such incompatibility that they cannot co-exist. Our present system has been always and is just *as* much the legal standard of weights and measures as if it had been so declared by statutes in the very language of these bills; and yet there has never been a time when a contract expressed as to weight or measure in the terms of the metric or other system would not have been just as valid as if expressed in the terms in common use. And so it would be under either of these bills, — just as the parties may express themselves in any language they choose, so they may designate weight and measure in any language or by any system that expresses their meaning."

The *American Machinist* adds: "Each step toward the adoption of the metric system will be taken because at that time it will be a step that will pay the person taking it. That is to say, it will be to his commercial advantage to take the given step, and he will not be influenced by any arguments that may be presented to him tending to show whether the one system or the other is more convenient, more easily handled, or less liable to mistakes. We believe that it is the failure to comprehend this hard fact that misleads what we have called the metrophobists. They undertake to show that the metric system is not as good as the English. It is doubtful if they come anywhere near showing this, but the point we make is, that whether they do or not is of very little importance. The only question is as to whether the adoption of the metric system will be commercially advantageous or not. Experience seems to show, also, that very many of the arguments that are brought against the metric system and intended to show that it is not as good as the English, fade into nothingness after a very little experience with it."

The following extract from the *Electrical World* is also of interest: "The Committee on Coinage, Weights, and Measures of the House of Representatives has reported favorably the bill establishing the metric system as the legal standard of weights and measures in the United States, and requiring all Government Departments to use only that system, except in completing the survey of the public lands. This report was rendered only after a series of public hearings, at which opponents as well as friends of the system gave testimony; and that there were but two members of the committtee of seventeen who cast dissenting votes augurs well for the final success of the measure. In the same issue of the *New York Herald* which contained an announcement of the action of the committee there appeared a cable dispatch stating that at the annual conference, last week, of the Associated Chambers of Commerce of Great Britain and Ireland a resolution was adopted almost unanimously in favor of the metric system. In a recent issue we referred in general terms to the strong support that has been enlisted in favor of the metric system in the British Parliament. We have now before us a list of 259 names of members of the House of Parliament who have signified their approval of the adoption of the metric system for Great Britain. In addition, 30 members have signified their approval but withhold authority to publish their names. Some indication of the present strong trend of opinion in Great Britain is given by the fact that since January 30 thirty-one members of Parliament have signified their approval of the system. The movement in favor of the metric system has undoubtedly gained enormously in strength in Great Britaiu during the past several years, and the time for definite action there in its favor appears to be almost ripe. As the adoption of the system by either country will inevitably force its adoption in the other, we sincerely hope that Congress at the present session will pass the bill now before it and thereby secure for this country the credit of initiative in the great reform."

The interest in the metric system being so keen at the present time, may we not remind such of our readers as might desire fuller information about what the metric system really is, and how it is related to the system now in common use, that we have published a little book giving all these facts in great detail? It contains 196 pages, of which the first 36 are devoted to a brief history of the metric system, and to an explanation of the use of the tables that follow. The remainder of the book consists of tables in which the English and metric systems are compared with each other, and the arrangement of these tables is such that they are exceedingly convenient to use. We believe that there is no book available that gives such a complete and extensive series of comparisons, and as numerous firms and individuals have sent us order after order for copies of it, we feel assured that it has been found, in practice, to be fully as useful as we tried to make it. It is convenient in size for the pocket, and for general reference, the pages being $3\frac{1}{2}''$ wide and $5\frac{3}{4}''$ long. It is printed upon excellent paper, with red edges, and is bound in sheepskin, with the title printed in gold. It will be sent to any address, postpaid, upon receipt of the price, which is $1.25. In this form it is neat and durable, and will give full satisfaction; but for the benefit of those who desire it in a still more substantial form, we have prepared an edition that is printed upon bond paper, and bound in heavier leather, with full gilt edges. We can furnish the book in this edition, postpaid, for $1.50. We desire to add that we have prepared and issued this little book for the benefit of the public, and not at all as an advertisement for ourselves, except in the sense that it advertises anybody to do a good act towards his fellow man! We have freely contributed the labor of calculating the tables and of reading the proof, and the work was done so thoroughly that not a single typographical error in any of the numerous tables has yet been reported. The prices that we have made are intended to merely cover the cost of typesetting, paper, printing, binding, and postage. All orders should be addressed to the

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THERE are some popular fallacies regarding engineering questions it seems almost impossible to kill. One of them that used to be very widely held when less was known about the strength of boiler structures was that explosions were invariably due to "shortness of water," and that with a plentiful supply of water in the boiler explosion was impossible. The tenacity with which this belief was held by the general public undoubtedly tended to obscure the real cause of these disasters, and, indeed, in many cases, led to blame being thrown upon innocent persons. Engineers, of course, now know better: but the popular mind still clings to this belief, and it is seldom a serious explosion occurs without its enunciation again appearing in the daily press. Another equally silly but fixed theory is that when ships founder the boilers invariably blow up as they disappear under the waves, uttering, as it were, a death-knell over their unhappy fate. We are reminded again of this in connection with the recent sinking of the *Waesland* off Holyhead, the daily press accounts of which were accompanied with the usual story about the rush of steam from the bursting of the boilers as the ship disappeared. This popular fallacy appears to be based on the unquestioned fact that in such cases a rush of steam escapes from the funnels, and to an idea that the sudden drowning of the boilers makes them burst — that, in a word, they explode, if we may coin an antithesis, from "excess of water." The observed phenomena is, however, capable of very simple explanation, though it does not provide matter for the sensational "copy" in which the average reporter delights. That a rush of steam should escape up the funnels when the rising water reaches the level of the furnaces and suddenly quenches the fires is only natural; but the immersion of a steam boiler in cold water, far from causing increase of pressure, has a precisely opposite effect, and lowers it by condensation at an exceedingly rapid rate. The risk of damage, if there is any, is that due to the creation of a partial vacuum in the boiler, as a consequence of which the shell stands a chance of being collapsed or crushed. The chance of this, however, is small, and we have never yet heard of a case in which a vessel has been subsequently recovered by salvage operations being found with either a burst boiler or a collapsed one. The daily papers, of course, pay little or no attention to this sequel of events. The requiem of burst boilers becomes, like "shortness of water," reporters' tradition, to be stowed away till another disaster occurs, when it is trotted out again as one of the thrilling incidents of a catastrophe.—*The Mechanical Engineer* (London).

## Pulverized Fuel.

Several experimenters are at work upon the problem of burning coal by pulverizing it so finely that when injected into the furnace it burns like a gas. In some the coal is blown in with an air jet. In others it is thrown in by a rapidly revolving wire brush. We have recently seen a boiler operated by a device of the latter sort. The combustion was perfect and the evaporative results, according to the statement and records of the engineer, excellent. Ordinary grates were used and covered with a thin fire of what appeared to be ordinary coal, which we supposed was maintained for the purpose of insuring the combustion of the injected dust. But on inquiring about the renewal of this fire, it appeared that it was automatically maintained, a sufficient number of particles of which escaped immediate combustion, conglomerated into a fire composed of what appeared to be coal about the size of a walnut. Above this fire was a sheet of flame like that of an immense gas jet. The boiler could be forced far above its capacity with an ordinary fire, and the rate of evaporation was under perfect control down to a fraction of the normal capacity.

The delay in the adoption of this method of firing, which approaches in simplicity the use of liquid fuel, appears to be not that it cannot be done successfully, but that a supply of the pulverized fuel is not yet assured at a price which will allow it to compete with ordinary coal. A plant for pulverizing fuel could be probably put down to convert a cheap grade of coal into a concentrated and valuable fuel at a cost which would compare favorably with the coal now available, but this has yet to be demonstrated, and this demonstration is hampered by the possibility of spontaneous ignition in amounts of coal so finely divided. Many engineers are afraid that a bag or barrel of this coal powder may ignite spontaneously, some time, outside the furnace, and for this reason some inventors are working on the line of a pulverizer attached to the boiler itself which pulverizes the fuel only as fast as it is used, while others still believe it feasible to pulverize it in quantity and store it safely. Unfortunately, anthracite can be used only in combination with bituminous coal, so that the process, if successful, promises only a partial solution of the problem of the disposal of anthracite waste.—*Power*.

[We are of the impression that means have already been devised for pulverizing anthracite at a cost of not over twenty-five cents a ton. Some inventors claim to have reduced the cost of pulverization to ten cents a ton; but we doubt if such a low figure as this can be realized continuously in practice.—*Editor* THE LOCOMOTIVE.]

THE END OF THE BIG BETHLEHEM HAMMER.—The 125-ton steam hammer erected at the works of the Bethlehem Steel Co., South Bethlehem, Pa., in 1892—the largest steam hammer in the world—is being demolished. This hammer, as visitors who saw the full-size model at the World's Fair, in Chicago, in 1893, will remember, was a vertical-acting steam engine with a heavy ram at the lower end of the piston rod. The internal diameter of the steam cylinder was 76 in. and the normal stroke of the piston 16 ft., the maximum stroke being 20 ft. The total weight of the piston, the piston rod. and the ram was 125 tons. The hammer was operated by admitting steam below the piston to raise the ram, which was then permitted to drop by gravity. The machine stood 90 ft. high and was 38 ft. on the longest dimension across the base. The experience with this hammer was rather unsatisfactory, the action of the blow being so rapid that the compression of large pieces of metal could not be distributed uniformly through the mass. As a result, internal strains were set up in the metal, tending to the formation of flaws. For heavy forging it was found that hydraulic presses were more satisfactory, the pressure being applied slowly and continued uniformly to the end of the stroke, working the interior of the metal as thoroughly as the outside and making the forging homogeneous. As a result of the competition between these two classes of machines for heavy steel forging this large steam hammer has been standing idle for the past six or seven years. and finally it was decided to take it down and consign it to the scrap heap.—*Railwa Review*.

# The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XXIII. HARTFORD, CONN., MAY, 1902. No. 5.


## The Flaring of Boiler Tubes.

It is a familiar fact that man needs to have the moral law dinned into him at frequent intervals. He may know all about it, and yet he is likely to grow lax or forgetful, so that the only way to ensure his constant attention to the things that he should do and should not do, is to forever keep calling his attention to them. To a certain extent this principle applies also to boiler practice, and for that reason we have often republished, in The Locomotive, warnings and recommendations that have been given before in previous issues.

One of the things that we find it necessary to call attention to, on frequent occa-

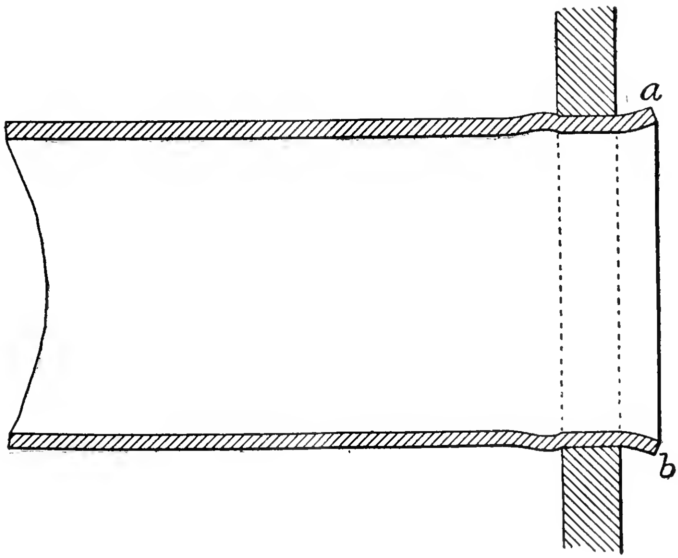


Fig. 1.— A Flared Tube-End.

sions, both in The Locomotive and otherwise, is the matter of the flaring of tube ends, in water tube boilers, in order to give the tubes the proper holding power. We have often been told that a tube has sufficient holding power, even when it is merely expanded, without being either flared or beaded. Under some circumstances this is undoubtedly the case, and we have many boilers under our care whose tubes are neither flared nor beaded; but in this matter, as in all others, good judgment must be exercised, and a construction that may be accepted as satisfactory for a low pressure and easy running condition, will not necessarily commend itself when the pressure to be carried is high, or the feed water is so bad that a heavy deposit of scale, and consequent overheating, may be regarded as easily possible.

The question of the stress that tends to pull a tube out of its header in a water tube boiler was discussed in a thorough and elementary manner in THE LOCOMOTIVE for December, 1900. In the present place it will only be necessary to say, therefore, that the force that tends to pull the tube out of the header is numerically equal to the total pressure of the steam against a circle whose diameter is equal to the outside diameter of the tube. To take a numerical example, let us suppose that the tube is 4 inches in diameter, externally, and that the pressure to be carried is 200 pounds per square inch. We wish to know the force tending to pull the tube out of its header. That means that we have to calculate the total steam pressure against a 4-inch circle. The area of a 4-inch circle is 12.57 sq. in.: and the pressure against each square inch being 200 pounds, the total pressure against the 4-inch circle would be $12.57 \times 200 = 2,514$ pounds. That is, the force tending to pull out a 4-inch tube, in a water tube boiler running at 200 lbs. per sq. in., is 2,514 pounds.

Let us now compare this result with the known holding power of tubes that are expanded, and with those that are flared. In the issues of THE LOCOMOTIVE for May, June, and July, 1881, we printed articles on the holding power of tubes set in various ways; and we give certain of the tabulated results again in this place, in order to emphasize the fact that the holding power is greatly increased when the projecting end is belled or flared. The tubes upon which these experiments were made were three inches in diameter, externally, in the body.

It will be seen that the holding power of the tubes tested averaged about 6,300 pounds for those that were merely expanded, and about 19,700 for those that were expanded and flared. Flaring therefore multiplied the holding power by about three. If we assume that the holding powers of 3-inch and 4-inch tubes are not greatly different, the increased thickness of the header (over that of the tube sheet that was used in the experiments here quoted) being perhaps compensated for, roughly, by the larger diameter of the tube, then it is easily seen that a 4-inch tube, running under a pressure of 200 pounds per square inch and merely expanded into place, has a factor of safety of $6,300 \div 2,514 = 2.5$, which is entirely too small. With the tubes properly flared, the corresponding factor of safety, under similar conditions, would be $19,700 \div 2,514 = 7.8$, which is quite large enough.

We are well aware that there are plenty of water tube boilers that are running, at this moment, with tubes that are merely expanded into place; but that does not invalidate our argument. Some few years ago, when the prevailing pressures were materially less than they are now, constructions might be approved as quite safe for general use, which can no longer be considered advisable. The tendency, in practice, is ever towards higher and higher pressures, and pressures of 200 pounds are now quite common. It is to be expected that boiler makers will modify their standard methods of construction to meet this change in conditions; and while we should not want to say that all water tube boilers must have flared tubes, it is at least fair to refer once more to the matter of flaring tubes, and it is fair to say that a boiler that is to carry a pressure so heavy that expanded tubes will not give a proper factor of safety, must certainly have its tubes flared before we shall be willing to certify that it is safe, and issue a policy of insurance upon it.

A tube in order to be properly flared, should project beyond the header from one-quarter to three-eighths of an inch. If the projection is much less than one-quarter of an inch, the tubes cannot be properly flared; and if it is much greater than three-eighths of an inch it is difficult to flare the ends properly without causing them to split. Sometimes, even when they do not split, tubes that project to a considerable distance possess so much spring that they cannot be flared properly. This is especially true of steel tubes. A tube that splits when being flared under reasonable conditions, is made of material that should not be used for boiler tubes. It is not uncommon to find tubes projecting from $\frac{7}{8}$ in. to 1 inch through the tube holes. This is entirely too much, for it is practically impossible to flare a tube with so great a projection in a correct manner.

A tube should always be flared so that its diameter, at the extreme end of the flare (that is, at *a b* in Fig. 1), shall be at least one-eighth of an inch greater than the diameter of the hole in the tube sheet. In the case of the vertical nipples that are found in water tube boilers, connecting the parts of the boiler with one another, the ends of the nipples should *always* be flared, whether the boiler is to carry a light pressure or a heavy one; for strains of some considerable intensity, due to the expansion and contraction of the parts of the boiler, are thrown upon these nipples, and the effects of the vibration which is common to all steam generators are also concentrated at these points, so that there is a tendency to loosen the hold of the nipples upon the headers or boxes with which they connect. A short nipple of the sort we refer to is shown in Fig. 2, which is reproduced from our issue for July, 1900. The longer nipples that connect the various headers and drums and other units together should also be flared just as carefully as these shorter ones. We recommend that these nipples be made to project through the headers about three-eighths of an inch, and that they be flared at least *three-sixteenths* of an inch.

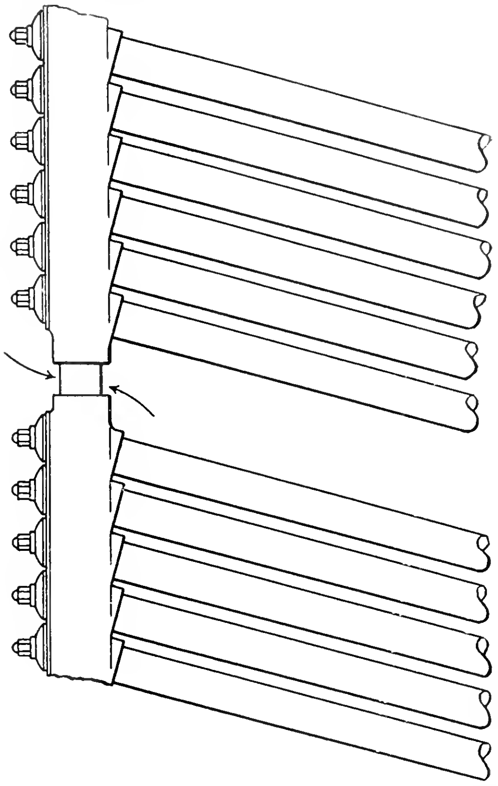

Fig. 2.—Short Nipple Connecting Two Headers.

We know from expensive experience, that if these precautions are not taken, especially in boilers that are to carry heavy pressures, a small amount of leakage or overheating is likely to lead to deplorable results.

## Explosion of a Bed Warmer.

Mrs. Gottlieb Hussman of 225 South Fourth Street, Lafayette, Ind., was seriously burned about the face and hands by hot water thrown on her as she was preparing to retire on February 9th, by the explosion of a hermetically sealed heating pan. She had placed the pan under the covers of her bed and was about to lie down, when it exploded. The bed looked as if a tornado had hit it.— *Cincinnati Enquirer.*

## Boiler Explosions.

December, 1901.

(369.) — A flue burst, on November 17th, on a Great Northern locomotive at Brockton, near Havre, Mont. Fireman James Edwards was scalded to death.

(370.) — On November 20th two limited passenger trains collided on the Santa Fe railroad, near Needles, Cal. The west bound train was being hauled by two locomotives, and the boilers of both exploded immediately after the crash. The debris took fire, and five cars were burned. As the result of the collision and explosion, seven men were killed, and sixteen persons were injured.

(371.) — The boiler of a Lake Shore locomotive exploded, on November 29th, at North Amherst, near Elyria, Ohio. The fireman was badly scalded, but the engineer escaped without injury.

(372.) — A boiler exploded, on December 3d, in Ellis Henderson's sawmill, at Yellowstone, sixteen miles southeast of Bloomington, Ind. Marion Lutz, Perry Mitchell, and Ellis Henderson were killed, and four other employees, whose names we have not learned, were injured. Two farmers, who were standing near, also received minor injuries. The property loss is probably about $3,000.

(373.) — On December 3d a boiler exploded in J. H. McNeil's cotton gin, at Sneed, I. T. Mr. McNeil was badly scalded and bruised.

(374.) — On December 3d the boiler of locomotive No. 886, on the Erie railroad, exploded near the Pennsylvania Avenue crossing, at Elmira, N. Y. Fireman M. M. Latham and Brakeman Charles Ostrander were injured badly, but both will recover. The explosion consisted in the failure of the crown sheet.

(375.) — On December 3d a boiler, used to run a corn shredder, exploded on the Gerhardt Steinkamp farm, at Holland, near Huntingburg, Ky. The engineer was fatally injured, and three other men were also injured seriously.

(376.) — A boiler exploded, on December 4th, in the state conservatories in Capitol Park, Harrisburg, Pa. The end of one of the rose houses was blown out, and the loss is variously estimated at from $250 to $600.

(377.) — On December 5th a boiler exploded in L. Waldo Thompson's hardware store, Woburn, Mass. The explosion blew out the front of the building and set fire to the ruins. The stock in the store included gunpowder, gasoline, and other inflammable substances, and the fire was very hard to control. The gunpowder exploded shortly after the arrival of the fire department. The total loss, due to the explosions and the fire, is estimated at $4,500. Nobody was seriously injured.

(378.) — On December 6th a boiler exploded in the Houlton Water Company's plant, at Houlton, Me. One man was scalded. The property loss was small.

(379.) — A heating boiler exploded, on December 11th, in the Haws Avenue M. E. Church, at Norristown, Pa. The boiler was badly damaged, but, fortunately, no harm was done to the church.

(380.) — On December 12th a tube burst in No. 2 boiler of the Easton Power Company's plant, at Easton, Pa. Manoah Shockency, Jacob Johnson, Thomas Miller, and Frederick Simons were painfully injured.

(381.) — On December 14th a boiler exploded in Uptegrove's factory, at Johnson City, Tenn. Noah Collins, a machinist, was scalded so badly that he died within a short time.

(382.) — The Sluss sawmill, at Sundance, Wyo., was wrecked by the explosion of a boiler on December 15th, but nobody was seriously injured. The boiler was thrown several hundred feet, the buildings were shattered, and the machinery was considerably damaged.

(383.) — On December 16th a boiler exploded in the Star laundry, at Mayfield, near Paducah, Ky. Nobody was injured, and the damage was mostly confined to the boiler.

(384.) — A boiler exploded, on December 16th, in the Indiana Bottle Company's plant, at Shirley, Ind. The building in which the boiler stood was demolished, and the office and a neighboring dwelling were slightly damaged. Nobody was hurt.

(385.) — On December 17th a boiler exploded in the North school, at Lancaster, Wis. We have not learned further particulars, except that the schools were necessarily closed while repairs could be made.

(386.) — A boiler exploded, on December 17th, in Theodore Busch & Co's. sawmill on the Valley river, some three miles south of Wheeling, W. Va. Samuel Kiger was killed almost instantly, and the mill was damaged to the extent of about $2,000.

(387.) — A boiler used in drilling an oil well for the Springfield company exploded, on December 18th, at Logan, near Lima, Ohio. The shelter house in which the boiler stood was blown to splinters. Nobody was injured.

(388.) — A slight boiler explosion occurred, on December 18th, in the basement of the opera house at Carthage, Mo. The boiler was used for heating purposes. The damage was not great, and nobody was injured.

(389.) — On or about December 18th a heating boiler exploded in the Alpha Tau Omega fraternity house at Champaign, Ill. We have not learned further particulars.

(390.) — A boiler exploded, on December 19th, in the Richardson sawmill, at Benville, near Kingston, Ill. Charles Cook was seriously injured.

(391.) — Two boilers exploded, on December 20th, at the Black Diamond Steel Works, Pittsburg, Pa. Six men were killed, and twelve others were seriously injured. The mill in which the boiler exploded belonged to Park Brothers, and was completely wrecked, the debris being piled from fifty to seventy-five feet high. The boiler works of the McNeil Company, adjoining the Black Diamond works, were also destroyed. One account that we have received states that "there is not a straight piece of iron or steel left in the building; even the bolts in the beams and stringers are twisted like screw nails." The estimates of property loss that we have seen are various, and range from $25,000 to $100,000.

(392.) — On December 21st a boiler exploded in the plant of the American Steel and Wire Company, on Neville Island, near Emswith, Pa. One man was killed, and the plant was considerably damaged.

(393.) — A heating boiler exploded, on Dec. 21st, in the Lees Memorial bathhouse, at Louisville, Ky. William Charlton and John Averill were painfully scalded and burned.

(394.) — On December 23d two boilers exploded in the Singer-Nimick West End plant of the Crucible Steel Company of America, at Pittsburg, Pa. Eleven men were scalded very badly, and several others received lesser injuries. Of the injured, William Reed, Alvin K. Pershing, John P. Brown, Ford B. Reed, and William Sharp have since died, and two others are in a critical condition.

(395.) — On December 22d a boiler exploded in Wunderly's planing mill, at Nazareth, Pa. The boiler house was wrecked, but nobody was injured.

(396.) — Three boilers exploded, on December 22d, at the No. 9 Colliery of the Lehigh and Wilkesbarre Coal Company, at Sugar Notch, near Wilkesbarre, Pa. The boiler house was destroyed, and several small buildings close by were somewhat shattered. As the explosion occurred at eleven o'clock Sunday night nobody was injured.

(397.) — On or about December 22d, a locomotive fell through a bridge over Lycoming Creek, near Williamsport, Pa., and when the locomotive was recovered it was found that its boiler had exploded. No trace of the bodies of the engineer and fireman could be found, and it is believed that they were killed by the explosion.

(398.) — A slight boiler explosion occurred, on December 23d, in the street railway power house at Canton, Ohio. Fireman Charles Rake was burned somewhat. There was no serious property loss.

(399.) — On December 24th a boiler exploded in F. M. Head's distillery, at Gethsemane, Ky. George Wethers and another man were severely injured, and the building was considerably damaged.

(400.) — A slight explosion occurred, on December 24th, in the pumping station at Jefferson, Iowa. Nobody was hurt, and the damage was confined to the boiler.

(401.) — A boiler exploded, on December 24th, in J. L. Norton's fertilizer manufacturing plant, at Delaware, Ohio. Two men who were standing within a few feet of the boiler escaped without injury. A portion of the building was blown away.

(402.) — On December 25th a boiler exploded in the National Biscuit Company's new building at Pueblo, Colo. Engineer E. H. Marsh was badly injured.

(403.) — A boiler exploded, on December 26th, in McKenna Bros'. slaughter house, at Connorsville, Ind. Nobody was injured. A large part of the south wall of the building was blown out, and a hole twenty feet square was made in the roof.

(404.) — A boiler exploded, on December 28th, at Charlotte, near Grand Rapids, Mich. Claude Sawyer was badly injured. We have not learned further particulars.

(405.) — On December 31st a boiler exploded in Blackwater Lumber Company's plant, at Davis, W. Va. Nobody was injured, although there were several very narrow escapes. The explosion wrecked two other boilers, and blew out one side of the boiler house.

(406.) — A heating boiler exploded, on December 31st, in the basement of the Sacred Heart Institute, at Duluth, Minn. The building was damaged to the extent of about $3,000, but nobody was killed or injured. Evening devotions were in progress in the chapel, and Bishop McGolrick was pronouncing the benediction, when the explosion occurred with a terrific report. Fragments of the boiler came up through the floor, and the woodwork above the boiler room took fire.

(407.) — A boiler exploded, on Dec. 31st, at Britt's Switch, some nine miles from Prescott, Ark. Timothy Moore, James A. Hogue, and A. T. Callahan were instantly killed. Thomas Hudson, George Williams, and several other men were injured.

# The Locomotive.

HARTFORD, MAY 15, 1902.

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

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

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

WE print, in this issue, an article on the elementary principles of arithmetic. It might be thought that we should offer some sort of an apology for printing matter of this kind, that ought to be given in every school boy's arithmetic; but we desire to say that we do not agree with this view of the case. Many of the engineers who read THE LOCOMOTIVE have not had the advantage of any very great mathematical training, and to such the article in question is addressed. Others will please pass it by.

## Boiler Explosions During 1901.

We present, herewith, our usual annual summary of boiler explosions, giving a tabulated statement of the number of explosions that have occurred in the United States during the year 1901, together with the number of persons killed and injured by them.

We desire to say once more, that it is by no means easy to make out accurate lists of boiler explosions, because the accounts that we receive of them are often unsatisfactory. We have spared no pains, however, to make this summary as nearly correct as possible. In making out the detailed monthly lists from which it is extracted (and which are published from month to month in THE LOCOMOTIVE) it is our custom to obtain as many distinct accounts of each explosion as possible, and then to compare these different accounts diligently, in order that the general facts may be stated with some considerable degree of accuracy. It may be well to add, too, that this summary does not pretend to include *all* the explosions of 1901. In fact, it is probable that only a fraction of these explosions are here represented. Many accidents have doubtless happened, that were not considered by the press to be sufficiently "newsy" to interest the general public; and many others, without doubt, have been reported in local papers that we do not see.

The total number of explosions in 1901 was 423, which is 50 more than we recorded for 1900. There were 373 in 1900, 383 in 1899, 383 in 1898, and 369 in 1897. In nine instances during the past year two or more boilers exploded simultaneously. In such cases we have counted each boiler separately in making out the summary, as we have done for some years past; believing that in this way a fairer idea of the amount of damage may be had.

The number of persons killed in 1901 was 312, against 268 in 1900, 298 in 1899, 324 in 1898, and 398 in 1897; and the number of persons injured (but not killed) in 1901 was 646, against 520 in 1900, 456 in 1899, 577 in 1898, and 528 in 1897.

It will be seen from these figures that during the year 1901 there was, on an average, 1.16 explosions per day. The figures in the table also show that the average of the deaths and injuries during 1901, when compared with the number of explosions, was as follows : The number of persons killed per explosion was 0.74 ; the number of persons injured (but not killed) was 1.53 ; and the total number of killed *and* injured, per explosion, was 2.27.

In making out the number of killed and injured, we have tried to be perfectly fair to the records already published in our monthly lists. For example, on January 31, 1901, there was a boiler explosion in William Wicke & Company's cigar factory, New York City. Fire followed the explosion, and as the result two men were killed and twenty-two others were injured so badly that they were removed to the hospital for treatment. In this case we have not counted any of the killed or injured in making out our summary for the year, because the deaths and injuries were not the *direct* result of the explosion. They were the *indirect* result of it, it is true, but we have thought it fairer not to count them in making out the table, because they would not have occurred if fire had not followed. Again, on August 14th a fire broke out in a temporary water

SUMMARY OF BOILER EXPLOSIONS FOR 1901.

| MONTH. | Number of Explosions. | Persons Killed. | Persons Injured. | Total of Killed and Injured. |
|---|---|---|---|---|
| January, | 41 | 9 | 54 | 63 |
| February, | 30 | 13 | 30 | 43 |
| March, | 45 | 23 | 63 | 86 |
| April, | 30 | 21 | 37 | 58 |
| May, | 31 | 22 | 55 | 77 |
| June, | 23 | 19 | 20 | 39 |
| July, | 29 | 22 | 48 | 70 |
| August, | 41 | 45 | 99 | 144 |
| September, | 29 | 20 | 43 | 63 |
| October, | 40 | 34 | 78 | 112 |
| November, | 44 | 56 | 73 | 129 |
| December, | 40 | 28 | 46 | 74 |
| Totals, | 423 | 312 | 646 | 958 |

works crib at Cleveland, Ohio, and a boiler explosion followed, with the result that eleven men were killed. Here, also, we did not count the casualties in making out our summary, because it is very difficult to distinguish between the results of the fire and those of the explosion. We make these explanations in order that it may be clearly understood that we have carefully avoided any tendency that we might be supposed to have, to emphasize the horror of boiler explosions, for business reasons, in any unfair way.

In one or two cases explosions that were at first reported as boiler explosions, and were so given in our regular lists, afterwards were found to have been due to other causes. These have been omitted in making out this summary. One explosion was also reported twice by mistake (see Nos. 128 and 216). This error has also been corrected.

The most serious explosions of the year, so far as loss of life and personal injuries are concerned, were as follows : At the Doremus laundry, Chicago, on March 11th, nine persons were killed and 25 others injured ; the port boiler of the steamer *City of Trenton* exploded on the Delaware river, near Philadelphia, Pa., on August 28th, with the result that some 25 persons were killed and some 50 others injured; and on November 26th a boiler exploded in the shops of the Penberthy Injector Company, at Detroit, Mich., killing 28 persons and injuring 30 others.

We are aware that it would add greatly to the interest of these annual summaries that we print, if some estimate of the property loss could be given. We are often asked about this point, and we should be glad to give the desired information, if we could get it. Usually, however, it is very difficult to obtain reliable estimates of the loss resulting from a boiler explosion, unless the boiler is insured; and hence it is impossible to arrive at any trustworthy figures for the total destruction of property for the year.

## Smoke Abatement in Large Cities.

The crusade against the smoke nuisance in this country is of a comparatively recent date. A hundred years ago, when most of our population was confined to the Atlantic seaboard, with its extensive forests, wood was the almost universal fuel, but our forests were slaughtered so recklessly that within the past fifty years wood has become scarce and dear, except in the wilds of Maine and the newly settled regions of Minnesota and Wisconsin. The use of bituminous coal is of even more recent origin, since the early mines in eastern Pennsylvania were mostly anthracite or semi-bituminous.

As the center of population moved farther west, more and more reliance was placed on the soft coal fields of the central States, with their almost illimitable area. It is safe to predict that bituminous coal will be for years to come the principal fuel for factories and large business blocks, its price being but little over half that of hard coal. In certain thickly settled districts, particularly in the heart of our larger cities, it may be possible to enforce the use of coke and smokeless coal, but no amount of legislation could ever compel the general use of such expensive fuel.

The problem, then, which we have before us today is that of burning ordinary soft coal with the least possible amount of smoke. It may be said at the outset that the total prevention of smoke from this class of fuel is an impossibility, and that no city where bituminous coal is burned will ever be as clean as those where the use of anthracite is insisted upon. The Eastern cities will have the advantage, since they are so near the anthracite coal fields, and have but to make early and strenuous efforts to keep out the smoky coals of the central States. In cities like Chicago, Cleveland, and St. Louis, the smoke evil is already a gigantic fact which must be met and grappled with, so that the war becomes one of offense rather than defense.

The first plan which naturally occurs to the municipality is that of prohibitory legislation, or stringent laws against the production of black smoke, which shall be enforced by the city police, with suitable penalties for infraction. Such laws are a part of the municipal code of nearly every Western city. In some they are entirely a dead letter, no attempt being made to enforce them; in others spasmodic efforts are made from time to time to carry out their conditions. In some instances the city ordinances have been so arbitrary and unreasonable in character that they were declared invalid by the courts; even where the ordinance has stood the test of trial, the defendant companies or corporations have often found it more profitable to carry the case from court to court, with the probability of its being ultimately knocked out, than to acquiesce and pay the fines. Whatever the outcome of these prosecutions, the effect on the smoke evil has been very slight. One of the causes of failure seems to be common to nearly all of our cities: namely, the fact that the office of smoke inspection, whatever its title, has been usually one of the political "plums" given, without reference to fitness for the office, as a reward for partisan service.

The city of Cleveland first established a department of smoke inspection in 1883, and the agitation against smoke has been carried on in an intermittent sort of way ever since. In the early days the inspector acted only on complaints, then served legal notices on the offenders with some definite time for abatement, usually thirty days. As far as the records show, this usually resulted in nothing, as there are only three prosecutions recorded in a period of nine years, two defendants being fined the costs, and one ten dollars and costs, with the sentence suspended. The records of abatement usually read "partially abated." The column of remarks is full of good promises, but there is little to show any improvement. During the past five or six years several test cases have been tried in the courts with very poor success, some of them failing in the police courts, the judge declaring the ordinance defective or the evidence inconclusive. Others dragged along for years and were finally thrown out by some of the upper courts. Whatever reduction of smoke occurred during this time may be attributed, not to legal measures, but to a growth of public sentiment, and to the voluntary introduction of improved furnaces as a matter of business economy or civic pride.

The subject was carefully investigated by a society organized for that purpose, and considerable educational work was done, which has shown its results. About two years ago the Municipal Association of Cleveland appointed a committee of five, principally manufacturers, to investigate the matter and report. The members of that committee held a number of meetings, and made a careful study of the subject in all its bearings. As a result of their investigations they decided that methods of legal process had proved a failure; that a campaign of education and argument would be more effective; that the matter should be put into the hands of a new department which should be organized for this express purpose, and that the chief inspector should be appointed by the Mayor for a term of not less than five years to insure the removal of the office from party politics. This committee secured the passage of a law by the Legislature which should meet these conditions, and in July, 1900, the writer was appointed supervising engineer. The department as at present constituted has a working staff consisting of a supervising engineer, three assistant engineers, and a clerk. This is rather too small a force for a city of the size of Cleveland, but it was thought better to have the number of appointees too small rather than too large.

It seemed advisable as a beginning to get a comprehensive view of the situation, and to know at first hand the condition of each chimney, so as not to be dependent upon the complaints of inexperienced and careless observers. A canvass of the city was immediately begun, and a card index started to show the number of boilers and kind of furnaces in use at each establishment, together with such other data regarding fuel and working force as might be useful. This list has just been completed, and shows for the city of Cleveland over a thousand distinct plants, operating nearly twenty-two hundred steam boilers. About the same time a series of systematic observations was commenced to determine the smoke record for each chimney. Some citizens have felt inclined to criticise the observation part of the scheme, claiming that it was merely guesswork; but any unprejudiced person will readily see that observations made by a trained engineer, day after day, will give a much better idea of the smoke situation than can be had from the casual observation of the ordinary individual.

The city being divided into districts, some favorable observation point was selected from which all the principal chimneys in the district could readily be seen. The inspector stations himself at one of these points, takes readings from each chimney once in five minutes, and records the rating on a blank prepared for the purpose. In all, one hundred such readings are taken, covering a period of about eight hours, from eight o'clock in the morning until four o'clock in the afternoon. To make the average still more reliable, these observations are divided into two-hour periods, taken on different days. The readings are then averaged on a scale of one hundred, the latter per cent. meaning dense black smoke. A report is then immediately sent to all of the firms interested, showing not only their own standing, but that of their neighbors. In case the smoke average is too high, the report is accompanied by a letter urging immediate attention to the subject, and this is followed in a week or two by a personal visit from one of the inspectors. The idea is to urge better equipment, both from the standpoint of interest in the welfare of the city, and from that of fuel economy. It is easy to demonstrate the saving in fuel by reference to actual examples near by.

In nearly all cases the inspectors are courteously received, and promises to investigate are made. But this is not the end; unless the subject received immediate attention at the hands of the firms visited, their attention is called to it again and again by letters and visits. Some of them immediately set about remedying the difficulty, while others wait until they find that the department really means business. In many instances it has taken a year of this work to start some of the proprietors in the right direction, and there are still many that are holding back. An improvement of this kind gains momentum as it proceeds, however, and, like the rolling snowball, increases in weight more and more rapidly as it goes on. Like all reforms that affect the pocket-book, this one moves slowly, and there is much to discourage; but, on the whole, the influence is far more effective than that of coercion. There is comparatively little of that feeling of antagonism and opposition which is so frequently aroused by the use of legal processes.

The case of railroad engines offers a striking example of the advantages of the educational campaign. Previous to the institution of this department, notices had frequently been served upon the railroads, with orders to abate the smoke within thirty or sixty days. Of course no attention was paid to these admonitions, and nothing could have been done in the time indicated. As soon as practicable, the city appointed an assistant engineer who had been a railroad man of long experience, and who was familiar with all the ins and outs of locomotives. This inspector has devoted all of his time to the railroad problem. Meetings were held to confer with the officials of the various roads, and to get their advice in the matter. A meeting of representative engineers and firemen was also held, and their views ascertained. It was the unanimous opinion of both superintendents and engine men that a great improvement could be effected by the one-shovel system of firing, with proper attention to the opening and closing of the doors, together with such aid as might come from brick arches and combustion tubes. The inspector watches the locomotives as carefully as the other engineer does the stationary chimneys, although the method is of necessity somewhat different. Without going into the details of the work, it may be said that the reports of this inspector, which are sent in every two or three days to the railroad officials, are so satisfactory and so reliable that they feel like proceeding against offenders at once. In some cases crews have been suspended, in others merely warned. The reports have been posted in the roundhouses and in other places where the crews could see them, and most of the railroads have appointed inspectors and traveling engineers to instruct the firemen of the engines in the best methods of stoking. The result can be best shown by a comparison between the records of March, 1901, and those for November of the same year, which is given below.

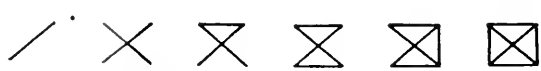
Each of these rates represents an average from some twenty-five observations on different engines. This improvement is due solely to improved methods of "firing" resulting from the efforts of this office in co-operation with the officials of the railroads.

| | March. | November. |
|---|---|---|
| Cleveland & Pittsburg railroad, | 28% | 8% |
| C., C., C. & St. Louis railroad, | 35% | 13% |
| Erie railroad, | 35% | 12% |
| N. Y. C. & St. Louis railroad, | 35% | 10% |
| L. S. & M. S. railroad, | 34% | 11% |
| C. T. & Valley railroad, | 20% | 11% |

Work with tugs and other boats on the river has but just begun, but there is no reason apparent why similar improvement cannot be made in this direction. The large manufacturers and the superintendents of the railroad lines are practically unanimous in their approval of the method now in use, and say that it is the only rational way to attack the problem. The fact that during the time since this movement was inaugurated, in July, 1900, over two hundred smokeless furnaces of various sorts have been installed shows a good rate of progress. The further fact that, almost without exception, new power plants are properly equipped shows that the next five years will make a decided change for the better.— CARLES H. BENJAMIN (Supervising Engineer), in *The Outlook.*

## The Philosophy of Numbers.

We are so accustomed to the symbols that we call "figures" that we are apt to think of them as being the *numbers themselves,* instead of mere marks upon paper, by the aid of which we can *represent* those numbers briefly to the eye. There is no magic in the particular things that we call "figures." Any ingenious person can easily devise a system of symbols that will stand for the numbers just as well as these do. For example, we might have the following:

| Number to be represented: | "One." | "Two." | "Three." | "Four." | "Five." | "Six." |
|---|---|---|---|---|---|---|
| Symbols that were used by the Romans: | I. | II. | III. | IV. | V. | VI. |
| Symbols now used by the Chinese: | 一 | 二 | 三 | 四 | 五 | 六 |
| Symbols that are now used in the United States: | 1. | 2. | 3. | 4. | 5. | 6. |
| Other symbols that would serve just as well: |  | | | | | |

and so on, every number being represented by a symbol of its own, up as far as we choose to go, or until our imaginations cease to provide us with new ideas for the shapes. We should then study addition and subtraction and multiplication and division and all the other operations of arithmetic with the new symbols, in just the same way that the little child studies them with the symbols that we grown folks have used so long that we don't always stop to think what they mean — or, rather, what they *don't* mean. It is easier for the child to get correct ideas about these things (in some respects) than it is for adults; because adults have certain set ideas about them rooted in their minds so firmly that it is hard to get them out. For example, we are all so familiar with the idea of addition that it is not easy to understand that there can be much philosophy to the thing. Suppose, however, that you were required to add the two simple numbers "eleven" and "seventeen" for the first time in your life, and that you had never read what the sum is, and that nobody had ever told you. Suppose, furthermore, that you were a Roman, and that the only way of representing these two numbers that you had ever heard of was the old Roman method, that we use now only for the faces of watches and clocks, and for the headings of chapters in books. You would then represent "eleven" by the symbol XI, and "seventeen" by the symbol XVII. The problem before you, then, would be this:

XI added to XVII makes what ?

If you are honest with yourself, and don't allow yourself to be influenced by your previous experience with numbers, you will find that this is quite a problem, and in order to solve it you will find yourself reduced to the necessity of *counting* up the sum, beginning with seventeen, and counting on from that point until, by the aid of your fingers or some other convenient objects, you know that you have counted eleven numbers beyond seventeen. You will then find that you have arrived at the number twenty-eight, and you will learn in this way, for the first time in your life, that eleven and seventeen make twenty-eight. To verify this process you can turn it the other way around, and add seventeen to eleven, instead of eleven to seventeen ; that is, you can start with the number eleven and count onward until (still making use of your fingers) you have counted seventeen numbers beyond the original number eleven. If you do this, you will find that you have come to the number twenty-eight, just as you did before. You have satisfied yourself, now, that your first operation was correct, and you will remember, for the rest of your life, that seventeen and eleven make twenty-eight, whether you add the eleven to the seventeen, or the seventeen to the eleven ; and your memory will save you from going through with all this labor the next time you happen to want to perform this particular addition.

We have dwelt at some length upon this question of simple addition, in order to illustrate as clearly as possible how our knowledge of the *sums* of numbers was obtained. Our knowledge of the sums of all the smaller numbers was obtained by precisely the process outlined above, and nowadays the child in school is supposed to go through with a sufficient amount of this kind of work to familiarize himself thoroughly with the idea. Until recent years this was not the case, and most of us, it is to be feared, learned from our books how much four and three make, without having the least notion how anybody really *knew* they made seven; although the mystery grew less as we grew older — not because we ever then took the pains to verify the thing, but because, by frequent repetition, the idea became as familiar as our own names (which might just as well have been something else, by the way), and we found that by always assuming that the book was right we were never led into difficulties in our accounts or in calculations of any sort.

The particular symbols that we now use to represent numbers were devised either by the Hindoos or by the Arabs. Their origin is lost in the obscurity of the past. The Arabs have usually been credited with the invention, however, and we shall, therefore, speak of the figures commonly in use as the "Arabian numerals." The most valuable contribution of the Arabs to arithmetic was not the precise *forms* of the figures they proposed, although these have, indeed, been found very convenient. A far more important contribution was the now familiar *system* by which they contrived to represent all numbers by the aid of only ten different symbols, or figures. As a basis for this system, they represented each of the first nine numbers by a single, separate, and distinct sign or "figure," and then devised an ingenious way of making these symbols serve, by a suitable method of grouping them, in representing *all* numbers. There is no good reason why they should have selected the first *nine* numbers for representation by individual symbols. They might have chosen any other number, so far as any inherent necessity is concerned, and in some respects it would have been a vast improvement if they had gone two units further, and denoted the first *eleven* numbers by separate symbols. It would take us too far away from our present purpose to tell why the plan here suggested would be superior, but the thing was discussed by mathematicians many years ago, and it has always been admitted, by those who have given the matter enough attention, that the exact plan followed by the Arabs was probably not the best one. But there is no use in discussing what *might* have been done, because our present system is so firmly established by usage that it can never be changed, and it will be more profitable to confine our atten ion to the understanding of just what the original idea of the Arabs was.

Having provided for the representation of the first nine numbers by means of the familiar symbols "**1**," "**2**," "**3**," etc., up to "**9**," — symbols of which, as has already been said, we are accustomed to speak and think as though they were the *numbers themselves*, whereas a moment's thought shows that they are nothing but the *signs* by which the real numbers are briefly represented — the next step that the Arabs took was to provide for the numbers "ten," "twenty," "thirty," etc., up to "ninety" ; and it is here that we meet with the simple, though highly ingenious and valuable, artifice which has caused the Arabian system of number symbols to supplant and supersede all other systems throughout the civilized world. This artifice consists in the introduction of another symbol, "**0**," which does not stand for a number, but which is written after any given number-symbol to signify that the number is *multiplied by ten*. Thus the Arabs did not provide a separate symbol for "ten"; they did not regard "ten" as being a distinct number calling for a separate sign, but they considered it as being tenfold greater than "one," and so they represented it by "**1**" with the symbol "**0**" written after it, that is, by "**10**." "Twenty," in the same way, was regarded, not as a number that is distinct from all others that precede it, as "nine," or "eight," or "seven," were regarded: — they looked upon it as being ten fold greater than "two," and hence, by employing the same artifice that was used in the case of "ten," they represented it by the symbol "**20**." In the same way they formed the symbols for "thirty," "forty," etc., up to "ninety."

By an extension of the same idea, the Arab mathematicians provided symbols for "one hundred," "two hundred," and so on. The Romans considered "one hundred" to be just as distinct a number as the Arabs considered "three" or "four" to be, and they represented it by a distinct symbol, "C"; but the Arabs, still clinging to their central idea of the use of the sign "**0**," regarded "one hundred" as being merely tenfold greater than "ten," and so they represented it by writing another "**0**" after the symbol for "ten," thus getting the sign "**100**" for it. "Two hundred" was regarded as tenfold greater than "twenty," and hence it was represented by "**200**"; and so on. When we come, in this way, to "five hundred," we find that here again the Romans differed from the Arabs, by regarding "five hundred" as a number that is distinct from all that come before it, and representing it, accordingly, by a separate, individual symbol, "D;" while the Arabs, with a fine sense of the logic of their process, refused to consider "five hundred" in any other light than as "ten times fifty," and in accordance with their basic idea they represented it by "**500**."

By proceeding in this way the Arabs obtained a sort of framework of signs, or symbols, upon which to build an entire system of signs, which should cover *all* numbers. The symbols that we have already described are

**1, 2, 3, 4, 5, 6, 7, 8, 9,**
**10, 20, 30, 40, 50, 60, 70, 80, 90,**
**100, 200, 300, 400, 500, 600, 700, 800, 900,**
etc. etc.

Numbers that are not provided for on this general scheme, or skeleton, were regarded as equal to the sums of two or more smaller ones. Thus "forty-seven" was regarded as "forty, plus seven"; and could be represented by "**40+7**." "Five hundred and thirty-eight" was regarded as "five hundred, plus thirty, plus eight"; and it could be represented by "**500+30+8**." Now since the symbol "**0**" does not stand for a number, but is used only to denote a multiplication of something by ten, the Arabs perceived that no confusion could arise by abbreviating such expressions as the foregoing, so as to compress them into a more compact form. So instead of denoting "forty-seven" by "**40+7**," they shortened this sign up into the familiar form "**47**," it being understood, all the time, that "**47**" is really formed by the fusion of two distinct symbols — one for "forty" and the other for "seven." "Forty-seven" means, according to the Arabian idea, "forty and seven." In the same way they shortened up the sign for "five hundred and thirty-eight" by condensing it into the form "**538**," from the longer one "**500+30+8**." Here, too, as in all cases of this sort, we should remember that "**538**" is merely an abbreviation for the three individual symbols which represent the three individual numbers of which, according to the Arabian view, this number is composed.

School children and others of an older growth sometimes have trouble in writing down certain classes of numbers, in which some of the figures, according to the common method of notation, are ciphers. There should be no trouble if what we have said above is once thoroughly understood. For example, let the number be "ten million, six hundred and eight thousand, and seven." Let us write the numbers separately, over one another, in the following manner:

| | |
|---|---:|
| Ten million, . . . | **10,000,000** |
| Six hundred thousand, . . | **600,000** |
| Eight thousand, . . . | **8,000** |
| Seven, . . . . | **7** |
| | **10,608,007** |

There is no trouble in writing down the various constituent numbers separately, and after we have done so, the correct statement of the result becomes an easy matter. We may regard this operation as an example in *addition*, if we wish; but if we look at it in the more strictly logical sense, we see that it is merely an aid to assist us in writing down correctly the abbreviation, "**10,608,007**," which stands, according to our accepted way of writing numbers, for the longer form "**10,000,000+600,000,+8,000+7**."

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The Rev. Mr. Hahn recently took leave of his little flock at Centerville, N. J., with the following words: "Brothers and Sisters, I have come to say good-bye. I don't think God loves this church, because none of you ever die. I don't think you love each other, because none of you marry. I don't think you love me, because you haven't paid my salary. Your donations are moldy fruit and wormy apples, and 'by their fruits ye shall know them.' Brothers, I am going to a better place. I have been called to be Chaplain of a penitentiary. I go to prepare a place for you, that where I am there ye may be also. May the Lord have mercy on your souls. Good-bye." — *Boston Daily Advertiser.*

# The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XXIII. HARTFORD, CONN., JUNE, 1902. No. 6.

## Explosion of a Locomotive Boiler.

We present, herewith, some photoengravings that illustrate the explosion of the boiler of a small locomotive, from the failure of its staybolts. The barrel of the boiler was constructed in three courses, and was 9 feet 8 inches long, and 48 inches in diameter. The plate was $\frac{7}{16}$ in. thick, and the joint was an ordinary double riveted lap joint, with rivet holes $\frac{13}{16}''$ in diameter, pitched $2\frac{1}{8}''$ from center to center. The dome of the boiler was

FIG. 1. — THE BARREL OF THE EXPLODED BOILER.

26″ in diameter and 30″ high, and was secured to the shell in the usual manner, the dome being flanged to the shell, and the shell also flanged upwards to fit the dome. The dome plates were $\frac{3}{8}''$ thick, and the head (which was of cast-iron) was $1\frac{1}{8}''$ thick.

The boiler had been provided with two pop safety-valves, each $2\frac{1}{2}''$ in diameter, but these were both broken off by the explosion, and could not be found. The crown sheet, which was $\frac{3}{8}$" thick, was 78" long and 45" wide, and was secured to the shell by staybolts pitched $4\frac{1}{2}$" from center to center, each way. The staybolts on the side sheets were pitched $3\frac{1}{2}$" from center to center, each way. The staybolts used in the legs were of $\frac{7}{8}$" stock, while those in the crown sheet were of 1" stock.

At the time of the explosion the locomotive was drawing a train. It had just reached the summit of a grade, when the boiler exploded with extraordinary violence. The engineer and fireman were killed instantly, the fireman's body being blown literally to fragments. Such information as can be had about the explosion must therefore be inferred from the position and character of the wreckage. It is evident that the barrel of the boiler was shot out of the frame, being thrown upwards and forwards, away from the

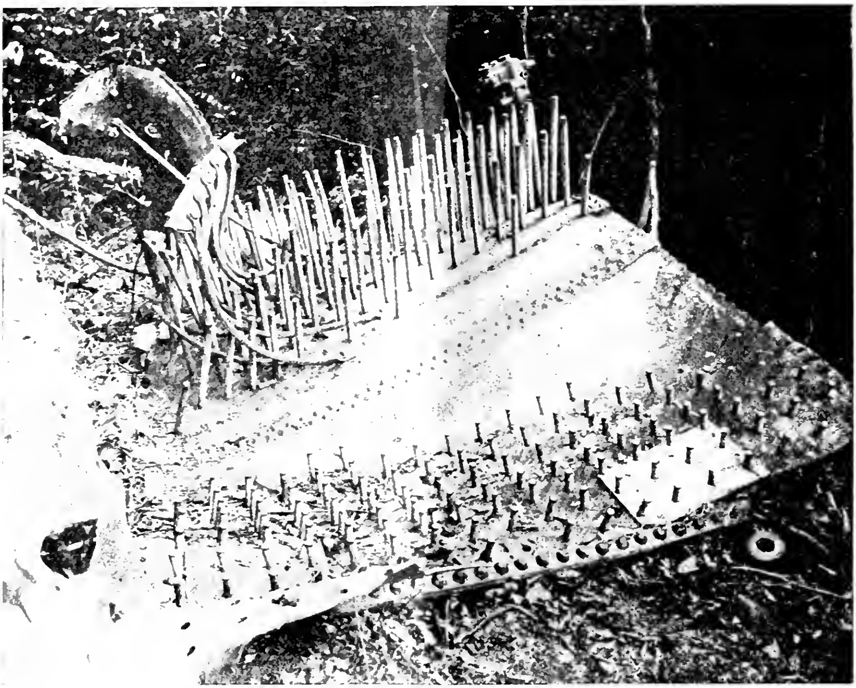

FIG. 2.—A FRAGMENT OF THE FIRE-BOX.

rest of the engine. It followed the general direction of the track, but as the accident took place on a curve, it came finally to rest about 25 feet from the track, on the outside of the curve. An inspection of the ground showed plainly that the barrel struck first on its front end, and that it then turned two complete somersaults, striking the ground each time it turned over, until it finally came to rest some 210 feet ahead of the spot where the explosion occurred.

Of the remaining fragments of the boiler, one of the largest was thrown to the right to a distance of 110 feet, colliding, in its course, with a tree. Another was found 100 feet behind the site of the explosion, and about 70 feet to the right of the track.

We cannot say positively what the precise cause of the explosion may have been, but there was no evidence of low water, and we have no reason to suppose that the

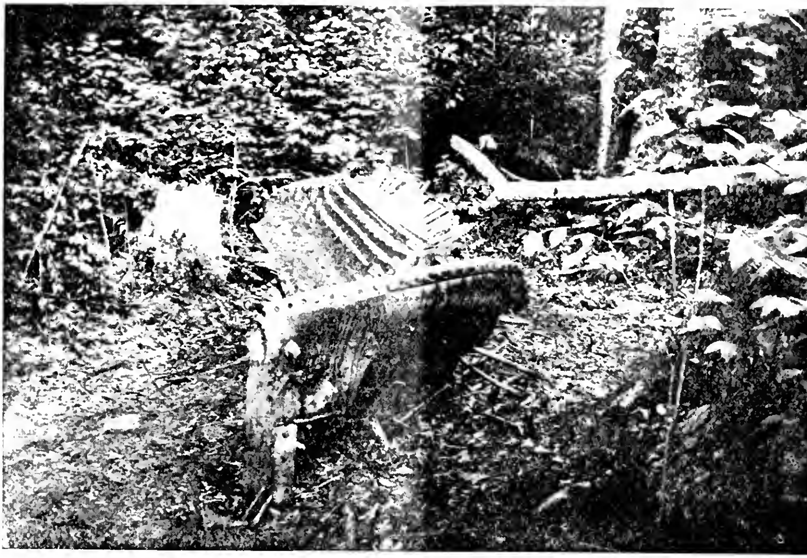

Fig. 3.—A Fragment of the Fire-box.

Fig. 4.—A Fragment of the Fire-box.

pressure was unusually high. A number of the staybolts were broken before the accident, and it is very probable that the explosion was due to loss of strength from this cause. The engravings show the violence of the explosion, and will serve as a reminder of the extreme importance of attending carefully to the condition of staybolted structures of all kinds.

## Boiler Explosions.

JANUARY, 1902.

(1.) — A boiler exploded, about January 1st, on the Milton Underwood farm, in the oil fields of Doddridge county, West Virginia. The boiler was in use by the South Penn Oil Company for drilling an oil well. Harry Rhoden, Merrick Frick, and J. D. Ash, who were in the boiler house at the time, were fearfully scalded. They made their way for nearly a mile to the next boiler house, but all three died some eight hours after the explosion.

(2.) — On January 2d the boiler of freight engine No. 1475, of the Central Railroad of Georgia, exploded in the roundhouse at Macon, Ga. E. W. Hodges, J. M. McDonald, J. I. O'Neal, and Uriah Cornelius killed; W. M. Wilson, Alderman Willis, Henry Fox, Edward Hambrick, Peter Hammond, Wesley Johnson, and a man named Meadows were injured. The explosion wrecked the roundhouse. The dome of the boiler, and a portion of the shell, were thrown to a distance of 500 yards, and portions of the exploded locomotive were found 1,000 yards from the wreck. There appears to have been good evidence of the existence of plenty of water in the boiler, and so the local experts, instead of explaining the explosion by the usual low-water theory, were driven to resort to the alternative "mysterious gas" theory. Thus one expert, who "has seen many explosions and has studied them," said to a reporter of the Macon *Telegraph*: "It is conceded that there is an unknown gas that sometimes accumulates in a boiler or other place where steam is confined; but what that gas is, or what causes it to generate, has never been learned by scientists; and until its nature and the cause of its production are ascertained, boiler explosions will continue to occur without explainable cause." We understand that the railroad officials attribute the explosion to a "defective valve," which we understand to mean a defective *safety valve*; and this last explanation appears to us (at this distance) to be altogether reasonable and plausible.

(3.) — On January 2d a boiler exploded in the office of the *Montrose Record*, at Montrose, near Flint, Mich. Considerable damage was done, but we have not learned of any personal injuries.

(4.) — A heating boiler exploded, on January 2d, in the Howell street public school at Chester, Pa. There was some confusion among the pupils, but no panic, and nobody was injured.

(5.) — The boiler of passenger locomotive No. 7, on the Lehigh Valley railroad, exploded, on January 3d, between Penn Haven Junction and Black Creek, Pa. Fireman Philip Adams was thrown from the cab and instantly killed, and Engineer Frank Bowman was injured.

(6.) — On January 3d a boiler exploded in Craven Langstroth's sawmill, at Golden Grove, near St. John, N. B. Nobody was near the boiler at the time, so that there are no personal injuries to record.

(7.) — A small boiler used for roasting peanuts exploded, on January 4th, at Dowagiac, Mich. Frank Laconto was thrown about twenty feet, and was badly injured about the hips. It is believed that he will recover.

(8.) — On January 5th a boiler exploded in the Cloud City Ice Company's plant, at Robinson, about twelve miles from Leadville, Colo. Jacob Buffehr and Fireman George Murray were badly scalded, and Edward Scanlan also received injuries about the head and hands.

(9.) — On January 5th a heating boiler exploded in the residence of Mr. Beall R. Howard, at Washington, D. C. Windows and glass doors were broken, and pictures, statuary, and other objects were thrown to the floor. The heating apparatus was blown to pieces, and the basement of the building was wrecked from end to end. The house was damaged so badly as to be uninhabitable, and the property loss is estimated at $20,000, though this figure is probably somewhat too large. The butler, William Fogus, was injured so badly that he died on the following day. His skull was fractured, and he was never able to tell precisely how the accident occurred.

(10.) — A boiler exploded, on January 6th, at the Henderson oil wells, some ten miles south of Lander, Wyo. Fireman Archibald Carter was killed.

(11.) — On or about January 6th the crown sheet of a boiler gave out in the power-house of the Maine General Hospital, at Portland, Me. We do not know further particulars.

(12.) — A boiler exploded, on January 8th, in Peter Shaffer's saw and gristmill, at Island Branch, near Charleston, W. Va. The little son of the owner of the plant was killed, and Paul Shaffer, Peter Shaffer, Joseph Shaffer, Everett Shaffer, George Shaffer, and John Haynes were very badly injured. The boiler passed through the roof of the building it was in, and demolished the millhouse.

(13.) — On January 9th a boiler exploded at the Hartwell mines, near Petersburg, Ind. The boiler room and the adjoining engine house were demolished, and timbers and fragments of machinery were thrown all about, for some distance. The property loss was probably about $6,000. Nobody was injured.

(14.) — The Rev. Charles N. Vines was instantly killed, on January 9th, by the explosion of a boiler in a sawmill, cotton gin, and gristmill that was operated by him at Temple, Carroll county, Ga. The boiler was blown almost to atoms. Mr. Vines was a Methodist clergyman.

(15.) — On January 10th a boiler exploded in George Rickenberg's sawmill, some four and one-half miles west of Napoleon, O. Engineer Samuel Williard was buried in the wreckage, and was injured so badly that he lived only a few minutes after being removed from the pile of débris under which he lay. Charles Roddy was injured, though not very badly. The boiler house was blown to pieces and scattered about over the neighboring fields.

(16.) — A boiler exploded, on January 10th, in Bauhans & Heinig's sawmill, at New Cleveland, near Ottawa, O. John Bauhans, who was standing near the boiler, was scalded from head to foot, and at last accounts it was thought that he might die.

(17.) — On January 10th a boiler exploded in Lincoln Midkiff's lumber mill, on Madison creek, some fifteen miles south of Huntington, W. Va. Lincoln Midkiff, Benjamin Messinger, and Burt Trippett were killed, and Hiram Harvey, Frank Bills, William Bills, and Albert Bills were seriously injured. The entire mill was wrecked, and parts of the boiler were found a quarter of a mile away.

(18.) — A boiler exploded, on January 11th, on a pumping boat belonging to the Clipper coal works, and operating in the Fourth Pool, in the Monongahela river, near Fayette City, Pa. Two men, whose names we have not learned, were seriously injured.

(19.) — A small boiler exploded, on January 17th, in the General Chemical Works, at Shadyside, near Hoboken, N. J. Nobody was injured.

(20.) — The boiler of locomotive No. 503, of the Rock Island railroad, exploded at Victor, Ia., on January 18th, while hauling Denver limited passenger train No. 5 at a speed of forty miles an hour. Engineer W. Williams and fireman E. Hoar were killed, and baggagemaster Shaffer and two other employees were injured. The accident consisted in the failure of the crown sheet. The baggage car, buffet, and four sleepers were thrown on their sides, and one of the sleepers rolled down an embankment. Fortunately none of the passengers were seriously injured.

(21.) — On January 19th a flue failed in a locomotive drawing a fast freight train on the Lehigh Valley railroad, while passing Reddington, some five miles east of Bethlehem, Pa. Engineer Joseph Hess was badly scalded, and his clothing was set afire by live coals from the firebox. He extinguished the flames by crawling into the water tank on the tender.

(22.) — Engineer Thomas White was badly scalded, on January 20th, by the failure of some of the staybolting on a boiler belonging to the Lawson Oil Company, on Little Yellow creek, near Wellsville, O. He will recover.

(23.) — On January 20th a boiler exploded in the Fall Brook coal breaker, owned and operated by John Murrin, and located on the mountain side near the Falls in Fell township, near Carbondale, Pa. The explosion destroyed considerable property, but fortunately nobody was injured.

(24.) — On January 22d a slight explosion occurred in the furnace of a Wisconsin Central freight engine, at Cylon, near Chippewa Falls, Wis. Fireman Deboe and brakeman John Tillman were painfully scalded, but will recover.

(25.) — A boiler exploded, on January 23d, in the Ithaca Street Railway Company's power plant, in Fall Creek gorge, near Ithaca, N. Y. William Weir, William Simons, and John Considine were badly burned and scalded. It is doubtful if Weir and Simons recover.

(26.) — A heating boiler exploded, on January 24th, in the residence of Adam Cornelius, 42 Linwood Avenue, Buffalo, N. Y. Considerable damage was done to the house, but nobody was injured.

(27.) — The boiler of a hoisting derrick exploded, on January 25th, while engaged in clearing up a bad wreck on the Northern Pacific railroad, near Dilworth siding, west of Glyndon, Minn. The engineer was severely scalded over the entire body.

(28.) — On January 27th a boiler exploded in the Read pulp works, at Sobrante, Contra Costa county, Cal. Fireman George McCullough was instantly killed, and George Wells and George Duggan were seriously injured. The property loss was about $5,000.

(29.) — A boiler exploded, on January 28th, in Philip Hodle's sawmill in Madison township, near Ft. Wayne, Ind. Both heads of the boiler blew out. Nobody was injured, although five men were in the boiler room at the time. The mill was badly damaged.

(30.) — A boiler exploded, on January 28th, in the Original bathhouse, at Mt. Clemens, Mich. The building took fire as a result of the explosion, and the total property loss was something like $50,000. So far as we are aware, nobody was injured.

(31.) — A boiler exploded, on January 29th, in Shurtleff's feed mill, at Belington, W. Va. Roscoe Shurtleff was seriously injured, and the building was wrecked.

(32.) — On January 30th one of the boilers used by William Sturms in drilling the "Smith" oil well for the Denver Oil Tank and Pipe Line Company exploded at Beaumont, Texas. Fireman Ralph Wilkerson was instantly killed, and the boiler-house was demolished. A fragment of the boiler was thrown half a mile, where it crashed through a building and passed within a few inches of another man's head, eventually burying itself in the ground.

## No Place Like Charleston.

Messrs. William S. Hastie & Son hold in their insurance agency in this city the management of the Hartford Steam Boiler Inspection and Insurance Company for the States of North and South Carolina, Georgia, and Florida. They have sent a circular to all the great manufacturing corporations in these states, whose boilers are inspected and insured by that company, to visit the Exposition and to make their office their home; and they have enclosed with this invitation the following statement:

WHAT CHARLESTON HAS DONE AND IS DOING.

She discovered that rice could be successfully grown in South Carolina.

She discovered that long staple cotton and tobacco could be successfully grown in South Carolina.

She built what was, at the time of its completion, the longest railroad in America.

She gallantly and successfully defended herself against persistent and incessant naval attacks during three different wars.

She built the first iron-clad vessel.

She discovered the use to which phosphate rock could be applied, and through the fertilizers into which it is manufactured revolutionized the agricultural system of the South by causing cotton and other products to grow where previously they could not mature. By this act she made it possible and practicable to establish cotton mills in the Piedmont section, and to that industry she most liberally subscribed.

She inaugurated and still sustains one of the largest and best public school systems in the United States.

She is now holding the greatest Exposition that the South has ever known.

She is the site of what will presently be a great naval station.

She is becoming the great South Atlantic station for the army and navy of the United States.

She has now, through persistent effort with the government for many years, one of the finest deep water harbors in the world, and for the benefit of the people of South Carolina and adjacent states, as well as for her own benefit, she wishes to be in the future, what she has been in the past, the great port of entry of the South Atlantic coast.— *Charleston News and Courier.*

## Lord Kelvin on the Metric System.

Lord Kelvin, the distinguished Scotch scientist, appeared before the Committee on Coinage, Weights, and Measures of the House of Representatives, on April 24th, and testified as to the desirability and practicability of the adoption of the metric system. Anything that Lord Kelvin has to say, either on this subject or on any other, is well worthy of attention; and for this reason we reprint the following extracts from his remarks, in order to aid in giving them the widest circulation possible.

"You propose," he said, "the general question as to the possible universality of a system of weights and measures. It seems perfectly obvious that it must be for the benefit of the world that the system of weights and measures adopted should be world-wide. I do not think this point needs discussion. It is perfectly clear that one connected system is desirable. It will be a certain benefit to all, that there should be one and the same system everywhere.

"You have also asked my opinion as to what system would be best, if there is to be but one system. If the matter were a *tabula rosa*, and no such thing as a system of weights and measures existed, it might be considered what would be the best foundation for a general system of weights and measures. That question, however, the French philosophers and statesmen took under their very effective guardianship, more than a hundred years ago, and with very great wisdom they chose a system that is almost ideally perfect. There is just one point in it that seems to be less than the ideal.

"The fault, if it were a fault, is easily explained. The French metrical system, as we all know, was founded on a measurement of the dimensions of the earth. The ten-thousandth part of a quadrant of the earth is one kilometer. Now, concurrently with that, they proposed a centesimal division of the quadrant of a circle in respect to angles. That which we all now call 90 degrees they called 100 degrees. What we call 30 degrees, they inconveniently called $33\frac{1}{3}$ degrees, or 'thirty-three, point, three, three, repeater' — an endless decimal. The centesimal division of the quadrant was used for a time in trigonometry, and trigonometrical tables founded on the centesimal division of the quadrant were published. Even Laplace, the great French mathematician, in his great work, 'La Mécanique Céleste,' uses the centesimal degree, the centesimal minute, and the centesimal second. But that system has not been continued in use.

"The value of having the third part of a right angle an integral number of degrees is too obvious. That settled the matter against the centesimal division of the right angle. If it had been known that the centesimal division of the quadrant or right angle would not be permanent, it seems to me that the French philosophers who so wisely chose the base of a metrical system would not have divided the quadrant of the earth into ten thousand parts; but, having divided it into 90 degrees, would have founded the metrical system on the length of a degree. That would have been still more convenient than the existing French system, for terrestrial measurements. For navigation, it would have been convenient to make the nautical mile, or length of the sixtieth part of the ninetieth part of the journey from equator to pole, the unit of measurement, and to base a decimal system on *fathoms;* that is, the nautical mile divided into thousandths.

"But this suggestion is now of no importance. I merely speak of it to refer to an argument — not at all a wise argument — in respect to the British inch in competition with the French meter. The British inch Sir John Herschel found to be nearly a five hundred millionth of the polar diameter of the earth. That has been brought forward again and again in English newspapers, seriously, as a merit of the British inch; and even Sir Frederick Bramwell, I believe, sanctioned this idea. But those who contend that definite subdivision of a diameter of the earth is a proper base for a metrical system forget that usually we travel upon the *surface* of the earth, and not on lines through its center. It is, in fact, not convenient for terrestrial purposes to know that the polar diameter of the earth is a round number of inches. But it *is* convenient to know that the ten-thousandth part of the quadrant, or forty-thousandth part of the earth's circumference, is a kilometer. I would say that if we were to make the choice over again, I do not think we could do better, practically, than take the French metrical system as it is; and it is admirably convenient just as we have it now. No change has been suggested that could better it.

"I have heard it quite seriously argued that the meter is too long for the arms of men or women using it in sales shops, and that the British yard is better for measuring ribbons than the French meter. This is a mere foundationless fancy. I have had a good deal of occasion to hear about convenience and inconvenience in such matters from friends who have had plenty of practical experience, and I have never heard of this meter being too long. I know that English ladies in Madeira, where the French metrical system has been forty years in use, find the meter and centimeter perfectly convenient for all measurements in shops, and really more convenient than yards and inches.

"Mr. Herbert Spencer argued that if we were to make a change at all it ought to be to the duodecimal system of arithmetic, and corresponding denominations in measurement. We had better wait until we have 6 digits on each hand before we refuse to be satisfied with the experience of mankind in respect to the old Arabic numeration. But even if we had a duodecimal arithmetic, it does not affect the metrical question. We would have the French system just the same, founded on one definite set of units,— the meter for length, the square meter for area, the cubic meter for bulk, and for the ton a cubic meter of water.

"In speaking of the metrical system I venture to suggest that we should not use the word 'decimal' system, but simply the 'French metrical system.' We should not be ashamed to use the word 'French,' nor refuse the name of the people of the country to whom we are indebted for the system. We have in America and England a metrical system, or rather a metrical jumble of our own; and we have in all our scientific work the excellent French metrical system, one simply connected system of weights and measures founded primarily on measurement of length.

"The American and British workmen are constantly hampered in their everyday work by their use of the British inch. It is really much more convenient to reckon by centimeters and millimeters. I think my friend Mr. Westinghouse will agree with me that our workmen are seriously handicapped by eighths of an inch, sixteenths, thirty-seconds, sixty-fourths, and one hundred and twenty-eighths. A great deal of ordinary mechanics' work must be correct to the sixty-fourth of an inch, and a great deal is correct to the eighth, or the sixteenth, or the thirty-second; but when the workman comes to sixty-fourths, he has got to deal with such fractions as seven sixty-fourths, or nineteen sixty-fourths. Notwithstanding their intelligence, American workmen dealing with seventeen sixty-fourths find it very awkward.

"In the metrical system, for rough measurements we ordinarily use quarter and half centimeters. Sir Frederick Bramwell triumphs when in using centimeters we come to halves and quarters, because he thinks he sees in this an abandonment and a practical failure of the 'decimal system.' I answer that it is always convenient to halve and quarter the smallest named or the smallest commonly used unit in measurement of any kind; but when we reckon finer than to a quarter the decimal division of tenths *is much the more convenient.* (I must explain to the committee that I have had a running fight with my old friend, Sir Frederick Bramwell, for twenty years, and that he is almost offended if I use the word 'inch' without attacking him.)

"We cannot call the American or British measures of area and of bulk a system; hardly even a jumble of systems. There is no system. We do not find the units of area founded clearly and simply on units of length. An acre! What is an acre? How many of those legislating about acres can tell how many square feet, or square yards, or square poles, or square chains, there are in an acre? I believe the origin of an acre was really from a certain breadth and a certain length. It is an interesting fact that plowing a certain length and a certain number of furrows gave an acre; but the acre is not founded, definitely and simply, on one unit of length. In the British Houses of Parliament, population is generally reckoned per square mile; but on agricultural subjects legislation is usually on the basis of acres. How many, in discussing these matters, can tell how many acres, or how many square yards, there are in a square mile? You must look it up in a book.

"For bulk measurement we have gallons, quarts, pints, gills, bushels, pecks, etc. Then we have larger practical measures for grain and liquors, founded on convenient sizes of barrels, etc. It is not necessary that barrels or bushels be exactly an integral number of cubic centimeters. They must be convenient for the wine grower, the brewer, the cooper, the carrier. The widest latitude must be left to the particular trades to make every article, whether for storage or for transport, of convenient size. But their definitive measures of bulk should all be in cubic centimeters, or in liters, or in cubic meters.

"Leaving the lengths, areas, and bulk measures, we have the weights. There is a very great convenience, in the French metrical system, in respect to weights and measures; and that is, that the unit of weight (or mass) is the quantity of water in a cubic decimeter (or liter) for the kilogram, a cubic meter for the ton, and a cubic centimeter for the gramme; and that the temperature at which this is taken is the temperature of maximum density of water. This makes it perfectly easy to verify weights and measures very approximately; and provides also for extreme accuracy. One of the most accurate measurements in science is the comparison of the heaviness of the standard kilogram with that of a cubic decimeter of water at the temperature of maximum density. That is the foundation of the standards of weight in the French metrical system, and it is ideally good.

"Just think of the great simplification it gives in calculating weights for engineering works. With the French metrical system, the only thing to be remembered in practice is the specific gravity of the material. A cubic meter of any material weighs a ton, multiplied by the specific gravity of the material. Now, think of a contract to level down two or three acres of land; to remove, say, three feet seven inches of earth from one part of it, two feet one inch from another part, and so on, according to a definite specification. In the English system you want to know how much cartage is needed, per square yard, in each part of the field; and you must know, or learn from earthwork tables, the weight according to data for vertical measurement in feet and inches. If there were not work enough, and you wanted to make more office work for surveyors and engineers and draughtsmen, you could not do better than perpetuate the American and English weights and measures. I believe I am not overstating the truth when I say that half the time occupied by clerks and draughtsmen in engineers' and surveyors' offices, — I am sure at least one-half of it, — is work entailed upon them by the inconvenience of the present farrago of weights and measures. The introduction of the French metrical system will produce an enormous saving in business offices of all kinds,

—engineering, commercial, and retail shops. Nothing can be more convenient than the French metrical system for every kind of business and science. There is no case, large or small, in respect to measurement, where the French metrical system is not satisfactory."

At this point in Lord Kelvin's remarks, the chairman, Mr. J. H. Southard, referred to the possible inconvenience attending the introduction of the metric system into the machine shops or manufacturing concerns, and said that the statement had been made that certain machinery would have to be replaced, and that the expense involved by reason of such changes would be great. He also referred to the tendency to work to even sizes. Lord Kelvin replied that he did not think that the new system would involve the displacement of any useful machinery. He admitted that there will be some initial inconvenience in the tendency to work to even sizes, but stated that he believed that this would be overcome in a week or a fortnight.

"It is not a great expense," he said, "to get equally accurate standards and gauges in the metrical system, to replace those founded on the inch. Instead of being inconvenienced, or having a spasm of extra work in prospect to make the change, the first fortnight will more than compensate for it by the ease and simplicity afforded by the French metrical system.

"The international system of electrical units, in which everything electrical is measured, is the same in America, Germany, France, England, etc., and our instruments are founded on the centimeter and the gramme. British and American workmen all work on this system, but they have to work also to feet and inches, and thus really they have to use two standards. Every instrument-making workshop and engineering establishment on a large scale in England is now obliged to use two sets of standards in executing home and foreign orders. We are putting ourselves to a great inconvenience and unnecessary labor with our double system; and as to the workman in an establishment, he will find himself happier and will work with greater ease with the centimeter scale and the gramme than with the scale of feet and inches and pounds and ounces."

"We have received a letter, here," said Chairman Southard, "from the secretary of what is known as the Decimal Association of Great Britain, in which the names of two hundred and fifty-nine members of Parliament are given, all of whom have signified, in writing, their willingness to vote to make the metric system compulsory in Great Britain. It is said, also, that thirty or forty more have likewise agreed to do so, but desire their names to be withheld. We desire to have you say a word as to the attitude of your people concerning the adoption of this system."

"I am glad to hear the figures you give us," replied Lord Kelvin, "and I think they promise well for an early adoption of the reform in England. I believe there will be no difficulty at all in carrying it out, when statesmen undertake to do it. I am sorry that we are not so far advanced as we would like to be. We shall find it coming suddenly in England, and while, with local patriotism for England, I would rather that England should introduce the new system first and America should follow, yet I would very much prefer that America should lead, if the end can so be accomplished sooner. *And if America decides to make this reform, England will follow very quickly.* I believe that England, with the example of a great nation like this adopting a reasonable reform which has been now well tested for a hundred years,— adopting it not rashly, but as a reasonable reform, the practical workings of which have been proved and found good — England will see an argument which will be sufficient to overcome all residual sluggishness. With England and America adopting the French metrical system, it will be practically a universal system."

# The Locomotive.

HARTFORD, JUNE 15, 1902.

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

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

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

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


## Obituary.

MR. GEORGE E. NELSON.

We regret to announce the death of Mr. George E. Nelson, which occurred on January 20, 1902, at Erie, Pa. He was born at Natick, Mass., in 1844, and was therefore 58 years of age. He left home at an early age to go to sea. He served as a first-class fireman in the United States Navy, Mediterranean Squadron, and also saw other service in the navy during the Civil War. Later, he served as fireman and engineer on the Boston and Maine Railroad, and as stationary engineer for various plants in various parts of the country. He was always considered a good mechanic, and an excellent authority in his business. He had been inspector for the Hartford Steam Boiler Inspection and Insurance Company, at Erie, Pa., since about 1887. Mr. Nelson left a wife and three children. His eldest son, Charles A. Nelson, succeeds to the position made vacant by his father's death. Mr. Nelson was a member of the Masonic fraternity, and also of the B. P. O. Elks, these societies jointly taking charge of his funeral.

## Earthquakes and the Trans-Isthmian Canal.

In the March issue of THE LOCOMOTIVE we discussed the matter of the proposed canal across the isthmus between North and South America, endeavoring to present the case as fairly as possible, and to state the main points that have been urged for and against both of the proposed routes. We purposely omitted all mention of earthquakes (except in connection with the Darien ship tunnel), because we were of the opinion that the danger to the canal from this cause was substantiully the same at Panama as at Nicaragua. Further data are now available, thanks to Gen. Abbot. We quote the following passage from *The Engineering Magazine:*

"The appendix to the Canal Commission's report contained the statement that 'in the northwestern part of Nicaragua, slight earthquakes are frequent; scarcely a month passes without one or more being noticed.' In Panama, on the other hand, to quote M. Bunau-Varilla, 'there is no volcano within a distance of 180 miles,' and the 'rare and small seismic vibrations come from distant centers.' Gen. Henry L. Abbot has just contributed to the *Evening Post* a summary of a year's seismographic observations in Central America — probably the first systematic, scientific comparison yet made of the two routes in this particular. Briefly, the Panama record for 1901, taken in the city of Panama, showed five movements, — one 'sensibly felt,' three 'very light tremors,' and one so slight as to be questionable. All came from the east or northeast. The disastrous Guatemalan earthquake of last April produced not even a tremor at Panama. But at

San José de Costa Rica, the observing point near the Nicaraguan route, *fifty* seismic movements were recorded during the year, twenty-seven being classed as 'shocks,' and seven as 'strong shocks,' while two others, though defined as 'light shocks,' were sufficient to cause persons to run out into the streets."

The same magazine also gives a brief account of the eruption of Mt. Coseguina in the Nicaragua region, which it had printed in June, 1901, but which we had overlooked. "The explosion of the volcano Coseguina in 1835," it says, "lasted 44 hours. The noise was heard at a distance of 1,000 miles, and ashes were carried 1,400 sea miles by the winds. During these 44 hours the volcano ejected, every six minutes, a volume of stone and ashes equal to the total volume of the prism of the Nicaragua canal." Referring also to the very recent eruption of Momotombo, the editorial goes on to say: "And even as these words are being written, report is received that the volcano Momotombo, on Lake Managua (which is an extension of Lake Nicaragua) has been 'discharging showers of ashes accompanied by great quantities of smoke. This was followed by an earthquake that destroyed the docks at Momotombo and the terminus of the railroad running from the lake to Corinto on the Pacific.' It need scarcely be pointed out that a canal supported by dams, embankments, and locks is immeasurably more vulnerable to seismic attack than even docks and railway structures."

The facts presented above, and particularly General Abbot's direct comparison between Panama and Nicaragua, are certainly impressive. The recent volcanic horror at Martinique, when taken in connection with the data here outlined, doubtless had much to do with the decision that Congress has now given, in favor of the Panama route; and in view of all the facts, we believe that the selection of Panama was wise.

In the matter of political concessions, too, developments subsequent to the publication of our previous article favored the Panama route to an extent that we hardly could have anticipated. Colombia has manifested a willingness to grant us rights that would probably be acceptable, though they do not include the sanitary control of either Colon or Panama. The Nicaragua route lies along the boundary between Nicaragua and Costa Rica, and hence it would be necessary to obtain concessions from both of those governments. There was reason to believe that Nicaragua would grant us satisfactory concessions; but when our previous article was prepared, there was no certain indication as to what Costa Rica would do. Subsequently the statesmen of the latter country showed a disposition to insist that the United States should first choose the route, and then talk over the matter of concessions afterwards. Such a policy appears to us so suicidal and inane that we can hardly believe that it was the authoritative utterance of the Costa Rican government; but whether this noncommittal plan really did represent the Central American idea of clever diplomacy or not, our own Congress, by choosing the Panama route, has now spared the Costa Ricans all further worriment on the subject.

## Lord Kelvin.

Lord Kelvin, who recently visited the United States, has the proud distinction of being, without question, the most distinguished living exponent of physical science. In early life he was known merely as Mr. William Thomson. Later, in recognition of his achievements and his eminence in physical science, he was knighted, and for years he was known as Sir William Thomson. Some eleven years ago Victoria did herself honor by raising him to the peerage, and he has since been known as Lord Kelvin, taking the name "Kelvin" from a little brook that flows through his estate.

Kelvin's achievements in electrical engineering have been many times retold, and are better known to the public than his even greater triumphs in other lines of work. He has done much to establish the physical side of the molecular theory of matter upon its present basis, and (so far as we recollect) he was the first to actually obtain numerical estimates of the sizes of the molecules. In connection with the modern theory of light, too, he has done much that is original and valuable. If his "semi-labile" ether theory had been his only contribution to physical science, that alone would have insured him a high standing in the world of physical investigators; and yet his other accomplishments have been so numerous and so noteworthy, that few even know what his ether theory is.

We venture to suggest that out of all Kelvin's many achievements, the most satisfying, to himself, may have been his discovery of two other geniuses in his own field,— Maxwell and Joule. Maxwell, as a student, showed a marvelous aptitude for mathematics, and a wonderful amount of that "scientific imagination" which is so indispensable to the original worker. It was Kelvin who drew Maxwell's attention to the subject of electricity, and advised him to study Faraday's *Experimental Researches*, and to translate the general ideas therein contained, into mathematical language. Maxwell followed the advice, and as a result he gave the world his wonderful treatise on *Electricity and Magnetism*, which is one of the most wonderful compositions yet produced by man. In particular, this treatise contains the celebrated electromagnetic theory of light, which has practically overthrown all other theories on this subject, and given us a marvelously clear insight into the phenomena of the physical world. It is not too much to say that Maxwell's theory of light proved to be the forerunner, and in fact the direct inspiration, of most of the progress, both theoretical and experimental, that has been made since his time in connection with light. By way of popular illustration of this fact we may say that Hertz's celebrated experiments upon electric waves were merely an attempt to verify, by experiment, the theoretical equations of Maxwell; and out of these successful experiments of Hertz, the wireless telegraph has now arisen.

Thomson's discovery of Joule was made in the following manner, although we may possibly be incorrect on some of the smaller details, as we write from memory: Joule, who lived in Manchester, England, had made some experiments which appeared, to himself, to indicate that heat energy and mechanical energy can be actually converted from either form into the other, so that for every heat unit that disappears, some 778 foot-pounds of mechanical energy are produced, and *vice versa*. He had promised to read a paper, describing his results, before the Manchester Literary Association; but when the time for the paper arrived, the president stated that as the other papers had taken up a good deal of time, he would ask Mr. Joule to dispense with the reading of his, and to give them the substance of it in a few words. This Joule very obligingly did, and the president was going on to other business when a young man arose in the audience and asserted that the matter that was being so lightly passed over was of the profoundest importance, and that if the correctness of Joule's results could be established, he had made a discovery whose effects in physical science would be revolutionary. The stranger was William Thomson, and the friendship and coöperation that began that night between Joule and Thomson continued for many years.

Lord Kelvin's journey from place to place, during his recent visit, was marked by an almost continuous series of receptions and ovations, and at least three of our greatest universities,— namely Columbia, Cornell, and Yale,— held special functions in his honor. We quote, below, some notes regarding his life and work that were printed in the May issue of the Sibley College *Journal of Engineering*.

"Lord Kelvin," says that journal, "was born in Belfast, Ireland, in 1824. He was the son of James Thomson, a well-known mathematician, who was appointed professor of mathematics in the University of Glasgow in 1832. William Thomson entered that university at an unusually early age, and distinguished himself as an undergraduate by his ability in mathematics. In 1839 he entered the University of Cambridge, England, where he was graduated in 1845 with the highest mathematical honors. The following year he was appointed professor of natural philosophy in the University of Glasgow, which position he held until 1899, when he retired, after fifty-three years of service, to be succeeded by his old pupil and assistant, Professor Andrew Gray.

"Thomson's earlier work was largely mathematical in its character, and it was through his contributions to the theories of electricity and thermodynamics that his extraordinary powers were first manifested. In the early fifties he began to interest himself in the numerous problems upon which the success of submarine telegraphy depended, and when the project of laying a cable across the Atlantic began to be seriously considered, he became the electrician of the company. From 1854, in which year he published the law which expresses the effect of distributed capacity of cables upon the rate of transmission, until 1870, when his siphon recorder superseded all other instruments as the most suitable apparatus for the receiving of cable messages, much of his time was devoted to the application of physics to submarine telegraphy. In 1866, when the first permanent cable across the Atlantic was completed, his labors were publicly recognized by the conferring upon him of the Order of Knighthood.

"In spite of the arduous character of his services to the cable companies and the time devoted to the devising and development of the long series of electrical instruments which we owe to his ingenuity, Thomson has been one of the most prolific writers on theoretical physics of our time, and of the three hundred and more papers from his pen an extraordinary proportion have that fundamental character which alone gives permanent value. In 1882, Thomson began the republication in collected form of his mathematical and physical papers, of which, up to 1890, three volumes had appeared.

"The almost unparalleled achievements of William Thomson have in these last years been recognized in every way in which it is in the power of the world of science to express itself. Degrees and distinctions have been showered upon him. In 1891 he was made President of the Royal Society, and was raised to the peerage of Great Britain under the title of Lord Kelvin. In him the world has witnessed the extraordinary phenomenon of a man capable of following throughout a long life three distinct careers with a degree of success in each scarcely equaled by any of his contemporaries. He is an electrical engineer of the first rank, and an inventor whose instruments, such as the absolute electrometer, the quadrant electrometer, the mirror galvanometer, the siphon recorder, the electrostatic voltmeter, the current balance, the apparatus for deep sea sounding, and the compensated compass, form a class by themselves. They are a concrete embodiment of the complete mastery of the mind that devised them and the principles upon which they depend. They express in a way that could not be done by words the power of the inventor to fulfill in the most perfect and simple manner the conditions of satisfactory and accurate performance. Finally, and more important than these, because more rare, we have Kelvin's lifelong activity as a theoretical physicist. To be able to really contribute something to the world's knowledge in this field is given to but few. Years ago it was said of Helmholtz that he was the first mathematician, the first physiologist, and the first physicist of Europe. It may with equal truth be said today of Lord Kelvin that he is the foremost electrical engineer, inventor, and physicist of the English speaking world."

# The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XXIII. HARTFORD, CONN., JULY, 1902. No. 7.

## A Boiler Explosion due to the Accumulation of Scale.

We illustrate, this month, a boiler explosion that was apparently due to the accumulation of scale around the ends of the tubes. The boiler under consideration was situated in a Texas salt-refining plant employing some 160 men. When the boiler was examined after the explosion it was found that both of the heads were bulged to the extent of something like five and a half inches. The rear ends of the boiler tubes had pulled out of the rear head, and the reaction of the flow of water and steam from the

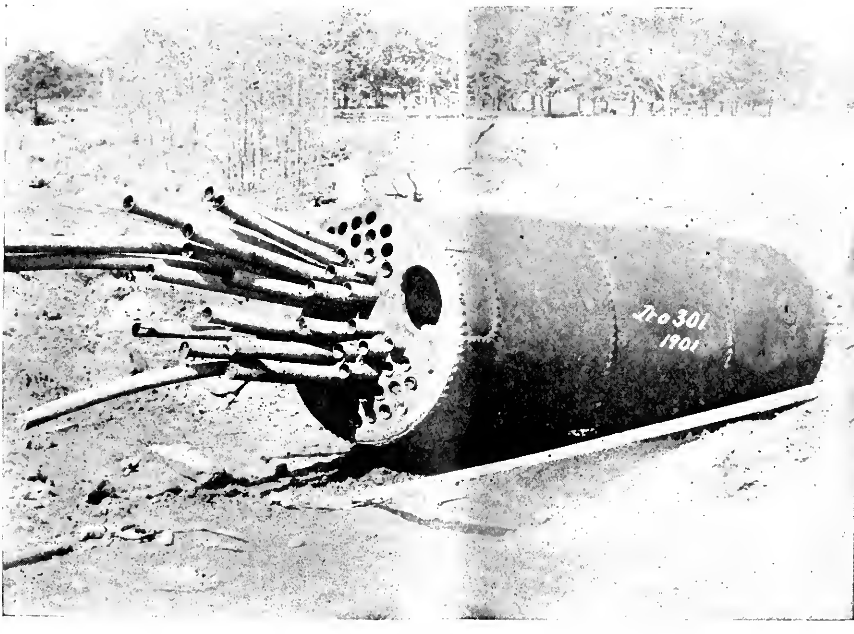


FIG. 1.— FRONT END OF THE EXPLODED BOILER.

56 tube holes caused the entire boiler to be projected forwards in a westerly direction, to a distance of 173 feet. The shell of the boiler was found to be intact, save for a few dents. All of the tubes remained in the boiler with one exception, though most of them were protruding from the front head. One tube was found 273 feet southwest of the original position of the boiler. This tube had at one time leaked near the front head, and it was plugged with scale, so that the steam pressure forced it out through

the head, as though it were a solid cylinder. The direction taken by the boiler in its flight was a most fortunate one, for, after tearing its way out of the boiler room, it landed in a vacant lot. Had it gone in the opposite direction, it would have done great damage to the building and to the salt in storage; while if it had gone to the north or south it would have destroyed considerable machinery.

The settings of the two adjacent boilers were completely demolished, and the roof and front of the boiler house were destroyed. A great deal of damage was also done to the salt in storage, and the total property loss was variously estimated at from $4,800 to $6,700.

J. F. Clay, who was employed as a pipe-fitter, was injured so badly that he died a day or two later. James Wilson and W. E. Price were also seriously hurt, and T. J. Smith received injuries of less severity.


FIG. 2.—REAR END OF THE EXPLODED BOILER.

The safety-valve was found after the explosion, and an examination of it indicated that it was in good working order, and no traces of corrosion or foreign matter could be noted about its seat. There is no reason to suppose that the explosion was due to the safety-valve failing to open when it should.

The water of condensation from the salt-evaporators was returned to the boilers and used for feeding, but of course there was some waste, and the "make-up" water that was used to supply the place of the waste was taken from a well some sixty feet deep. As this well is situated in a salt-producing district, the water from it produced a considerable amount of scale, and fragments of such scale, varying in thickness from $\frac{3}{16}''$ to $\frac{3}{8}''$, were afterwards removed from the rear ends of the tubes of the exploded boiler. Some trouble from this scale had evidently been experienced in the past, for new tubes were put into the boiler some four years previous to the time of the explosion. These tubes were expanded into the head, but were not beaded; and in the course of time they became thinned at the ends, particularly at the rear, where measurements subsequent to the explosion showed the thickness to be as small as 0".094 in some places, the normal thickness of a $3\frac{1}{2}$" tube being 0".120. The boiler was of course cleaned from time to time, but we do not know how long it was before the time of the

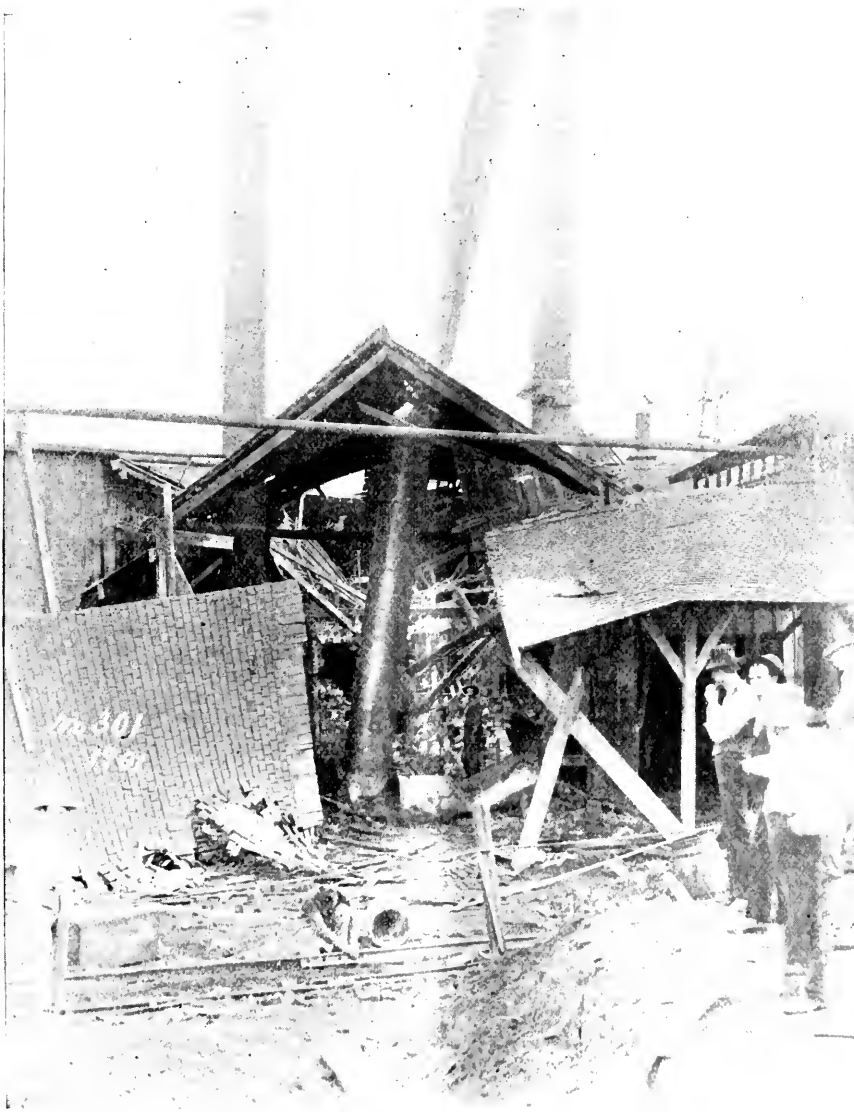

FIG. 3.—GENERAL VIEW OF THE RUINS.

explosion that it was last thoroughly scaled. An examination of the rear head showed that the tubes had been leaking somewhat, and when all the available data are considered, it appears probable that the explosion was caused in the following manner: The tube ends became thinned from wear, and the scale that formed around them and against the rear head caused these parts to become hot, so that the holding power of the tubes was materially reduced. The stress that was thus thrown upon the braces proved too much for them, and they broke under the ordinary working pressure. The heads then bulged outward, drawing the tubes out of their holes, and the rest of the observed results followed as a natural consequence.

This explosion serves to emphasize the importance of beading or flaring the tube-ends of boilers, for if the tubes in this boiler had been flared or beaded it is not likely that the explosion would have occurred, without signs of distress first making themselves visible. Further discussion of the matter of flaring boiler tubes will be found in the issue of THE LOCOMOTIVE for May, 1902.

Another thing to which this explosion again directs our attention is the importance of keeping the tube-ends of boilers as free from scale as possible. We have frequently drawn attention to the importance of this matter, which can hardly be overestimated. Thick scale on a boiler never does the boiler any good, but when it occurs around the tube-ends it is almost certain to cause trouble, either from consequent leakage and corrosion, or from the direct failure of the holding power of the tubes, as in the present case.

[The legend "No. 301, 1901," which appears on the engravings accompanying this article, signifies that the explosion is No. 301 in our regular list for the year 1901. No. 301 will be found on page 13 of the issue of THE LOCOMOTIVE for January, 1902.]

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## Boiler Explosions.

FEBRUARY, 1902.

(33.) — On January 27th a boiler exploded at Vest, some seven miles from Hindman, Ky. Engineer Henry Moore and fireman Reece Bolen were killed, and several other men were injured badly. The gristmill in which the boiler stood was blown to pieces.

(34.) — A slight boiler explosion occurred, on January 31st, at the Salem mines, Salem, Ohio. We have not learned particulars. It was reported that one of the employés was injured, but this report was authoritatively denied.

(35.) — On January 31st a boiler exploded in a brick plant at Marion, S. C. One man was fatally injured, and several others were injured less seriously. The damage to property was considerable.

(36.) — A small boiler exploded, on January 31st, in the Creamery Package Manufacturing Company's plant, at Portland, Ind. We have not learned of any personal injuries. [News of this and the preceding explosions was received too late to secure notice in the regular January list.]

(37.) — On February 1st a boiler exploded in the sawmill at Blaine, Me., owned by Allston Cushing and Parker P. Burleigh. Nobody was injured, but the machinery in the mill was badly wrecked.

(38.) — A boiler used for heating, in the basement of the Y. M. C. A. building at Malden, Mass., exploded on February 1st. Fortunately nobody was injured. The property loss is estimated at about $5,000.

(39.) — A boiler exploded, on February 1st, in the Davidson-Benedict Company's sawmill, at Hohenwald, near Nashville, Tenn. Walter Hollister, the manager, was instantly killed, and Arthur Paxton, the foreman, was fatally injured. Edward Johnson and Thomas Mason were also painfully scalded and otherwise injured. It is doubtful if Johnson can live. The mill was wrecked.

(40.) — On February 2d a boiler exploded in D. A. Layton's brickyard, at Catfish, Marion county, S. C. One man was seriously injured.

(41.) — On February 5th a boiler exploded on the Monongahela River Consolidated Coal and Coke Company's towboat *John W. Ailes*, just as the boat was passing the Turtle Creek chute, near the Edgar Thomson Steel Works, at Braddock, Pa. William Perrie was killed, and John W. Bake, Florence L. Sill, William Campbell, and John Caulfield are missing, and are believed to be dead. Edward Mitchell, Maria Walker, Reuben Watt, James Williams, Weaver Wolf, and Brooks Null were badly injured. The *Ailes* was destroyed, and the property loss is estimated at from $15,000 to $25,000.

(42.) — A small boiler used for heating water exploded, on February 7th, on Adolf Hagerbaumen's farm, about four miles east of Hooper, Neb. Mr. Hagerbaumen and William Hartwig were slightly scalded, but nobody was seriously injured. Our account says that the owner of the boiler bought it "from some peddlers a short time ago," and then goes on to say that "Mr. Hagerbaumen is at a loss to explain the cause of the accident." Perhaps the peddlers might offer some intelligible theory about it, if they could be found!

(43.) — A boiler used for heating purposes exploded, on February 8th, in the county house at Brcesport, N. Y. The explosion occurred during the night, and nobody was hurt. The property loss was also small.

(44.) — A boiler exploded, on February 8th, in Brooklyn, N. Y., during the course of a big fire at the Shadbolt Manufacturing Company's plant, at Cumberland street and Flushing avenue. One man was killed and ten others injured during the fire, and a property loss of $300,000 resulted. The personal injuries were not due to the explosion, however, nor was the loss of property, except a small proportion of it.

(45.) — On February 8th a boiler exploded in the flouring mill of A. C. Hutchens & Sons, of Williamsburg, near Batavia, Ohio. Henry Kunz was injured. The roof and one end of the boiler house were destroyed, and the foundations of the building were also demolished.

(46.) — The boiler of a freight locomotive on the Lake Erie & Western railroad exploded, on February 9th, while the locomotive was standing on a siding at St. Mary's, near Wapakoneta, Ohio. Fireman Charles Brown was instantly killed, and engineer Frank Casey was scalded so badly that he died a short time afterwards. A. H. Devore, a watchman, was also badly cut and scalded, and may not recover.

(47.) — John Oglesby, a fireman in the employ of the Yaryan Company, was seriously burned about the face and hands, on February 10th, by the explosion of a boiler at the Company's plant at Evanston, Ill.

(48.) — A boiler exploded, on February 10th, in the Cambridge colliery, at Shenandoah, Pa. Dominick Madden, who was on the boiler at the time, was blown through the roof of the building, landing on a culm bank, 30 or 40 feet away. He was badly bruised and scalded, but will recover. One end of the exploded boiler landed 300 feet west of the boiler house, and the other end 150 feet east. The boiler house was completely wrecked, and the brick settings of the other boilers in the battery are fractured and settled.

(49.) — On February 10th a boiler exploded in the Webster Woolen Company's lower mill, at Sabattus, Me. The explosion occurred early in the morning, about twenty minutes before the workmen had begun to assemble, and nobody was injured. The boiler room was considerably damaged.

(50.) — On February 10th a boiler exploded in the Red River Iron Company's limestone quarry, at Clarksville, Tenn. John Williams and William Bell were instantly killed, their bodies being blown to pieces. The boiler house was wrecked.

(51.) — A boiler exploded, on February 11th, on the Santiaguillo hacienda, near Guanajuato, Mexico. Refugio Reina was killed, and F. Amexcua, C. Velez, A. Ojeda, and E. Vasquez were badly hurt. Portions of the boiler were thrown more than 300 yards, cutting down two mesquite trees in their flight.

(52.) — On February 11th a boiler exploded in Thackeray & Rawlins' sawmill, at Pembroke, Ont. George Rawlins, one of the owners of the mill, was seriously hurt, and the engineer, Martin Greber, was crushed badly. The mill was almost totally destroyed.

(53.) — A small explosion occurred, on February 11th, in the bridge works at Elmira, N. Y. Nobody was hurt.

(54.) — On February 13th a tube failed in a boiler in the seven-inch mill of the Valley iron works, at Youngstown, Ohio. We have not learned of any personal injuries.

(55.) — A boiler exploded, on February 13th, at one of the South Penn Company's oil wells, at Gallatin, near Mannington, W. Va. The boiler house was wrecked, but nobody was injured, as the engineer was not in the building at the time.

(56.) — On February 13th a boiler exploded in the Baker sawmill, some six miles from London, Ky. Henry Barnett was thrown 200 feet, and was injured so badly that he cannot recover. James Baker, Greene Pope, Henry Baker, and Robert Baker were also injured, and it is doubtful if James Baker recovers.

(57.) — Frank M. Shay, of Geneva, N. Y., a fireman on the New York Central railroad, died at Penn Yan, N. Y., on February 14th, from injuries caused by the bursting of a flue in the boiler he was firing.

(58.) — A boiler exploded, on February 15th, in G. W. Bailey's knitting factory, at South Williamsport, Pa. The engine room was wrecked, and the machinery of the plant was badly damaged. Nobody was hurt.

(59.) — A boiler exploded, on February 15th, in Angus McLeod's pump factory, at Portage la Prairie, Manitoba. Duncan McLeod, a brother of the owner of the plant, was fatally injured, and Frederick Blakely and John Braden were injured very badly. Braden may not recover. The interior of the factory was badly damaged, and part of the boiler was thrown to a distance of 200 yards, passing over numerous houses in its course.

(60.) — On February 17th a boiler exploded in William J. McClure's establishment, on Third and Kerlin streets, Chester, Pa. We have not learned further particulars.

(61.) — A boiler exploded, on February 17th, in the Winnebago Furniture Company's plant, at Fond du Lac, Wis. The boiler room and a frame building adjoining it were completely wrecked. The property loss was about $5,000. Nobody was injured. The engineer and fireman had been in the room only a few moments before, but both had stepped out just before the explosion came.

(62.) — On February 17th a small boiler exploded in the basement of the medical school connected with the Johns Hopkins Hospital. Nobody was near at the time, so there are no personal injuries to record. The property loss was not large.

(63.) — A boiler exploded, on February 17th, in the Lafayette Gas Company's pumping station, at Fairmount, near Lafayette, Ind. The boiler house was partially wrecked, but nobody was injured.

(64.) — A small boiler exploded, on February 19th, in the Model Printing Company's plant, at Birmingham, Ala. George Russell, J. B. Bullock, Greene Harrison, R. W. McNeil, and E. J. McNeil were badly bruised and scalded. The rear and side of the power house were blown out, and the boiler was thrown into the air to a height of about 100 feet.

(65.) — A railroad wreck occurred, on February 19th, on the Columbus, Sandusky & Hocking railroad, in the suburbs of Columbus, Ohio. Two locomotives and thirty-two cars were wrecked, and the boiler of one of the locomotives exploded. William Smith, who was an engineer on one of the locomotives, was killed, but we do not know whether his death was due to the explosion, or to the overturning of the train.

(66.) — A heating boiler exploded, on February 20th, in an apartment house on Kingston avenue, Brooklyn, N. Y. The building took fire, and the flames spread to three other similar buildings, so that all four were destroyed. Nobody was injured, but the total property loss will amount to $30,000.

(67.) — An upright boiler exploded, on February 21st, in the Clear Lake creamery, at St. Cloud, near Minneapolis, Minn. The property loss was small, and we have not learned of any personal injuries.

(68.) — On February 21st a slight boiler explosion occurred in the lower plant of the Creve Coeur Lake Ice Company, at Creve Coeur Lake, near St. Louis, Mo. John Kolm, C. G. Cooper, F. Blakeman, John Malone, and E. Conley were injured.

(69.) — A boiler exploded, on February 21st, in Yearwood's sawmill, some three miles east of Vienna, Ga. Marshall Brown, Julius Allen, Henry Manuel, and Archibald Self were killed, and Thomas Ellis was fatally injured. We have not learned particulars about the damage to property.

(70.) — On February 21st a boiler exploded in Eli Snyder's grain chopping mill, three miles west of Brookville, Pa. E. V. Brosius was instantly killed, and Sidney Snyder and Robert Thompson were severely injured. The boiler house and an adjoining blacksmith shop were entirely demolished.

(71.) — On February 24th a boiler exploded on James Moss' ranch, near Rifle, Col. Marion Beard was severely injured by a flying fragment of the boiler.

(72.) — A boiler exploded, on February 24th, in the La Belle tin mill, at Wheeling, W. Va. William Braddock was severely injured, and several others were injured slightly.

(73.) — A boiler exploded, on February 25th, on the steamer *T. H. Bacon*, plying the Tennessee river between Loudon and Kingston, Tenn. The explosion occurred seven miles below Loudon. Engineer Estil Hudgins was killed, and Albert Claiborne and Cook Smith, and deckmen Walton, Salmons, and Dawson were seriously injured. The boat took fire and sank, and was an almost total loss. Robert Bird, a soldier returning from the Philippines, took command, and obliged the passengers to take to the boats. Through his efforts a large quantity of mail was saved. He also personally saved the lives of several of the passengers, and remained aboard the boat until he was forced to swim ashore.

(74.) — On February 25th a boiler exploded in the planing mill of the Trigg Lumber Company, at Noble, La. One man (whose name we have not learned) was killed.

## Inspectors' Report.

JANUARY, 1902.

During this month our inspectors made 12,716 inspection trips, visited 24,457 boilers, inspected 7,367 both internally and externally, and subjected 919 to hydrostatic pressure. The whole number of defects reported reached 11,210, of which 927 were considered dangerous; 85 boilers were regarded unsafe for further use. Our usual summary is given below:

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment, | 978 | 35 |
| Cases of incrustation and scale, | 2,905 | 120 |
| Cases of internal grooving, | 180 | 10 |
| Cases of internal corrosion, | 738 | 71 |
| Cases of external corrosion, | 540 | 39 |
| Broken and loose braces and stays, | 209 | 42 |
| Settings defective, | 394 | 28 |
| Furnaces out of shape, | 587 | 29 |
| Fractured plates, | 326 | 52 |
| Burned plates, | 461 | 77 |
| Blistered plates, | 121 | 2 |
| Cases of defective riveting, | 301 | 25 |
| Defective heads, | 90 | 18 |
| Serious leakage around tube ends, | 1,765 | 148 |
| Serious leakage at seams, | 441 | 22 |
| Defective water-gauges, | 344 | 56 |
| Defective blow-offs, | 196 | 53 |
| Cases of deficiency of water, | 16 | 9 |
| Safety-valves overloaded, | 97 | 22 |
| Safety-valves defective in construction, | 89 | 29 |
| Pressure-gauges defective, | 407 | 35 |
| Boilers without pressure-gauges, | 4 | 4 |
| Unclassified defects, | 21 | 1 |
| Total, | 11,210 | 927 |

## A Possible Extensive Source of Fuel.

The question is often asked, what are we going to do for fuel when the coal supply is exhausted? The answer cannot be given at the present day, though it cannot be doubted that as coal becomes scarcer and higher in price the wits of inventors and scientists will evolve some substitute or other, perhaps (and probably) not a fuel, but at least a substitute in the sense that by its use we shall be enabled to operate our factories and our railroads, and to keep ourselves warm in the winter. In the meantime, it is worth while to cast our eyes about to see what visible substitute may suggest itself. Peat has often been considered, and, while it is hardly probable that it will ever become a fuel of any great importance in the United States at large, its possibilities are worthy of attention. The appended article from *Railway Machinery* will be found of interest in this connection:

"Peat is partially carbonized vegetable matter, consisting of decayed moss, grass, sedge, etc., in which masses of fibrous roots are incorporated, the whole, when well dried, forming an excellent fuel. Large areas of the earth's surface are covered with swamps, morasses, and bogs, from which peat can be obtained in practically unlimited quantities, and at small expense as compared to mining coal. Peat beds are sometimes found of great depth, even as great as forty feet, though this is unusual. The use of peat for fuel is common in many northern countries of the Old World, but its use in the United States is quite limited, especially for steam-making. One pound of perfectly dry peat has about the same calorific value as three-quarters of a pound of good coal. The chief bar to the use of peat for fuel is the difficulty of drying it, and unless it is dry a considerable part of its heat value is absorbed in evaporating the entrained water. In its natural state peat contains from 75 to 80 per cent. of water, and when air-dried it still retains about 25 or 30 per cent., so that air-dried peat has a calorific value only about one-half as great as that of coal, pound for pound.

"It is practically impossible to dry peat in the open air, in many parts of the country, on account of the uncertainty of the climate; and in some places the natural humidity of the atmosphere is so great that the percentage of moisture cannot be reduced to much less than one-half its natural amount as removed from the bog. We understand that experiments have been made with various apparatus for drying peat, but that the results have not been generally satisfactory. Recently, however, tests have been made of a new peat-drying process at the University of Michigan, at Ann Arbor, with encouraging results. It is even predicted, as the result of these experiments, that the extensive peat beds of Michigan and other states will eventually become important sources of fuel for all purposes, peat becoming a rival of both coal and petroleum. The importance of a successful process for making peat a commercial fuel is unquestionably great, especially for parts of the country that are remote from coal mines, but which have extensive swamp lands from which peat can be obtained."

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A BOILER exploded on January 18th in a spinning mill at Puente de Vilumara, near Manresa, Spain. The explosion was of terrific violence, and it is said that sixty persons were killed and one hundred were injured. At last accounts it was expected that at least thirty of the injured would die. The explosion also destroyed half of the village of Puente de Vilumara. The buildings collapsed entirely, and the debris was thrown to great distances, destroying other buildings and killing and injuring numbers of persons in the neighborhood. The dead included many children.

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A TOY BOILER operated by Claude Sawyer, son of William Sawyer, manager of the gas works at Charlotte, Mich., exploded with serious results on December 31st. Several boys had arranged a boiler about four feet long and twelve inches in diameter, over an arch. Filling it partially with water, they closed all its vents and kindled a fire beneath it, expecting to have all kinds of fun blowing a whistle that they had attached. The resulting explosion threw chunks of iron in all directions, and Claude was injured so badly that his left leg had to be amputated.

# The Locomotive.

HARTFORD, JULY 15, 1902.

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

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

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

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

THE number of boiler explosions for the year 1902 bids fair to equal the number recorded for 1901, although there were an unusual number in that year. The number that we have recorded for January and February, 1902, is 74, the number for the corresponding months of last year being but 71.

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WE desire to acknowledge the receipt of the latest issue of *The Polytechnic Engineer*, which is the annual organ of the Engineering Society of the Polytechnic Institute of Brooklyn, N. Y. The present issue (for 1901–1902) contains a number of very creditable papers, and the publication maintains its usual high standard.

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WE have received a copy of *The Electrical Catechism*, issued by the Hill Publishing Company, and compiled from the regular issues of *Power*. We do not like the question-and-answer form of giving information in books, but we are well aware that many engineers and others do like it, and therefore we have no idea of criticising the present volume on that score, nor, indeed, on any other; for, so far as we have examined it, it appears to be very well and faithfully done. The science of electricity has become so much developed that it is impossible to get a thorough knowledge of it from a book, and those who take up the present volume with the idea of gaining such a knowledge, without a good deal of practical experience in addition, will of course be doomed to disappointment. But as an aid to a systematic study of the practical applications of electricity, the *Catechism* appears to be well worthy of commendation. It must not be forgotten that electricity is an essentially mathematical subject, and without some mathematical training, nobody can hope to follow the modern theory of it very far. So it must be expected that formulas will be found in any book on the modern applications of electricity, that is really good for anything. The author of the present book has given a certain number of formulas, but he has not entered upon the more abstruse mathematics of the subject, and he has not given formulas at all except where he conceived them to be essential to clearness or brevity. We imagine that some of the readers will be troubled by the Greek letters that occur occasionally; but our author has not introduced anything of that kind (so far as we have observed) except in connection with things that are always designated by these same Greek letters in all books on the same subject. The *Catechism* is very fully illustrated, and is well printed, on good paper. It contains more than 500 questions and answers, relating to all manner of electrical things that would be likely to interest the practical man. We regret that the author's name is nowhere given. (Hill Publishing Company, World Building, New York; cloth, 210 pages, $2.00.)

William Thornton, Sr., engineer at the Richardson Shoe Factory, at Menominee, Mich., was severely injured, on March 2d, by an explosion that occurred in an empty boiler upon which repairs had just been made. The boiler in question had been out of service for several days, and when the repairs had been completed, and the boiler was about to be filled again, Mr. Thornton opened a handhole to examine the interior. Finding it necessary to insert a candle, he lighted one and thrust it in through the open handhole. The explosion followed immediately, accompanied by a blinding flash and a loud report. We have no positive information concerning the cause of this explosion, but we have little doubt that it was due to the use of petroleum or kerosene, or some similar substance, in the boiler, for loosening up the scale. Such results not infrequently follow the use of petroleum or its derivatives in steam boilers, if proper precautions are not taken. Whenever a boiler is opened up after any such substance has been used, especial care should always be taken to thoroughly ventilate the interior of the boiler before a light is brought near. Volatile gases are produced from the oil by the heat of the boiler, and a naked light is apt to produce a bad explosion if the ventilation is neglected. We have referred to this source of danger a number of times, but the present unfortunate accident may well serve as the text for another word of caution.

## The Panama Canal.

Now that Congress has definitely given preference to the Panama route for the Atlantic-Pacific canal, the prospect is good for the completion, at no distant date, of a serviceable waterway between our eastern and western coasts. The Isthmian Canal Commission estimated that the Panama canal could be completed by 1912, if work were begun upon it at once, under the supervision of the United States. It is natural that the deepest interest should be felt by the public in an undertaking so replete with vast engineering problems, and so important to the development of our commerce; and the technical press has responded to this interest, and endeavored to stimulate it still further, by the publication of numerous and timely articles upon all phases of the canal question. We cannot undertake to give even a list of these numerous papers, but we should like to call especial attention to the July issue of the *Popular Science Monthly*, which contains the first installment of a rational and very interesting article, by Professor William H. Burr, on "The Panama Route for a Ship Canal." Another article that is worthy of special mention is S. A. Thompson's "Effect of Waterways on Railway Transportation," which will be found in the July issue of *The Engineering Magazine*. Mr. Thompson undertakes to show that the canal will not injure our railroad interests, but, on the contrary, will be beneficial to them. His article closes with this rather roseate prophecy: "The development of the Northwest, which has come chiefly in consequence of the building of the locks at the outlet of Lake Superior, marvelous though it is, is but a faint and shadowy image of the development, similar, but multiplied a thousand fold, which will follow fast upon the completion of an Isthmian canal. Since it is 'not mileage, but cost of transportation, that is the true commercial measure of distance,' the continent will shrink until its eastern and western coasts are commercially but half as far apart, while yet no single acre of its wide expanse is lost. Manila, Yokohama, and Hong Kong will be brought close to New York, Boston, and New Orleans, while San Francisco, Portland, and Seattle will become neighbors of Liverpool, Antwerp, and Hamburg. Mines will be opened, deserts made to blossom as the rose beneath the magic touch of irrigation, towns and cities will spring up, and the western commonwealths grow populous and great, while the manufacturing cities of the Eastern States, the cotton planters of the South, and the grain growers of the Middle West, will find new and enlarged markets for their products. I can think of no portion of the United States that would not share in the benefits showered abroad by the construction of an Isthmian canal; but if I were asked to point out the interest that would receive the most abundant share of the benefits that would most certainly accrue, I should without an instant's hesitation, name the railroads of the Western States."

The Spooner bill, upon which the action of Congress was based, is thus epitomized by the *Railroad Gazette:* "The President is authorized to acquire, at a cost not exceeding $40,000,000, all of the rights, right of way, unfinished work and other property owned by the New Panama Canal Company of France on the Isthmus of Panama, and all its maps, plans, drawings, records, on the Isthmus of Panama and in Paris, including all the capital stock, not less, however, than 68,863 shares of the Panama Railroad Company, owned by or held for the use of the said canal company, provided a satisfactory title to all of said property can be obtained. The President is authorized to acquire from the Republic of Colombia, upon such terms as he may deem reasonable, exclusive and perpetual control in perpetuity of a strip of land, the territory of the Republic of Colombia, not less than six miles in width, extending from the Caribbean Sea to the Pacific Ocean. The President may acquire such additional territory and rights from Colombia as will in his judgment facilitate the general purpose hereof. The President shall cause to be constructed a ship canal from the Caribbean Sea to the Pacific Ocean, and he shall also cause to be constructed such safe and commodious harbors at the terminals of said canal, and make such provisions for defense, as may be necessary for the safety and protection of said canal and harbors; the President is authorized for the purposes aforesaid to employ such persons as he may deem necessary and to fix their compensation.

"Should the President be unable to obtain for the United States a satisfactory title to the property of the New Panama Canal Company, and the control of the necessary territory of the Republic of Colombia and the rights mentioned in Sections 1 and 2 of this act, within a reasonable time and upon reasonable terms, then the President, having first obtained for the United States exclusive and perpetual control, by treaty, of the necessary territory from Costa Rica and Nicaragua, upon terms which he may consider reasonable, for the construction, perpetual maintenance, operation, and protection of a canal, shall cause to be constructed a ship canal from a point on the shore of the Caribbean Sea near Greytown, by way of Lake Nicaragua, to a point near Brito, on the Pacific Ocean. The sum of $10,000,000 is appropriated toward the project contemplated by either route so selected. And the President is authorized to cause to be entered into such contract as may be deemed necessary. Appropriations therefor shall from time to time be hereafter made, not to exceed in the aggregate the additional sum of $135,000,000, should the Panama route be adopted, or $180,000,000 should the Nicaragua route be adopted.

"To enable the President to construct the canal there is created the Isthmian Canal Commission, to be composed of seven members, who shall be nominated and appointed by the President by and with the advice and consent of the Senate, and who shall serve during the pleasure of the President, and one of whom shall be named as the chairman of said commission. Of the seven members of said commission, at least four shall be persons learned and skilled in the practice of engineering, and of the four at least one shall be an officer of the United States army and at least one other shall be an officer of the United States navy, the said officers respectively being either upon the active or retired list of the army or of the navy. Said commissioners shall each receive such compensation as the President shall prescribe until the same shall have been otherwise fixed by Congress. In addition to the members of said Isthmian Canal Commission, the President is hereby authorized, through said commission, to employ in said service any of the engineers of the United States army at his discretion, and likewise to employ any engineers in civil life, at his discretion, and any other persons necessary for the proper and expeditious prosecution of said work. The compensation of all such engineers and other persons employed under this act shall be fixed by said commission, subject to the approval of the President."

## Thunderstorms and Atmospheric Electricity.

The Egyptologist Brugsch concludes, from certain inscriptions, that the pylon towers that flanked the entrances of Egyptian temples were provided with grooves for the reception of masts designed to intercept the destruction threatening from the sky. Some obelisks are also supposed to have served as lightning conductors. This opinion is not shared by other Egyptologists, however. The Phoenicians and Hebrews seem to have known lightning guards. The Greeks and Romans are reported to have drawn fire from the sky, and Tullus Hostilius is said to have perished in a sacred experiment of this kind. Reminiscences of such knowledge can be traced through the Middle Ages. But the study of atmospheric electricity is more than a century younger than that of electricity. Franklin's experiments commenced about 1747, and his first lightning conductor is said to date from 1755. Electricity was decidedly in the air then. It is fairly certain that Procop Divisch, a learned priest, put up a lightning conductor at Prendiz, Bohemia, in 1754, — a rod 130 feet high, with cross bars, iron filings, and more than 300 brass points, and chains hanging down to the ground, — and that he had to take it down again a year later, because it brought on a terrible drought, although he was patronized by the Emperor and Empress, Francis Stephen and Maria Theresa, who had witnessed many of his experiments. Franklin's rods, it will be remembered, caused an earthquake in Massachusetts! It is not likely that Franklin had heard of Divisch; but Divisch may have known that Reimann of Eperies, then belonging to Poland, saw lightning run along iron rods without injuring them, but shattering a stone between them, in 1717. Richmann was killed by a ball of fire jumping over from his insulated vertical bar in 1753 at St. Petersburg; Paris and Lyons were busy experimenting with atmospheric electricity; and there was excitement everywhere, in fact, except in London, where the Royal Society duly sneered at the unscientific dabblings of a tradesman.

The ancient sage and the modern tradesman would still be welcome if they could help us over the difficulty of the origin of atmospheric electricity. We have had theories established and disestablished again; and in fact there have been something like twenty-five new thunderstorm theories during the last twelve years, six of them in one year, as Professor Schuster remarked in 1895. That water and water vapor, — evaporation and condensation, — are important factors, was presumed in the early days. Volta thought that rising water vapor is negatively charged, the water from which it arises being positively charged; and Peltier believed that aqueous vapor carries up with it part of the electric charge of the earth. But we have no proof that the evaporation of water is accompanied by a separation of the two electricities, nor has it been established that the vapor from electrically charged water carries any charge with it. There is a great deal of experimental evidence, but it is not by any means in complete harmony. Bartoli could find no sign of electrification due to mere evaporation; and Pettinelli has continued this work with organic compounds, — alcohols, aldehydes, etc., — with the same negative result. Lord Kelvin, Magnus MacLean, and Alexander Gall observed that a carefully dried air current charges pumice stone soaked in sulphuric acid positively, especially when the air has to bubble through the acid; but no charge was observed when the pumice stone was moistened with water. They further found that air bubbling through pure water becomes negatively electrified, while with salt water it becomes positively electrified. If the air is previously electrified, however, a positive charge is diminished by pure water and a negative charge by salt water; and the charges are increased if the original charges are opposite to those here supposed. But such charges, and, further, the charges imparted to air which is blown through a metallic case with a metallic point in the center, the case and point forming electrodes connected with an induction machine, disappear if the air is filtered through a sufficient number of wire-gauze screens or cotton-wool plugs. These observations, which were not all concordant, and the experiments with air currents passing through hot tubes, suggest that dust particles of various descriptions, and friction, play a part. Holmgren states that a fine current of air emerging from water is positively charged to seventy volts, and that concussions and friction between solids and water generate electricity. According to Lenard, confirmed by Wesendonck and others, waterfalls that dissolve in drops and mist make the air negative; while solids and liquids against which the air streams make it positive, the water itself appearing to be unelectrified. This is when the water is pure; for salt water sprays give rise to positive electrification.

S. A. Andrée, of balloon fame, filled one of two metallic spheres, about five inches in diameter, with a freezing mixture, and then placed both spheres, insulated, in a dusty room, whose air he electrified. The potential of the cold sphere on which the moisture was condensed rose more rapidly than that of the warm sphere. Thus the atmospheric electricity was possibly concentrated on the condensed vapor,— a view which experiments made in the open air appear to confirm. We know from the work of Coulier and Mascart, and from the more recent investigations of J. Aitkin, that the presence of dust facilitates the condensation of water vapor; and it has in fact been doubted whether condensation is possible without nuclei of some sort,— dust particles or their equivalents. But the term "dust" may be taken in a very wide sense. Barus considers that "dust-free" air, in the strict sense of the expression, may possibly never exist. Indeed, there must be "dust" of some kind where electric sparks are flying, or where platinum is glowing, or where a hydrogen jet is burning, since something,— the metal or the glass,—is always volatilized by the spark or the heat. It would appear from the researches of C. T. R. Wilson, however, that expansion suffices to bring about condensation in air that is saturated with aqueous vapor. Nuclei having a diameter of 0.000,000,025 of an inch are sufficient to produce cloud-like condensation, and these are always present in all gases containing water vapor. Rain-like condensation is produced only when somewhat larger nuclei are present. The influence of a slight electrification by induction on the nature of drops has long been known. A high vertical water jet soon breaks into drops, which are scattered in all directions; but when a piece of rubbed sealing wax is held near, the jet flows quietly and the drops coalesce. With a strong electrification, the scattering is worse than without any. Shelford Bidwell noticed that a jet of steam becomes dark and opaque when electrified, recalling to him the brownish-red shadow thrown by thunder clouds. He first supposed that the little globules in the steam coalesce, but it is more likely that they are dissolved into smaller and more numerous globules. One would feel tempted to fancy a connection between the electrified coalesced drops and the heavy rain drops falling after violent flashes of lightning, but possibly preceding them. This is a mere fancy, however, and Usener, for instance, considers that it is the falling drops that electrify the air. Perhaps the heavy drops are merely melted hail; for in the opinion of many persons there are no thunderstorms without hail, even though the hail, as such, may never reach the earth.

No generally accepted theory of thunderstorms has yet been built up; though it may be that we have come near to the real conditions in special cases. Thus Michie Smith has made a very plausible suggestion as to the sheet lightning that is often observed inland from Madras, India. There the dusty land breeze, charged negatively, and the sea breeze, charged positively by the salt spray, meet. The discharges usually take place between pairs of pillared cumulus clouds, the actual flashes being mostly hidden by the clouds. These clouds are rapidly sinking and are often surrounded by an iridescent fringe, whose colors (according to Aitkin) may be due to particles of dust and moisture left behind by the sinking clouds. In Aitkin's words, the storms are not the *cause* of the purification of the air, but its *effect*. Mohn distinguishes two kinds of thunderstorms,—heat thunderstorms and whirl thunderstorms. W. von Bezold, in common with many others, believes that strong ascending currents of air prevail in both kinds of storms, these currents preventing the large masses of water assembled in clouds from sinking until the unstable equilibrium breaks down, owing to local conditions (heat storms) or to changes initiated at a distance (whirl storms). Causes for the breakdown are the heating of the lower strata, the cooling of the higher ones, supersaturation with aqueous vapor, the overcooling of water drops, and changes in the state of aggregation.—*Engineering* (London).

[It is certainly strange that we have made so little progress towards an adequate, general explanation of the wonderful phenomena of thunderstorms, when the progress of electrical science in other directions is considered. The most difficult part of the problem relates to the origin of the enormous electric charges that are observed. It might not be so difficult to imagine some cause adequate to produce a charge having a potential of a few volts, or even of a few hundred volts; but how shall we explain the accumulation, apparently in the open air, of charges whose potential is measured by unknown millions of volts, and whose striking distance is probably hundreds, and perhaps sometimes thousands, of feet?]

## Power Lost in Flywheels.

The resistance which a flywheel offers to the air may give rise in some cases to a considerable expenditure of energy. Some tests were made in the Nürnberg central station which showed this very clearly. The station is provided with two tandem compound engines of 450 horse power, direct coupled to the dynamos and working at 95 revolutions per minute. In order to equalize the running with the great variations of load which occur, a very heavy flywheel was used with arms of a channel section. It was found that these arms offered a great resistance to the air, and created a powerful draft, and so it was decided to cover the wheel with sheet-iron in order to reduce the resistance and thus gain considerable power. In order to test the amount of energy lost, the dynamo was made to run as a motor, and thus drove the engine and flywheel at no load. When the latter had no protecting covering it was found to absorb 13,300 watts, but when the covering was replaced it took only 9,874 watts, thus showing a gain of 3,426 watts or 5.7 horse power, this being 1.2 per cent. of the power of the engine. Counting the current price per kilowatt hour and a day's run of 17 hours, it was found that this represented an economy of nearly $270 annually. Another test of a similar nature was made by M. Ingliss upon a 630 horse power engine, and showed an economy as high as 30 horse power, or 4.8 per cent. of the engine power, which was gained by properly diminishing the resistance of the flywheel.—*Scientific American.*

Incorporated 1866.

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HARTFORD, CONN.

Charter Perpetual.

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# The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XXIII. HARTFORD, CONN., AUGUST, 1902. No. 8.

## A Fearful Boiler Explosion.

The city of Detroit, Mich., was visited, on November 26, 1901, by a most disastrous boiler explosion, which occurred in the works of the Penberthy Injector Company, on Brooklyn avenue and Abbott street, at about half past nine in the morning. "In an instant more than a score of souls were hurled into eternity," says the *Free Press*. "What had been a three-story brick structure was instantly converted into a mass of rubbish, out of which stuck tangled masses of pipes, broken beams, and shattered tim-

Fig. 1. — Showing the Site where the Destroyed Building Stood.

bers. It came with such suddenness, such terror, such overwhelming force, that hours afterwards the awfulness of it could scarcely be realized by the thousands who hurried to the scene. Fire added its horrors, and if any of the unfortunates escaped the first crash they were either cremated, suffocated by the smoke, or drowned by the torrents of water the firemen were forced to pour into the ruins for many hours before they could begin the work of rescuing those still living, and recovering the bodies of the dead. For a moment after the roar of the explosion there was silence, broken after an instant by the falling of the debris. Then, in a cloud of dust, a dozen men rushed into the street, while the screams of agony that came from the ruins told of the terrible tortures that had come so suddenly upon their comrades who could not escape. At first there was no sign of fire; only a cloud of dust that hid everything from the sight of those around. This floated away, and for a few minutes there was no indication of the flames that were to bring so much misery in hours to come. All the workmen who had been in the one building that was not destroyed, and which adjoined the doomed structure on the south, rushed to the rescue. They frantically tore at the heavy timbers, and strove to lift the masses of wreckage that imprisoned their suffering fellow-

Fig. 2. — Showing the Shell of the Exploded Boiler.

men. Then, from a dozen places, tiny jets of smoke began to arise. They grew larger and denser, and soon the gallant rescuers were driven from the ruins by flames that cracked and leaped into the air. A dozen fire engines were soon at work, while firemen armed with long pikes and sharp axes strove to break their way under the mass of wreckage to the imprisoned men, or tear away openings through which streams of water might be advantageously played upon the blaze. But it was a useless task, and when they finally conquered the fire, charred timbers and twisted masses of iron and steel met them, and kept them busy for hours before they could get to the places where the poor men were thought to be."

The foregoing description will give some idea of the horrors of the situation; but the story is an old one, for substantially the same tale must be told after every great boiler explosion in which populous buildings are destroyed. The total list of casualties, when the record was complete, included thirty dead and thirty-five others seriously injured. The property loss was between $80,000 and $100,000.

The explosion occurred in the north plant of the Penberthy Company's works, in a brick building 100 feet long, 53 feet wide, and three stories high. Only three men were employed on the first floor. The second floor contained the brass shop, where fifty employés were at work. On the third floor was the foundry, with nine molders, four helpers, and about twenty-five employés in all. This whole building was utterly destroyed, barely a single brick being left in place. It is probable that the expanding steam threw the lower walls in all directions, thus leaving the upper portion of the

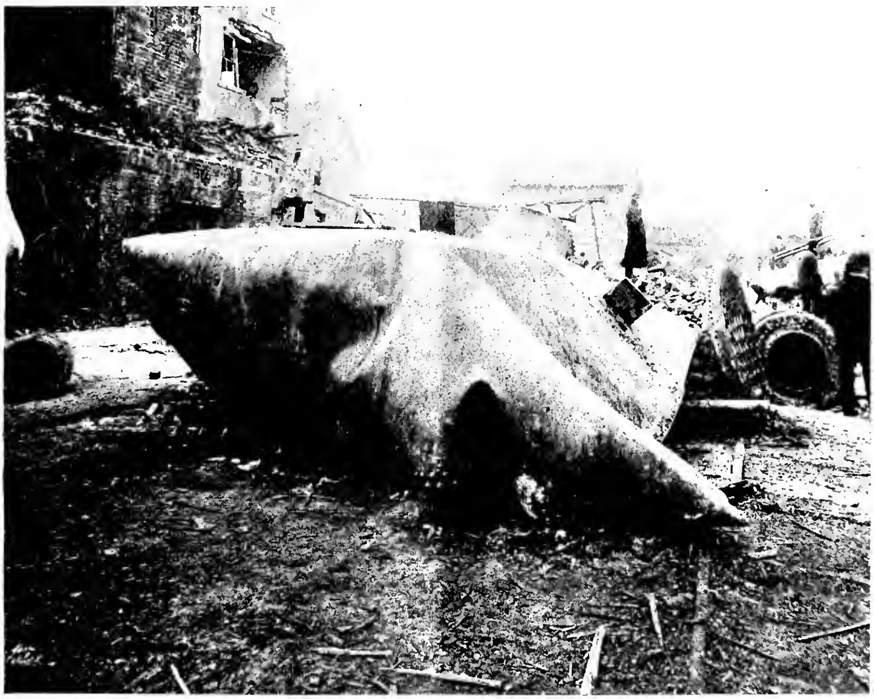

Fig. 3. — Another View of the Shell of the Exploded Boiler.

building entirely without support, and precipitating it, together with its precious contents, to the ground.

The boiler plant of the Penberthy Company consisted of two boilers, but at the time of the explosion one of these was out of service. The boiler that blew up was of the horizontal tubular type, and was 16 feet long and 66 inches in diameter, with 64 four-inch tubes. The shell was constructed of two sheets, each extending from one end of the boiler to the other, so that there were no girth joints. It was comparatively new, as it was built in 1894, and had therefore been in use only about seven years. The shell plates were $\frac{3}{8}$-in. thick, and the longitudinal joints were lapped and double-riveted with rivets $\frac{3}{4}$-in. in diameter, pitched 3 in. from center to center, longitudinally. It had always had the best of care, so far as we are aware, and up to within two or three years of the time of the explosion it had been insured with the Hartford Steam Boiler Inspection and Insurance Company. In order to guard against any misapprehension we desire to state that the insurance was *not* discontinued with us because we had considered the boiler to be uninsurable; for, so far as we are aware, the boiler showed no visible sign of the impending danger, even up to the very day of the disaster, and we have already stated that it had had the best of care. The coroner's jury, too, expressly exonerated the Penberthy Company from all responsibility. "We find the Penberthy Company," said the jury, "through its officers and the engineer in charge of said boiler, had given it proper care and attention, and are not responsible for the explosion."

Professor M. E. Cooley, of the University of Michigan, was retained by the prosecuting attorney of the city of Detroit as an expert in connection with the investigation, and the Penberthy Company retained Professor R. C. Carpenter, of Cornell University, in a like capacity. Professor Cooley computed the safe working pressure of the boiler, from measurements made by himself, and found that a working pressure of 97 pounds was permissible, with a factor of safety of five. The boiler had been allowed a pressure, by the inspectors who had examined it, of 100 pounds per square inch, and we have no reason to believe that it was ever operated at any higher pressure.

The boiler failed by fracture along the long longitudinal joint on one side of the shell, the break following the joint substantially in a straight line, extending from one

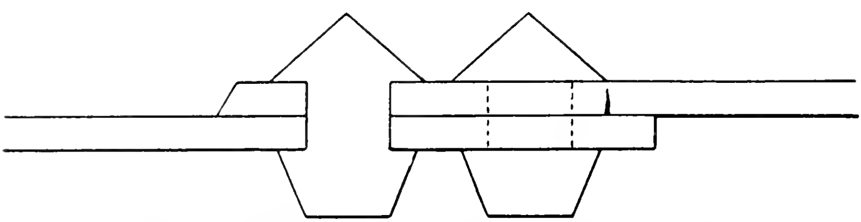

FIG. 4. — SHOWING THE POSITION OF THE HIDDEN CRACK.

head to the other. The entire shell was thus left in a single piece, which freed itself from the heads by the shearing of the head rivets. Two views of the shell are given in Figs. 2 and 3. Except for the line of fracture along the longitudinal joint, and for the indentations and irregularities caused by collision with obstacles in its course and with flying fragments of debris, the shell was practically uninjured.

There can hardly be any doubt about this explosion being due to a concealed crack that had gradually developed in the material of the sheet, as has been explained in previous issues of THE LOCOMOTIVE, — notably in the issue for January, 1897, a copy of which will be sent to any person applying for it, by mail or in person, at the Hartford office of this Company. The nature of these cracks may be made clear by quoting a few paragraphs from the issue here referred to. "If the plates are hard, or tend towards brittleness, they may be so weakened by punching the rivet holes that a subsequent fracture of some kind, along the joint, may be reasonably expected. It is therefore of the first importance to build the boiler of material that has proper *ductility*. Most of the fractures of the plate at the joint, however, are undoubtedly due to bending the plates in the rolls. From thirty to forty per cent. of the sectional area of the plate is removed, along the line of the joint, by the act of punching or drilling the rivet holes; and when the part that is thus weakened is passing through the rolls, the curvature of the plates at this point is sensibly increased, owing to the greater readiness of the weakened spot to yield to the stress imposed by the rolls. The sharpest bend will usually occur, too, along the *inner* row of holes, because here the rolls have a greater leverage than they have along the outer row. When plates thus affected are brought into position for riveting, they will not lie closely, but have to be knocked together with a sledge, or forced together hydrostatically, before the rivets can be driven. This means that there is a severe local strain left in the plates, the effects of which are likely to become visible at some time in the subsequent history of the boiler. When the joint has been riveted up, the parts of the plate that lie under the heads of the rivets are held together so firmly that the yielding action that occurs in every boiler as the pressure and temperature vary will not be felt at this point, but will be transferred to a point lying at, or just beyond, the edge of the rivet heads, as shown in Fig. 4. In the course of time these slight changes of form, when combined with the stress already existing along this line from the effect of the rolls, are likely to develop a crack starting from the inside surface of the outer plate, at a place completely hidden from view, and extending insidiously outward, until the final rupture of the plate is accomplished, and the boiler gives way in a violent explosion. The difficulty of discovering a crack of this kind is obvious enough, because the crack is entirely out of sight, and as it often does not run into a rivet hole, it cannot be detected by *leakage*, until it has actually perforated the plate in some spot. These hidden fractures can sometimes be detected by the presence of radiating, hair-like branch cracks, extending out from under the inside lap. These faint indications might easily be overlooked by the most competent and careful inspector, especially as the joints that are thus affected are often in such a position that minute examination of them is not possible; and too frequently the radiating cracks do not exist at all, so that there is no human means of knowing the true state of the joint, without cutting out the rivets and separating the plates — a proceeding altogether too heroic to be in favor among boiler owners, unless there is some tangible reason for suspecting the defect."

Sections were cut from the shell of the exploded Penberthy boiler, for the purpose of making physical and chemical tests of the material. The data obtained by Professor Carpenter are given in the issue of *Power* for April, 1902, to which we must refer the reader who desires detailed information on the subject. In a general way it may be said that the tested specimens had a high tensile strength, but were deficient in ductility, which is a very important element in boiler plates. Chemical tests also showed that the material examined contained from two to three times as much phosphorus as a high grade boiler plate ought to contain; and it is to the excess of this element that the deficiency in ductility was probably due.

In conclusion, may we not be allowed to draw attention to the bearing of this explosion on the question of boiler insurance? Here was a boiler that had been inspected regularly by an insurance company, and also twice a year (we believe) by a Detroit city inspector, and which was in charge of a competent, careful engineer who was properly licensed; and yet it blew up, with the disastrous effects outlined above. The point that we wish to make is that careful inspection and supervision, although both are exceedingly important, are nevertheless uncertain, and although they will surely diminish the chances of an explosion, too implicit a reliance must not be put in them. They should always be supplemented by *insurance*. We fancy that this lesson has already been taken to heart by the people of Detroit, for this is the second appalling boiler explosion that that city has had within some seven years, the previous one being that which occurred in the *Evening Journal* building, on November 6, 1895, and caused the death of thirty-seven persons, as well as a property loss of $100,000.

## Inspectors' Report.

FEBRUARY, 1902.

During this month our inspectors made 10,194 inspection trips, visited 19,425 boilers, inspected 6,198 both internally and externally, and subjected 619 to hydrostatic pressure. The whole number of defects reported reached 9,293, of which 806 were considered dangerous; 65 boilers were regarded unsafe for further use. Our usual summary is given below:

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment, | 806 | 24 |
| Cases of incrustation and scale, | 2,436 | 58 |
| Cases of internal grooving, | 132 | 17 |
| Cases of internal corrosion, | 663 | 39 |
| Cases of external corrosion, | 540 | 44 |
| Broken and loose braces and stays, | 153 | 29 |
| Settings defective, | 287 | 26 |
| Furnaces out of shape, | 318 | 7 |
| Fractured plates, | 273 | 60 |
| Burned plates, | 379 | 49 |
| Blistered plates, | 113 | 8 |
| Cases of defective riveting, | 318 | 59 |
| Defective heads, | 59 | 12 |
| Serious leakage around tube ends, | 1,204 | 123 |
| Serious leakage at seams, | 528 | 23 |
| Defective water-gauges, | 239 | 38 |
| Defective blow-offs, | 186 | 45 |
| Cases of deficiency of water, | 21 | 14 |
| Safety-valves overloaded, | 102 | 42 |
| Safety-valves defective in construction, | 105 | 40 |
| Pressure-gauges defective, | 370 | 29 |
| Boilers without pressure-gauges, | 13 | 13 |
| Unclassified defects, | 48 | 7 |
| Total, | 9,293 | 806 |

## Boiler Explosions.

MARCH, 1902.

(75.)—A heating boiler exploded, on March 3d, in the basement of Henry Hildreth's residence, 10,054 Avenue L, Chicago, Ill. Nobody was at home at the time. The house was partially wrecked, and the loss was about $1,500.

(76.)—The boiler of mogul locomotive No. 1701 of the Southern Pacific Coast railroad exploded, on March 3d, about eight miles north of Guadalupe, San Luis Obispo county, Cal. Engineer Richard Duggan and brakeman J. C. Henshaw were killed, and fireman W. Postlewaite was seriously injured. The locomotive was wrecked. It was running "light," hauling nothing but the caboose. Conductor S. C. Jones says that "just as the engine and caboose reached Deuman hill, there was a violent trembling of the locomotive, twice repeated, and the explosion followed a second later." This statement suggests that some of the stays gave way first, thus precipitating the catastrophe. The roar of the explosion was heard for miles.

(77.) — On March 3d a boiler exploded in Clark Neff's sawmill, at Pinewood, some sixteen miles west of Loveland, Col. Mr. Neff's skull was fractured, and he was otherwise severely cut and bruised about the head. W. H. Edmonds was also badly cut and scalded about the head. The mill was completely wrecked.

(78.) — A boiler exploded in Watkins' sawmill, at Whitwell, Tenn. We do not know of any personal injuries. Our account says that "someone blew up the boiler with dynamite, but no clue to the miscreant has been obtained." We guess that none will ever be obtained, for the simple reason that we do not believe the aforesaid miscreant exists, outside of the imaginations of the persons living in the vicinity of the exploded boiler. It is so hard for most persons to realize the enormous energy stored up in a steam boiler, and the consequent violence of a good, adult boiler explosion, that it is quite common for undoubted boiler explosions to be reported as the work of "miscreants" armed with high explosives of one sort and another.

(79.) — On March 7th a tube burst in a safety boiler at the electric light plant at Charleston, W. Va. John Gunter, an eight-year-old boy, was severely scalded and burned.

(80.) — A boiler exploded, on March 7th, in O. S. Oaks' sawmill, at Fernandina, Fla. Joseph Durrant, Thomas Harris, and another man named Bell were killed, and Gordon Hall and Philip Williams were severely injured. The mill was wrecked, and the ruins caught fire and burned until the destruction was complete. The property loss was about $6,000.

(81.) — The boiler house of the Peacock Distilling Company's plant, at Kiserton, near Paris, Ky., was badly damaged, on March 8th, by the explosion of a boiler. No person was injured.

(82.) — On March 10th a boiler exploded in B. W. Fleming's sawmill, at Blue Bank, near Tiptonville, Tenn. Engineer Samuel Burton was killed, his body being torn to small fragments. Thomas Wills was injured by flying timbers, but will recover. The mill was wrecked.

(83.) — A boiler exploded, on March 12th, while used in drilling an oil well on the Hogue lease, at "Big Moses," near Middlebourne, W. Va. Nobody was near at the time, so that there are no personal injuries to record.

(84.) — On March 13th a boiler exploded in Fugate & Meadows' sawmill, at the headwaters of Frozen Creek, near Campton, Ky. Engineer Jesse Burchfield, Philip Logsden, and John Stringer were killed, and Milton Blair, Asa Baumgardner, Michael Hughes, Henry Fanning, and Chapel Welsh were seriously injured. The mill was blown to fragments.

(85.) — A boiler exploded, on March 14th, at the Allen & Stern oil lease, on the Zugschwert farm, in Union township, near Findlay, Ohio. Park Elliott was seriously injured, but it is thought that he will recover. The engine house was totally wrecked, and considerable other damage was done about the lease.

(86.) — On March 15th a boiler exploded in John Wohrer's sawmill, at Hayden, near Vernon, Ind. Engineer Thomas Cox was instantly killed. We do not know the amount of the property loss.

(87.) — A boiler exploded, on March 15th, in Thomas Edwards' sawmill, two miles east of Barboursville, W. Va. Mr. Edwards and William Strank were injured so seriously that they may not recover, and six other men, whose names we have not learned, were also injured to a less serious extent. We have not learned further particulars.

(88.) — A boiler exploded, on March 15th, in the Little Rock Cooperage Company's plant, on Rose Hill, near Texarkana, Ark. The property loss was small, and nobody was injured.

(89.) — On March 18th a boiler exploded in Wheeler & Gavitt's sawmill, about ten miles east of Wausau, Wis. William M. Gavitt, Casper Goldman, and John Dohonescki were killed. The boiler room was wrecked, but we have seen no estimate of the property loss. It is said that the inquest developed the fact that the safety-valve on the boiler had long been out of repair.

(90.) — On March 20th a boiler exploded in Thomas J. Dunn's sawmill, at Sherman City, near Columbus, Kan. Mr. Dunn was thrown against the side of the mill with great force, and received severe injuries from the effects of which he died about two weeks later. We do not know the extent of the property loss.

(91.) — On March 20th a boiler exploded at No. 8 stripping of the L. & W. B., in Honey Brook, near Hazelton, Pa. Fireman John Letko was painfully burned about the face and hands.

(92.) — A boiler exploded, on March 20th, at the Citico furnace, Chattanooga, Tenn. Thomas Keener, Alonzo Holleyfield, William Dooley, and John Schoolfield were scalded and bruised.

(93.) — On March 21st a boiler exploded in the Edison Electric Light plant, at York, Pa. The explosion consisted in the failure of one of the tubes of the boiler. William Stewart was slightly scalded.

(94.) — Webb Johnson was fatally injured, on March 22d, by the explosion of a boiler in the Moore Lime Company's mill, near Eagle Rock, in Botetourt county, eighteen miles from Roanoke, Va. He died some six hours later. Walter Finney, at the peril of his life, entered the boiler room, which was full of steam, and dragged Johnson out. Finney was badly scalded.

(95.) — A boiler exploded in Charles C. Hopper's planing mill, at Nashville, Tenn., on March 24th. Mr. Hopper was badly injured.

(96.) — A hot water boiler exploded, on March 24th, in the I. X. L. barber shop, at Galena, Kan. The heater was thrown through the roof of the building, and, after passing over several other buildings, it landed in a vacant lot. The front of the building was blown out, but nobody was injured, although the shop was full of customers at the time.

(97.) — A boiler exploded, on March 24th, in E. O. Eshelby's tobacco factory, at Newport, Ky. Fireman John Kay was severely injured, and engineer Maurice Kates received minor injuries. The entire roof of the building was blown off, and the power plant was wrecked.

(98.) — Locomotive No. 1618, of the Southern Pacific railroad, was destroyed, on March 24th, by the explosion of its boiler, on Lake hill, not far from Promontory Station, near Ogden, Utah. George Wilton, Erwin A. Uphoff, Roy Munsea, and William

F. Myers were killed. The boiler of the huge locomotive was thrown more than fifty feet from the track, and was literally torn to shreds.

(99.) — On March 25th a boiler exploded in the Girard Flouring Mills, at Girard, Pa. Nobody was injured, and the property loss, although not stated, was probably not large.

(100.) — A boiler exploded, on March 26th, in R. F. Adams' sawmill, at Boulder, some fourteen miles northwest of Carlyle, Pa. Engineer William Cosgrove was injured so badly that he died some two hours later. Nobody else was hurt. The mill was partially wrecked.

(101.) — Ira Vantine was seriously injured, on March 26th, by the explosion of an oil well boiler at Kane, Pa.

(102.) — A boiler exploded, on March 27th, at the Multnomah Trunk and Box Company's factory, Portland, Ore. Nobody was injured, and the property loss was small.

(103.) — A boiler used for operating a corn crusher exploded, on March 29th, at Dudleyville, some four miles south of Greenville, Ill. John Revis was thrown fifty feet, and received injuries that are believed to be fatal. Emery Hilliard was also badly scalded. The building in which the boiler stood was completely wrecked.

(104.) — A boiler exploded, on March 30th, at the Independent Oil Company's well No. 9, near Bristol, Harrison county, W. Va. The explosion wrecked a dwelling house near by, but we have not learned further particulars.

(105.) — A boiler exploded, on March 31st, in Mrs. Lottie Andrews' laundry, at Smethport, Pa., wrecking the small building in which the establishment was located, and damaging other buildings near by. We have not learned of any personal injuries.

(106.) — On March 31st a boiler used for rendering grease exploded at the Howat Meat Company's slaughter house, Canton, Ill. A portion of the roof of the building was blown off, but nobody was seriously injured.

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Every business has its peculiar experiences. We recall a meeting held a little while ago of certain commissioners in a town not so many thousands of miles from our home office, at which a report was read concerning a stone crusher boiler that was insured by the Hartford company, and which had been recently inspected. The inspector reported that the boiler was in bad shape, and that it would be more economical to buy a new boiler than to make the extensive repairs that would be required to put the old one in good order. The commissioners at once voted to cancel the insurance on the boiler in question. It would appear that when a report of that kind had been received, it would be a good time to continue the insurance as long as the insurance company would carry it, or at least until such time as measures could be taken to put things in proper shape; but we cannot pretend to have the combined wisdom of an entire commission, and so we bow as gracefully as possible to the decision. We may add, however, that we never shed any tears of regret when a patron discontinues his insurance on such a boiler as this. We may also add that if the boiler should blow up, the commissioners would stand in an unenviable position, if they do not take immediate proceedings, on their own initiative, to fix the boiler up, or replace it. Ignorance is never a very good excuse, but when one cannot make even that plea, he is in a bad way, so far as moral responsibility is concerned.

The Locomotive.

HARTFORD, AUGUST 15, 1902.

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

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

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

## Obituary.

MR. LEVERETT BRAINARD.

It is with profound regret that we announce the death of Mr. Leverett Brainard, which occurred at his home at Hartford. Connecticut, on July 2, 1902. He was stricken with an attack of paralysis about a week before his death, and failed gradually until he passed away, as recorded above. Mr. Brainard's business life was contemporaneous with the development of the City of Hartford, where he spent the greater part of his life, and which he loved and served faithfully in many ways. He was a public spirited citizen, always willing to take an active part in anything that conduced to the development of Hartford, or to the welfare of its citizens. He was born at Colchester, Connecticut, on February 13, 1828, and was the oldest of three children. His youth was spent on his father's farm, and he was educated at the village school, and at Bacon Academy at Colchester. His father died when he was thirteen years of age, and from this time the care and management of the homestead devolved upon him; it was here that he learned the lessons of self-reliance, industry, and responsibility that were potent factors in his subsequent life of activity and heavy responsibility. In early manhood Mr. Brainard removed to Pittsburg, Pennsylvania, where he engaged in the life insurance business. He remained there two years, and then returned to Colchester. In 1853 he came to Hartford, and was elected the first secretary of the old City Fire Insurance Company. A few years later he formed a partnership with Newton Case and James Lockwood in the printing and publishing house of Case, Tiffany & Company. Mr. Brainard's connection with the company dates from January 1, 1858, and since that time he has been connected with it continuously.

In 1868 the name was changed to Case, Lockwood & Brainard, and in 1874 it was incorporated as The Case, Lockwood & Brainard Company, Mr. Brainard becoming the secretary and treasurer, which position he held until the death of Mr. Newton Case in 1890, when Mr. Brainard was elected president. The house is one of national reputation, and has been successful from the start. Mr. Brainard was a member of the common council in 1866, and served as a member of the board of park commissioners from 1872 to 1876. He was mayor of Hartford from 1892 to 1894. In 1884 he was a member of the General Assembly from the town of Hartford, and was House chairman of the committee on railroads. In 1890 he was appointed a member of the World's Fair committee from Connecticut, his associate being ex-Governor Waller. This resulted in his being appointed chairman of the committee on Manufactures — one of the most important working committees of the World's Fair. Owing to his prominence as a business man, and his wide and varied financial interests, he was on the directorate of many financial institutions, and we desire particularly to record his position as a member of the board of directors of the Hartford Steam Boiler Inspection and Insurance Company — a post that he had filled for many years with eminent credit to himself and benefit to this company. He was a man of rather retiring disposition, but he was ever ready with advice and assistance to those in need of either. He was genial and kindly to a fault, and his loss will be greatly felt by the community.

The board of directors of the Hartford Steam Boiler Inspection and Insurance Company, at a meeting held on July 10th, adopted the following minute, which was spread upon the records of the company, and was afterwards engrossed and transmitted to his family as evidence of the esteem in which he was held by his associates on the board :

"In the death of Mr. Brainard this company loses one of the earliest members of its board of directors. He was elected a director on September 18, 1867. He also for many years filled an important place on the financial committee. His advice and counsel were always wise and conservative. He was ready on all occasions to devote freely of his time to the interests of the company, and his faithful service is deeply appreciated by its officers.

"In placing upon their records this recognition of Mr. Brainard's services, the directors feel deeply their personal loss, also the great loss to the whole community, in which he has occupied so many important positions. Mr. Brainard was the friend of young men, and his words of encouragement have often dissipated gathering clouds and stimulated renewed efforts which ultimately brought success. We express our deep sympathy for his bereaved family, upon whom this great loss has fallen.

"J. B. PIERCE, *Secretary.*"

"HARTFORD, July 10, 1902."

## Boiler Explosions and Railway Accidents.

For some reason or other the reading public, as a whole, does not appear to take any special notice of the accounts of boiler explosions that are printed in the daily papers, and the impression prevails that boilers hardly ever explode, and that they can be left out of account as a serious factor in life. To show how erroneous this impression is, we present, herewith, a comparison of the boiler explosions that we have recorded in THE LOCOMOTIVE for the first three months of the present year and of the railroad collisions and derailments that have been compiled for the same period by the Interstate Commerce Commission (for which latter data we are indebted to the *Railroad Gazette*).

RAILWAY COLLISIONS AND DERAILMENTS DURING JANUARY, FEBRUARY, AND MARCH, 1902.

| CHARACTER OF ACCIDENTS. | Number of Accidents. | PASSENGERS. | | EMPLOYÉS. | |
|---|---|---|---|---|---|
| | | Killed. | Injured. | Killed. | Injured. |
| Collisions, . . | 1,220 | 26 | 501 | 104 | 763 |
| Derailments, . . | 838 | 15 | 298 | 53 | 351 |
| Totals, . . | 2,058 | 41 | 799 | 157 | 1,114 |

Boiler Explosions during January, February, and March, 1902.

| Month. | Number of explosions. | Persons killed. | Persons injured. |
|---|---|---|---|
| January, . . . . . . | 35 | 25 | 45 |
| February, . . . . . . | 38 | 24 | 46 |
| March, . . . . . . . | 32 | 22 | 32 |
| Totals, . . . . . . | 105 | 71 | 123 |

We would call attention to the fact that the Interstate Commerce Commission has every imaginable facility for collecting its statistics with regard to the number of railroad accidents, while the Hartford Steam Boiler Inspection and Insurance Company has to get its information with respect to the boiler explosions of the country in whatever way it can. It must be, therefore, that the statistics given above for railroad accidents are far more complete than those given for boiler explosions, and proper allowance should be made for that fact. As the figures stand they show several interesting things. In the first place, it appears that the railroad collisions and derailments are certainly more numerous than the boiler explosions, even after all allowance for the imperfection of the explosion record has been made. On the other hand, it is plain that boiler explosions are far more deadly than railroad accidents, since the number of persons killed and injured is much greater, in the case of the boilers, when the number of accidents is considered. The total number of persons killed by collisions and derailments, during these three months, was 198; and the total number of persons injured in the same way and during the same period was 1,913. The number of such accidents being 2,058, it follows that the number of persons killed, per accident of the kind considered, was 0.10 ; and the number of persons injured was 0.93. On the other hand, if we turn to the boiler explosions, we find that the number of persons killed per explosion was 0.68, and that the number of persons injured per explosion was 1.17. The boiler explosion account leads in both respects ; and when the figures for the number of killed (per accident) are compared, the railroad collision is left behind so far that it almost takes the appearance of a harmless and innocent diversion.

## The Gulf Stream Myth.

A number of years ago, so the story goes, a member of Congress (we cannot say whether it was a senator or a representative), having in mind the general belief that it is the Gulf Stream that tempers the climate of England, Spain, and France, so that they are warmer than might be expected from their latitudes, made the suggestion that we cut a big canal across the isthmus of Panama and run a dam across from Florida to Cuba, and then charge Europe so much a gallon for her Gulf Stream, on penalty of having it switched over into the Pacific Ocean. Of course the suggestion was not made seriously; it was a joke, but it was a good one until the experts on climatology began to study the matter more closely. We have known the Gulf Stream so intimately, ever since our school days, that it seems hardly reverent to question its importance; yet that is precisely what students of the ocean have been doing for some time past, and (if the metaphor may be forgiven) the Gulf Stream now has hardly a leg left to stand on.

"About thirteen years ago," says the New York *Sun*, "a writer in the *Sun* summarized the evidence collected by the leading oceanographers of the day with regard to the course of the Gulf Stream in the Atlantic, and the alleged effect of this current upon the climate of western Europe. The quotations in that article from such scientific leaders as Carpenter, Buchanan, Alexander Agassiz, Findlay, Thoulet, and others, clearly showed that all the evidence collected from the time of the *Challenger* soundings pointed unmistakably to the disappearance of the Gulf Stream as a distinct, traceable current a little to the southeast of Newfoundland. Oceanographers had proved, in fact, that the Gulf Stream ceases to exist before reaching the mid-Atlantic; and having settled this question beyond all dispute, they naturally began to combat the idea, promulgated by that gifted scientific writer Lieutenant Maury, half a century ago, that it is the Gulf Stream, which, crossing the Atlantic, warms the western coast of Europe and keeps the harbor of Hammerfest, within the Arctic Circle, free from ice.

"Some text-books, still used in our schools, assert that northwestern Europe would be a howling Arctic waste if it were not for the genial influences brought to its shores by the warm Gulf Stream. This fact illustrates the persistence of error when once universally accepted as truth and powerfully impressed upon the popular imagination. The *Proceedings* of the Royal Geographical Society predicted, ten or twelve years ago, that 'it will probably take a generation or two to eradicate the old erroneous notions of text-books and popular treatises concerning the Gulf Stream.' The present prospects, happily, are that it will not take more than a generation after the scientific revolt against Maury's baseless theory began to enlighten the text-book writers and disillusionize the school teachers.

"In none of the best reference books, atlases, and maps of today is the Gulf Stream represented as extending to the European coast. The truth discovered by the oceanographers, that the stream disappears in mid-ocean, is being spread abroad with powerful iteration and emphasis. The actual causes of the mild climate of western Europe, discovered through the accumulation of proven facts in the domain of meteorology, are having wider and wider circulation through popular as well as scientific publications. A few months ago the *Monthly Weather Review*, published by our government and edited by Prof. Cleveland Abbe, one of the leading meteorologists, contained an able article exposing the fallacies of the old Gulf Stream theory and giving the conclusions of modern science as to the causes of the mild climate of western Europe. The recent publications of the Deutsche Seewarte of Hamburg, devoted to hydrography and marine climatology, and those of the British Hydrographic Office, have left the Gulf Stream myth nothing to stand upon.

"The latest and one of the most valuable contributions to this subject is an article in the current number of *Scribner's Magazine* on the 'Gulf Stream Myth and the Anti-Cyclone,' by Harvey M. Watts of Philadelphia, an article that is not only scientific but also written in a manner to interest and edify unscientific readers. Mr. Watts is one of the increasing number of writers who are showing that a scientific topic may be adequately treated without being garbed in an unattractive literary dress. The article gives the history of the origin and promulgation of the belief that the Gulf Stream is the sole cause of the mild oceanic climate of western Europe. The writer shows how completely this theory failed to grasp the profound influence of the drift of the atmosphere in determining the nature of weather and climate. It is not a sea current, but the prevailing air current blowing from the Atlantic to the lands of Europe, that gives a genial character to the climate of those far northern regions.

"It would be to the advantage of most teachers of geography to read and study so clear an exposition as this article gives of our present knowledge of the laws of atmospheric circulation and the effect of these air currents in different parts of the world.

"The gist of the whole matter, so far as it relates to the climate of western Europe, is that 'since the atmospheric drift in the temperate zones is from west to east, this means that all coasts and countries that lie east of oceans have transferred to them oceanic ameliorations, while the eastern parts of continents naturally receive the atmospheric drift as affected by the land masses over which it has traveled.'

"This is the reason why England has a mild climate and fifty little ports of Norway are open all winter: the influence of the mid-Atlantic basin is carried by the air to the west coast regions of Europe, giving them their oceanic climate; while Labrador, no farther north, receiving the air currents of Arctic and sub-Arctic America and not of the ocean, is frigid. When it had been fully demonstrated that the Gulf Stream theory is a delusion, it would not have been possible to show, so clearly as Mr. Watts has done in his able article, the meteorological causes that determine the difference between the climates of England and Labrador. The modern belief is summed up in a few paragraphs which Mr. Watts quotes from Prof. Abbe, a part of which are given here:

"'The circulation of air in the northeastern part of the Atlantic Ocean determines the mild character of western Europe by distributing the moisture and warmth of the Atlantic Ocean surface as a whole, and not that of the Gulf Stream, since there is no apparent Gulf Stream in these latitudes.

"'The warmth of the southwest winds of Europe is due to the moisture they contain, which gives up its latent heat when it becomes cloud and rain. The winds take up this moisture from the surface of the ocean when the latter is warmed up by the sunshine, and they would do the same if there were no Gulf Stream in the Straits of Florida.'"

Alas for the ingenious scheme to sell the Gulf Stream to Europe for hot-water heating!

## Buildings of the National Bureau of Standards.

The newly established National Bureau of Standards (which, for the good of the country, ought to have been established many years ago) is to be properly housed, as will be seen from the following extract from the *Iron Age:*

Last month the work of construction of the buildings for the new National Bureau of Standards was begun, on plans which, when fully completed, will represent an outlay of more than $1,000,000. The two buildings for which appropriations are now available will cost $365,000, but the complete scheme contemplates several additional buildings, for which the appropriate committees of Congress have practically pledged the money when needed.

The first building to be erected will be known as the mechanical laboratory. It will be three stories in height, 135 feet long and 50 feet wide, and will contain the power and lighting plant, storage batteries, special alternating current machines for experimental and testing purposes, the refrigerating plant, the heating and ventilating plant, auxiliary apparatus, the machine shop and carpenter shop, as well as laboratory for heavy electrical testing, photometry, gas and water meter testing. In the boiler room two 125 horse-power boilers will be installed, space being provided for doubling this capacity. In the dynamo and engine room, two 80 horse-power high speed engines, each directly connected to two 25-kw. direct current generators with special alternators. The floor space will admit of doubling this power plant whenever necessary.

The latest devices will be employed in the combined heating and ventilating system. The air will be supplied to the various rooms by means of ducts, with the aid of electrically-driven fans, the temperature of any room in either building being independently controllable by a thermostatic damper at the bottom of the respective flues, where the heated or artificially cooled air will be mixed with the air from without. The ducts are so proportioned as to permit a complete renewal of air every 15 minutes. In winter the air to be heated will be passed over coils fed with exhaust steam, and in summer will be cooled by coils through which cooled brine is circulated. To cool the air and to provide artificial ice a refrigerating plant of 30 tons ice melting capacity will be installed. Although the building will be used only a portion of the 24 hours, provision will be made for fully utilizing the refrigerating capacity.

An instrument shop will also be contained in this building, and will be equipped with the latest types of motor-driven precision and engine lathes, milling machines, shapers, drills, presses, etc. A liquid air plant will be installed with a capacity for all experimental needs likely to arise, and an electric storage room will be fitted up for heavy current testing. The general equipment of the mechanical laboratory will be designed for power and instrument tests, and it is predicted that the demand for this work will increase so rapidly that the additional buildings planned for will be needed within a very short time after the laboratory is ready for occupancy.

The main building, which will include the office of the director of the bureau, and the construction of which will proceed simultaneously with the mechanical laboratory, will be four stories in height, approximately 150 feet long and 50 feet wide, and will contain about 50 rooms, all equipped with apparatus for verification work and for special investigations, and provided with gas, electric lights, compressed air, suction, hot and cold water, as well as with a number of independent electrical circuits, so that electrical currents of any desired character may be obtained. The importance of temperature control in a physical laboratory has long been appreciated, and it is especially desirable in an institution where standardizing work is to be done, as nearly every result depends, at least to some extent, upon the temperature at which the measurements are made. Accordingly, means will be provided for closely regulating the temperature of any room at any desired temperature, both in summer and winter.

An important departure in the construction of this building will be the fact that the basement, instead of being given up to heating, lighting, ventilating, and power plants, will be utilized solely for the more precise work of the laboratory. Four large rooms will be fitted up in the basement as special temperature rooms, and the entire underground story will be vaulted over, so that both the basement and the floor above will be practically free from vibration. The second floor will be set aside for the administrative and clerical work, and for a library and museum in which standards and apparatus of historical importance will be preserved.

A well-equipped chemical laboratory will be fitted up on the third floor, part of which will accommodate a laboratory for photometric research. There will also be provided on this floor a lecture room with a seating capacity of 150 or 200. As it will be the policy of the bureau to keep in close touch with the interests it serves, it is hoped that it may soon be in a position to extend invitations to scientific and technical associations to hold their meetings from time to time in Washington.

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WE desire to acknowledge the receipt of the thirty-second annual *Report* of the Norddeutscher Verein zur Ueberwachung von Dampfkesseln, of Hamburg, Germany.

# The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XXIII. HARTFORD, CONN., SEPTEMBER, 1902. No. 9.

## Boiler Scale and the Transmission of Heat.

Some strange views concerning the effect of scale in boilers are held by the writers of books upon the subject of boilers and boiler management. Thus it is commonly taught that a slight coating of scale lessens the efficiency of a boiler in a very marked degree; whereas it must be pretty well known to every person who has had large experience with boilers, and is willing to trust to what he sees with his eyes in preference to what he thinks he knows how to calculate, that a layer of scale of ordinary thickness,—say an eighth of an inch,—does not require the expenditure of any very considerable

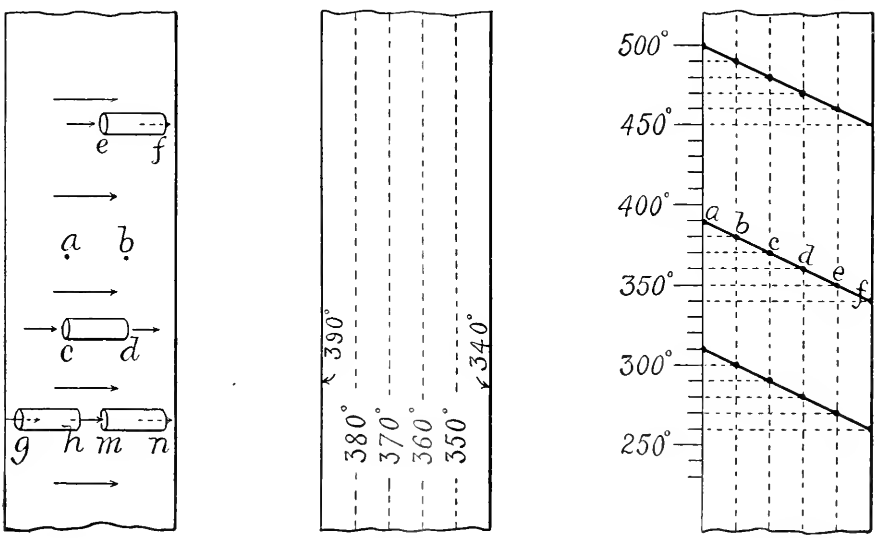


FIG. 1. FIG. 2. FIG. 3.

ILLUSTRATING THE PRINCIPLES OF HEAT-CONDUCTION.

excess of fuel over and above what the same boiler needs when it is clean. The most definite figures are frequently given concerning the waste of heat due to scale, though the writer could never discover upon what they are based. For example, the author of a certain standard reference book on steam engineering says: "More fuel is required to heat water in an incrusted boiler than in the same boiler if clean. A scale $\frac{1}{16}$ in. thick will require the extra expenditure of 15 per cent. more fuel; this ratio increases as the scale thickens. Thus, when it is $\frac{1}{4}$ in. thick 60 per cent. more fuel is needed; $\frac{1}{2}$ in. thick, 150 per cent., and so on." (The name of the book from which this passage is taken is purposely omitted, in order that the quotation may not appear in the light of an attack upon the author of it. Nothing of this kind is intended, for it would be easy to parallel this passage in many another book of the same sort; and the passage is introduced in this place for no other reason than to serve as a text for what is to follow.)

There can be no doubt but that a coating of scale does decrease the efficiency of a boiler by an amount varying with the thickness of the coating; but it would be hard to find experimental data that would justify any such numerical statement as that a layer of scale $\frac{1}{16}$ in. thick increases the coal expenditure by 15 per cent.; and the purpose of the present article is to show that such figures as are quoted above are excessive, and that scale of ordinary thickness is objectionable because it raises the temperature of the boiler plate, rather than because it cuts down the efficiency of the boiler.

In order to make the argument clear, it will be necessary to give a brief account of the elementary theory of heat conduction, so far as it relates to the problem in hand. Fig. 1 represents a piece of boiler plate, seen edgewise, the heat passing through it from left to right, as indicated by the arrows. Let it be assumed that the flow of heat through the plate is everywhere the same, and that the specific heat of the material of the plate is sensibly constant over the range of temperature that prevails within the plate at any given moment. Let $a\,b$ be two points within the plate, so situated that the flow of heat is from $a$ directly towards $b$. Then, according to the usual heat theory, the difference in temperature between $a$ and $b$ will be strictly proportional to the quantity of heat that is flowing through the plate, per square foot of surface, per minute. That this is so may be made more evident by supposing the points $a$ and $b$ to be situated at the opposite ends of a little imaginary tube, such as is suggested at $c\,d$. The length of this tube being in the direction of the thickness of the plate, no heat will pass in or out of it through its convex surface. The only heat that enters it is that which goes in through the end $c$, and the only heat that leaves it is that which passes out through the end $d$.

We know that heat is not material in its nature, but that it is merely a form of energy; and yet we also know that it may be regarded as a fluid, so far as the equations governing its flow through solids by conduction is concerned. Indeed, Fourier, who laid the foundations of the modern theory of heat conduction, believed that heat is a substance, and treated it accordingly in his great work on the subject, which was published in 1822. Since his time we have learned the true nature of heat, and yet it has not been found necessary to modify his equations in the smallest degree. It is therefore justifiable to think of heat, for the moment, as being fluid in its nature, like water; and if temperature be also thought of as analogous to pressure, it is plain that the assumption that the flow of heat through the little tube, $c\,d$, of given dimensions, is proportional to the difference in temperature between the two ends of the tube, is analogous to assuming that the flow of water through a similar tube would be proportional to the difference in pressure between the two ends. The analogy is not rigorously exact, it is true, but it is near enough for present purposes, and those who are disposed to quarrel with it are referred to the writings of Fourier and Poincaré, where the whole subject is threshed out in approved fashion.

Admitting the fact, then, that the difference in temperature between the two ends of the tube $c\,d$ is proportional to the flow of heat through the tube, and admitting also that the flow of heat is the same in all parts of the plate, it follows that if we conceive a multitude of little tubes, such as $e\,f$, $g\,h$, $m\,n$, etc., all precisely alike both in length and in diameter, to be located within the plate in any places whatever, but always with their lengths parallel to $c\,d$, then every one of these tubes will have the same difference in temperature between its two ends.

It is easy to see, from what has been said, that the fall in temperature between the two sides of a boiler plate must be *uniform*. That is, if the plate be divided into any number of imaginary layers of equal thickness, as shown in Fig. 2 by the dotted lines, then, as indicated by the figures, there will be the same difference in temperature between any two neighboring planes of division. For it is only necessary to suppose the plate to be filled up with little tubes just long enough to reach from one of the dotted sections to the next, and the proposition in question is proved.

The distribution in temperature in such a plate may be represented by means of the artifice suggested in Fig. 3. A scale of temperatures is here supposed to be drawn on the surface of the plate, and the temperature at any depth within the plate is represented by a single point. For example, the point *c*, in Fig. 3, represents the fact that at $\frac{2}{5}$ of the depth of the plate (starting from the fire side) the metal has the temperature 370°.

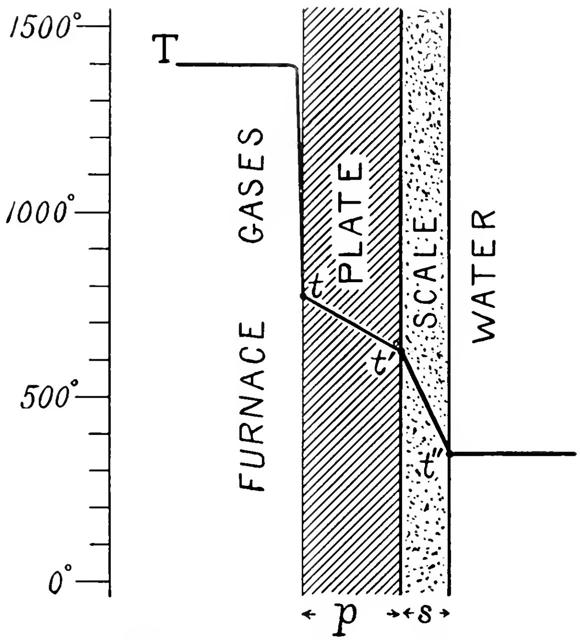


FIG. 4. — DIAGRAM SHOWING THE DISTRIBUTION OF TEMPERATURE IN THE PLATE AND THE SCALE LAYER.

In the same way the point *e* represents the fact that at $\frac{4}{5}$ of the depth of the plate (still beginning at the fire side) the metal has a temperature of 350°. A single line, *a b c d e f*, will then represent the entire thermometric state of the boiler plate.

The first point to be noticed about the line *a b c d e f* is that it is *straight*. This follows because it has already been shown that in the state of steady flow of heat equal changes of temperature correspond to equal differences in plate depth. The second point to note is, that the rate of flow of heat is determined entirely by the *slope* of this line; because it is the slope of *a f* that determines the difference in temperature between the ends of the little imaginary tubes. The absolute *height* of the line has nothing to do with the *difference* in temperature between the ends of these little tubes, and hence has nothing to do with the heat flow. It may be that the fire side of the plate is hotter or colder than the temperature represented by the particular point $a$; but if the amount of heat transmitted through the plate, per square foot per minute, is the same in all cases, then the inclination of the line $a\,f$ must also be the same. Thus the upper line in Fig. 3 represents the thermal condition of the plate throughout, when its fire surface is at a temperature of 500°, and the quantity of heat being transmitted is the same as before; and the lower line in the same figure represents the thermal condition of the plate throughout, when the fire side is at a temperature of 310°, and the rate of heat transmission is still the same as before.

If the rate of heat transmission is greater than that assumed in Fig. 3, there will be a greater difference in temperature between the two faces of the boiler plate, and the line $a\,f$, which defines the thermal state of the plate, will therefore be steeper than it is shown in the diagram, although it will still be straight. On the other hand, if the heat transmission is *less* than that supposed in Fig. 3, then the line $a\,f$ will be more nearly horizontal. In the special case in which there is no heat transmission at all, $a\,f$ will be perfectly horizontal, and the plate will therefore have the same temperature throughout. This corresponds to the case in which the boiler is out of service, and either cold, or else resting, with no steam being drawn and the pressure stationary, as when the fire is banked during the noon hour, or at night.

If the boiler plate were not made of iron, but of some other substance such as glass or stone, having a very inferior power of heat conduction, then, for the same heat transmission as before, the line defining the thermal condition of the new substance will be much steeper than that in the boiler plate; for, since it is a poorer conductor, a greater temperature-difference will be required to cause the flow of the same quantity of heat through the same thickness of material. Where the poorer conductor abuts directly against the better one (as is the case when a layer of scale is deposited upon a boiler plate), so that the flow of heat is the same through both, the line defining the thermal condition of the plate and of the adjacent substance will be a broken one,— straight so long as it continues in the same substance, but bent at the point where it passes from one substance into the other.

The distribution of temperatures within and adjacent to a boiler plate and a contiguous layer of scale will therefore be somewhat as suggested by the line $T\,t t'\,t''$ in Fig. 4. In order to simplify the problem we will first assume that the scale layer is entirely absent, and we will consider, in this special case, how the temperature, $t$, of the fire side of the plate may be determined. There is no theoretical reason why this temperature may not be investigated experimentally; but, although many attempts have been made to study the temperature of boiler plates directly, the difficulties are so great that the writer cannot refer to any experiments that can be regarded as very accurate. In most cases some unwarranted assumption has been made in calculating the results of the experiments, or else it has not been demonstrated that the means used to determine the temperature of the plate has not, by its very application, modified the temperature that was to be determined. It will therefore be necessary to infer the temperature of the fire side of the plate indirectly, until further direct investigations have been made.

It is known that a boiler plate, even when exposed to the direct action of very hot furnace gases, has a temperature far below the temperature of those gases, when it is in contact with water on its inner face. This being the case, the film of gas that lies immediately against the face of the plate must be much cooler than the body of the furnace gases. An attempt has been made to illustrate the falling off in temperature in this superficial layer of gas, by making the temperature line descend very sharply, in Fig. 4, just before the plate is reached. If $t$ and $t'$ are the temperatures of the plate, as measured just *within* the material of the plate, then the number of heat units that will be transmitted through the plate, per square foot of its surface per hour, can be expressed in the form

$$Q = \frac{t - t'}{r\,p}, \qquad (1)$$

where $p$ is the thickness of the plate in inches, and $r$ is a constant which is called the "specific internal thermal resistance" of the material. If $t$ and $t'$ are measured on the ordinary Fahrenheit thermometer, then the value of $r$, for boiler plate, is about 0.0043. The analogy between this expression for the flow of heat through a plate, and the familiar law of Ohm for the flow of electricity, will serve to fix the formula in the mind.

When the material through which the heat flows consists of two layers of different composition, as is the case in the practical example under discussion, the analogy with Ohm's law still persists. For let there be a boiler plate of thickness $p$, and, adhering to it, a layer of scale of thickness $s$, both $p$ and $s$ being measured in inches. Then if $t$ and $t''$ are the temperatures just within the plate and just within the scale, respectively, as suggested in Fig. 4, the value of $Q$ is given by the formula

$$Q = \frac{t - t''}{r\,p + R\,s}, \qquad (2)$$

where $R$ is the "specific internal thermal resistance" of boiler scale. Of course the value of $R$ will vary with the composition of the scale, and its precise value therefore cannot be stated. Rankine gives $R = 0.0716$ for carbonate of lime (marble), and, while boiler scale rarely consists exclusively of lime carbonate, this value (which is the best the writer has at hand) will suffice for purposes of illustration. It will at least give a general idea of the way in which the transmission of heat is affected by the presence of scale, and that is all that can be expected, unless the precise nature of the scale is specified.

It will be noted that in formula (2) all the quantities are known except $Q$ and $t$. If either of these were given, the formula would give the value of the other; but as neither is supposed to be known, it becomes necessary to find some further relation between the same two unknown quantities. If such an additional relation can be found, then $Q$ and $t$ can both be calculated, by the usual methods of algebra.

The transmission of heat through the boiler plate and scale layer has been treated above as though it depended upon the temperatures $t$ and $t''$. It is also possible to treat it as depending upon the temperatures $t''$ and $T$, the latter being the temperature of the furnace gases near the plate, but beyond the chilled film that covers its surface. The formula in this case is much the same as before, except that there is now an additional resistance to be considered, namely, the so-called "surface resistance," or "skin resistance," which the boiler plate offers to the passage of heat through its outer surface. Representing this "skin resistance" by $k$, the formula for $Q$ in terms of $T$ and $t''$ is

$$Q = \frac{T - t''}{k + r\,p + R\,s}. \qquad (3)$$

Rankine states that the value of $k$ for boiler plate may be taken as $k = \dfrac{180}{T - t''}$;

and with this value of $k$ formula (3) gives

$$Q = \frac{(T - t'')^2}{180 + (T - t'')\,(r\,p + R\,s)}. \qquad (4)$$

In this formula all the quantities are known on the right hand side of the equality sign, and it is therefore possible to calculate $Q$ from it. Then, when $Q$ has been calculated, we can introduce its value in formula (2), and so find the value of $t$. It will not be necessary to give all the details of the calculation, but it will be interesting to give the general results that formulas (2) and (4) yield for a particular case. Let it be assumed that the temperature of the furnace gases ($T$) is 1400°, that the temperature of the water in the boiler ($t''$) is 350°, that the boiler plate is three eighths of an inch thick (*i. e.*, $p = 0.375$), and that there is no scale in the boiler at all (so that $s = 0$). Then, with the values of the constants already given, formula (4) shows that $Q = 6{,}068$; that is, the plate, with no scale upon it, will transmit 6,068 heat units per hour per square foot of its surface. With this value of $Q$, formula (2) then shows that $t$, the temperature of the outer surface of the boiler plate, is 359.8°, or less than 10° hotter than the water in the boiler.

To find the effect of scale upon the heat transmission and upon the temperature of the plate, the calculation may now be repeated by using the same data as before, except that some value of $s$ different from zero is to be used. Suppose, for example, that the scale is an eighth of an inch thick (so that $s = 0.125$). Then with this value of $s$ and everything else as before, formula (4) gives $Q = 5{,}770$; that is, the plate, with an eighth of an inch of scale upon it, will transmit, under the same conditions as before, 5,770 heat units per hour, per square foot of its surface. Using this value of $Q$ in formula (2), it is easily seen that $t$, the temperature of the plate on the fire side, now comes out 410.9°, or 61° hotter than the water in the boiler. It is also plain that the effect of $\frac{1}{8}$ in. of scale has been to decrease the heat-absorbing power of the furnace plates by approximately five per cent., while raising the temperature of the fire side of the plate by about 51°. The efficiency of the boiler, as a whole, would not be reduced by as much as the five per cent. here indicated, because the furnace gases would enter the tubes at a higher temperature than they would have had if the boiler were free from scale, and hence the heat absorption in the tubes would be greater than before. A partial compensation would thus exist, which would reduce the thermal loss somewhat, and the efficiency of the boiler as a whole would not fall off by even the five per cent. that our figures have indicated for the scale-covered plate.

Of course no great significance can be attached to the exact figures given in this article, because the constants of heat conduction are not known very accurately. It is likely that a scale layer an eighth of an inch thick will cause the temperature of the boiler plate to be raised by more than the 51° here indicated, for most of the kinds of scale that are met with in practice. It is certain that some forms of deposit, even when they are very thin, cause an increase of plate temperature that is apparently out of all proportion to the deposit itself. It is probable, in such cases, that the "external thermal resistance" of the shell is small, so that instead of taking it at 180, as we have in this article, some considerably less figure should be used when these cases are under consideration. There is plenty of room for further experimental work in connection with these heat constants, and all that we can hope to do, with the data now available, is to show, in a general way only, what the effect of scale is upon the temperaturè of the shell, and upon the heat-absorbing power of the plates. More exact calculations cannot be made until better values of the constants can be had.

The main argument that we have tried to advance is that the principal objection to scale of ordinary thickness is, that it may cause the metal of the boiler to become heated so highly that there is danger of burning, or of bulging, or of leakage about the joints and tube-ends (and consequent corrosion), or of some other form of rapid deterioration. So far as efficiency is concerned, the writer is of the opinion that soot on the fire surfaces is often more detrimental than scale of ordinary thickness. Soot is a very good non-conductor, and for this very reason it is often used for clothing steam pipes.

## Boiler Explosions.

April, 1902.

(107.) — On April 1st a boiler exploded in the Henderson-Boyd Lumber Company's mill, at Richburg, eight miles east of Elba, Ala. Marion Wood and Henry Champion were killed. The ruins took fire, and six dry kilns, with half a million feet of lumber, were destroyed. The total property loss is estimated at from $25,000 to $50,000. The mill itself was totally wrecked.

(108.) — On April 2d a boiler exploded in Joseph Kraus's bakery, on East McMicken avenue, Cincinnati, Ohio. Bernard Boening was scalded.

(109.) — A boiler exploded on April 2d on the Stilley farm, near Coffeyville, Kan. The boiler was used for drilling an oil well. Fragments of the boiler were thrown hundreds of feet, and two tons of coal were scattered over twenty acres. Nobody was injured.

(110.) — A heating boiler exploded on April 2d in the Westbourne Ladies' College, Toronto, Ont. The property loss was small, and nobody was injured.

(111.) — A boiler exploded on Spindle Top Heights, near Beaumont, Texas, on April 3d. Walter Brandon was killed, and Samuel Garcia, J. H. Flaherty, and William Ridings were seriously injured. The men belonged to a crew employed by the Beaumont Oil and Pipe Line Company.

(112.) — On April 5th a boiler exploded at Gulick, near Naples, N. Y. Thomas Dolittle and Anthony Quinn were badly injured, and C. R. North and Harry Woodward were injured to a lesser extent. It is doubtful if Quinn recovers.

(113.) — On April 5th a boiler exploded in Aaron Uncapher's sawmill, in Munster Township, near Johnstown, Pa. Arthur McHugh was instantly killed, and Mr. Uncapher and his little daughter Daisy were badly scalded.

(114.) — A boiler exploded on April 6th in the electric light plant at the little city of Wyoming, thirty miles northwest of Peoria, Ill. The power house was utterly destroyed, and the property loss is estimated at $25,000. Engineer Slater had banked the fires about midnight, and had gone home, leaving only fifty pounds of steam on. He had hardly reached his house when the explosion occurred.

(115.) — A heating boiler exploded, on April 7th, in a school building at Odell, near Pontiac, Ill. Nobody was hurt, and no great damage was done.

(116.) — On April 8th the boiler of a threshing-machine outfit exploded on Robert Van Rensselaer's farm, at South Dayton, near Cherry Creek, N. Y. Nobody was injured.

(117.) — On April 9th a boiler exploded in Carter's sawmill at Peoria, near Grinnell, Iowa. Dudley Boyd, James Shafer, and Frank Myers were killed. Sylvester Myers and James Carter (the latter being the owner of the mill) were seriously injured.

(118.) — A boiler exploded on April 9th in the Dixie Soap Works, on the River road, near Richmond, Va. Randall Dudley and Andrew Timberlake were badly injured, but it is believed that both will recover.

(119.) — A boiler exploded on April 10th in the Blake Knitting Company's plant, at Beloit, Wis. The main building was seriously damaged, but, so far as we are aware, nobody was injured.

(120.) — On April 10th a boiler exploded in Robert Downs' sawmill, at Cleone, some ten miles south of Grandview, Ill. One side of the building was torn off, and the roof was blown off. Nobody was injured. One of our accounts says that "the gauge showed 125 pounds of steam just before the explosion, but, as the guage pipe was found to be stopped up with a piece of wood after the disaster, it was no doubt carrying much more than the register showed." It is certainly a relief to read an honest confession like this. In most cases an attempt would probably have been made to prove that the water was low, and that the plug in the gauge pipe was without serious significance.

(121.) — On April 13th a boiler exploded at the Johnson and Dull mines, at Ironville, near Hellertown, Pa. Engineer John P. Reichard was badly crushed and scalded. We have seen no estimate of the property loss.

(122.) — The boiler of a portable sawmill belonging to Gibson Price exploded on April 15th, at Farmington, Tioga County, Pa. One man, whose name we have not learned, was scalded.

(123.) — On April 15th a tube burst in the engine room of the New York Theater, 44th street and Broadway, New York city. Fireman Owen Lamb was scalded so badly that he will probably die. Assistant Engineer John Littlefield was also injured, though not seriously. This is the second steam accident that has occurred at this theater. On the night that the theater was opened in November, 1896, a steam pipe burst in the front of the building, killing two persons and injuring several others.

(124.) — On April 16th a boiler exploded at Millersburg, Ohio. Mr. Clemson L. Gadfield was very badly injured. The boiler was a portable one, and Mr. Gadfield was testing it in front of his repair shop when the explosion occurred. The five-hundred pound flywheel passed over two buildings into a vacant lot, and hot fragments of the boiler set fire to two barns. We presume that the verdict was that the test showed that the boiler was not safe.

(125.) — On April 18th a flue exploded in the boiler of the locomotive attached to train No. 10 on the Southern Pacific Railroad, at San Jose, Cal. Fireman Edward H. Tulley was badly scalded and bruised.

(126.) — A hot water boiler, used for heating purposes, exploded, on April 19th, in the basement of George W. Smith's residence, at White River Junction, Vt. The house was badly damaged. The floor of the dining room was torn up and the dining room furniture was wrecked. The whole house, which was among the finest residences in town, was thrown out of true, and the property loss was considerable. Nobody was seriously hurt, though the cook received slight contusions on the head.

(127.) — On April 20th a boiler exploded in a steam launch, near Weir's boathouse, at Hamilton, Ont. One man was slightly injured, and the boat was badly shattered.

(128.) — The boiler of a sawmill exploded, on April 24th, on the farm of Mr. Green Lemons, near Iron Gate, Va. Nobody was hurt. The live coals thrown out by the explosion kindled a fire in the dry leaves and underwood, which spread for miles; but no houses were destroyed, so far as we are aware.

(129.) — On April 24th a boiler exploded in the tugboat *John Anson* at Greenpoint, Brooklyn, N. Y. James Cunningham and John Kennedy were seriously injured. A deckhand named John Donnelly was missing after the explosion, and three hours later his body was found on the Hunter's Point side of the creek. He was thrown fully fifty feet, and probably killed instantly. The *Anson* sank immediately after the explosion. Three other tugs and a neighboring jute factory were damaged. The total property loss exceeded $20,000.

(130.) — A sawmill boiler exploded, on April 26th, at Nine Mile, Mason County, W. Va., on William Blaine's farm. Joseph Taylor, William Blaine, and Deputy Sheriff Ballard were killed, and William Woods was badly injured. The mill was destroyed.

(131.) — A boiler exploded, on April 28th, in the Hodd-Cullen Milling Company's mills, at Stratford, Ont. James Pringle, Sr., was seriously injured. The property loss is estimated at $5,000.

(132.) — On April 28th a boiler of locomotive No. 941, hauling the Hackettstown mail train on the Lackawanna Railroad, exploded about one mile east of Dover, N. J. Engineer George Trimmer and fireman Joseph Mayberry were killed, and the locomotive was demolished.

(133.) — A boiler exploded on April 29th, in the Hager Steel Company's rolling mills at Madison, Ill. The explosion set fire to the buildings, and the plant was destroyed. The total loss was probably about $250,000. So far as we are aware, nobody was injured.

(134.) — On April 30th the boiler of freight engine No. 310 on the Cincinnati, Hamilton & Dayton Railroad exploded at Carrollton station, eight miles west of Dayton, Ohio. Engineer William Huff was seriously injured.

(135.) — A boiler exploded on April 30th, at Swift's packing house, South Omaha, Neb. J. Brooks, Charles T. Graham, and Thomas Powers were injured. The building where the accident occurred is a one-story brick structure, containing four boilers, and adjoining the hog house. A portion of one of the boilers was blown through the roof, and the other three boilers in the battery were buried under the falling debris. The walls of the boiler house were considerably damaged.

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The September issue of the *Popular Science Monthly* contains an article by Mr. Percival Lowell, which, although its title ("Areography") may not suggest its real nature to the general run of readers, will nevertheless be found to be of considerable interest to all lovers of astronomy; for "areography" is the science that deals with the surface features of the planet Mars, just as "geography" is the science that deals with the surface features of the earth. Mr. Lowell gives twelve maps of the planet's surface that have been made by observers from time to time, beginning with those of Beer and Maedler and Kaiser, and coming down to his own work of 1901. We note that the dates given for Beer and Maedler's map, and for that of Kaiser, are erroneous in the cut lines, though given correctly in the text. (The proof-reading in the *Popular Science Monthly* is often wretched, like that of *Science*, now that the two journals are under the same management. The very title of the article under consideration is given wrongly in the list of contents, and mistakes due to careless reading of the proofs are painfully common now in both of the journals mentioned.) Many of us remember the delightful volume by Proctor entitled "Other Worlds than Ours," and especially the section devoted to Mars, in which a map of the planet was given, and the question of the habitability of the planet was discussed in a fascinating manner. But astronomy has advanced a great deal in the thirty-five years or so that have elapsed since "Other Worlds than Ours" made its appearance, and the problem of Mars no longer appears as simple as it did then. We did not think then of seriously questioning the existence of seas on the planet, and the chief thing to be done appeared to be to chart those seas as accurately as possible. But beginning with 1877 the Italian astronomer Schiaparelli made a series of discoveries about the markings on the planet that have revolutionized our ideas. He found that the parts of the planet's surface that were supposed to be land are crossed and recrossed by multitudes of delicate lines that appear to follow great circles, and which are arranged in a wonderfully geometric manner. These lines have been called "canals," because they are singularly suggestive of such waterways; but it is hardly necessary to say that we do not know what they really are. Mr. Lowell traces the history of the discoveries that have been made in connection with these singular markings, but does not theorize upon their nature. Indeed, the time is hardly yet ripe for much profitable speculation on the subject. (The reader who refers to Mr. Lowell's original article is hereby warned that maps Nos. 10, 11, and 12, as they appear in the *Popular Science Monthly*, are bottom side up, if we take the first nine as right side up. This is probably another example of the wretched proof-reading referred to above.)

# The Locomotive.

HARTFORD, SEPTEMBER 15, 1902.

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

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

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MR. R. T. BURWELL, Chief Inspector in the Gulf Department of the Hartford Steam Boiler Inspection and Insurance Company, has devised an ingenious instrument for the use of inspectors and others who have occasion to make rapid calculations concerning steam boilers. It consists of a series of diagrams, plotted on ruled paper, giving the efficiency of riveted joints, bursting pressures, areas of segments, number of braces required on heads, size of braces, and other useful data. These are mounted on a pair of rollers so that any portion of the diagram can readily be brought to view, and the whole is enclosed in a neat aluminum case. The appliance promises to be quite useful, and reflects credit on its designer.

IN the June issue of THE LOCOMOTIVE we printed, as No. 19 of our regular January list, an account of a boiler explosion that was said to have occurred at the General Chemical Works, at Shadyside, N. J. Our account was based upon an item that appeared in the Hoboken *Observer* for January 18, 1902; and as the *Observer* is a reputable paper, and is published in the vicinity of the alleged explosion, we had no doubt that its account was true. Mr. F. H. Wendell, who is master mechanic at the plant, writes us: "This account is entirely incorrect, as we never had a boiler explode since the works were established". As there is no authority better than that of a man who was present at the time, we take pleasure in printing this correction to our account.

## The Imperative Conditions for Forging Steel.*

In order that we may fully appreciate what a delicate material steel is now known to be, and therefore how intelligently it must be handled in all its stages of production from the raw material to the finished product, let us run through the processes now considered necessary to manufacture the grade of forgings which, if an engine builder desires to keep in the front of his profession, he must have supplied to his engines. Having carefully considered the service to which a proposed forging is to be put, the charge of raw material for the furnace is made up so that the finished product will have the particular chemical composition which, from previous experience, is found to be most satisfactory for the purpose in view. The elements carbon, manganese, silicon, phosphorus, and sulphur, all have an influence not only on the working of the metal in the shops, but upon the strength of the forging in subsequent service. The product of the open-hearth furnace is found to give eminent satisfaction, and has been generally adopted for making forgings. In order that the metal of a forging should be thor-

* From a paper by H. F. J. Porter, before the Engine Builders' Association, at Pittsburg, Pa.

oughly worked to give it strength and toughness, an ingot should be cast approximately 50 per cent. larger in diameter than the finished size. Besides this increase, there should be from 10 to 25 per cent. added to its length, to supply metal to fill "blow-holes" and "pipes," and to collect "segregation."

The extra length, having served its purpose, is cut off and returned to the scrap. The ingot is then ready for the forging process. The first operation in the process of forging is the reheating of the ingot. This operation is a very delicate one, as great care must be taken to make the heat penetrate the metal slowly and uniformly. The metal in the ingot, during the process of cooling, is being drawn out in all directions to fill the mold. When it is cold, therefore, it is in a condition of strain throughout its interior. If a cold ingot is put into a hot furnace to be reheated, the surface metal will immediately expand and pull still further away from the center, and thus an additional strain will be thrown upon the inside metal. In very large ingots cracks are thus apt to be started in the center, and forgings are very liable to break in subsequent service from the fact that they have not been properly reheated. A great many forgings fail from lack of care at this time.

Next comes the forging process proper, and one of the first requisites is the right selection of forging tools. The pressure applied in shaping a piece of steel should be sufficient in amount, and of such a character as to penetrate to the center and cause flowing throughout the mass. This flowing of the metal requires a certain amount of time, and the requisite pressure should be maintained throughout a corresponding period. The hydraulic press fills these requirements exactly. The effect of the impact of a light hammer may be simply to draw out the surface metal and leave the center behind to such an extent as to cause cracks or even cavities in the metal, and the use of such tools should therefore be avoided. Under the slow motion of the press, time is allowed for the molecules of the metal to move easily, and the pressure is felt throughout the forging. The center, being the hottest, and therefore softest, is squeezed out, and gives a convex shape to the ends of the forging. During the forging process, in which there is a gradual reduction in diameter and increase in length, a great deal of work is put into the metal. In order that the metal should be worked at the proper temperature, it is necessary to reheat it a number of times, and every time the press descends upon the metal the latter is worked under conditions differing from those existing when the press descended upon it before, because it has cooled a little in the interval. As, therefore, when finished, no two parts of the forging have been treated the same, it is natural to suppose that it is full of forging strains. It is also apt to have cooling strains in it, due to the fact that it has been reheated from time to time in different places, as the forging process passes from one end of the piece to the other. These strains, if not relieved, are apt to develop in service, for, constituting an initial load, they may throw the forging out of true, or even cause its complete failure if they happen to act in the same direction as the external working stress. To relieve these various strains, all forgings should be subjected to a final heat treatment called "annealing."

The rationale of this heat treatment is worthy of being considered carefully, as it was largely through its nonapplication that steel gained the reputation of being unreliable. If the rate of cooling of a steel ingot from the point of solidification to coldness is carefully noted, it will be seen that the temperature will fall with regular retardation in equal divisions of time until, between 1,300° and 1,200° Fahr., a point (whose precise position depends upon the carbon content) is reached where the fall of temperature suddenly stops, and the temperature temporarily remains stationary, or even rises for a short time, and then the rate of cooling continues as before. The point at which the change of cooling rate takes place is called the "recalescent" point, and from chemical and physical tests it is known that a change in the structure of the steel occurs here. The fluid steel begins to crystallize at the point of solidification, and the slower the rate of cooling from there down, the larger will be the crystals when the ingot is cold. At the point of recalescence, however, it would seem as if the crystallization, so to say, locks itself; for if, after the ingot has become cold, it is reheated to a temperature below this point, on again becoming cold it will be found that the crystallization is not affected; but if we reheat it a little above the recalescent point, then when it is again cold the crystallization will be found to be much smaller than before. In fact, it is known that if steel is heated slightly above the recalescent point, all previous crystallization is destroyed, and a fine, amorphous condition is produced at that temperature. As soon as cooling begins again, crystallization sets in, and continues until the ingot is cold. As, however, the time of cooling from the recalescent point is comparatively short, the resultant crystallization is correspondingly small. It can readily be understood that when heat treatment can completely change the internal condition of steel, it should bear an important part in the manufacture of forgings made of that metal.

Consider for a moment the changes that take place in the condition of the metal as it passes through the forging process. Beginning with the cold ingot which, having cooled slowly, is therefore composed of large crystals, the steel must be reheated to a forging temperature of from 1,800° to 2,000° Fahr., thus passing through the recalescent point, destroying all crystallization, and producing an amorphous condition. As soon as it is placed under the forging press it begins to cool, crystallization at once setting in; at the same time, however, the press begins to work upon it, and the work of forging tends to check crystallization. The work of forging may or may not continue (depending upon the size and shape of the finished piece) until the temperature has fallen below the recalescent point, but during this time more or less crystallization has occurred, and the crystals have been disturbed and distorted. The work of forging has, moreover, proceeded from one end of the piece to the other, the part last worked upon having crystallized considerably before work was applied to it, so that the two ends may be entirely different, as far as their internal condition is concerned.

If the forging were now considered to be finished, it would be found to be full of pulls and strains about which nothing would be known except that they might amount to several thousand pounds to the square inch. The magnitude of these strains becomes evident when a forging, finished as above described, has a cut taken from it in a lathe, or has a keyway cut on the surface. The strains in the fibers which are cut are relieved, and the piece invariably springs "out of true." Heating the forging to the proper annealing temperature will restore the internal structure to its normal state, when an entirely new crystallization is established, and the molecules of the metal are completely at rest. The smaller the crystals in a piece of steel, the stronger will be their adherence to each other; and if the forging, after being reheated above the recalescent point, is suddenly dropped into a bath of cold oil, no time being allowed during the cooling process for crystals to form, the amorphous condition of its structure at this temperature will be retained, and its physical properties correspondingly modified. This character of heat treatment is called "oil tempering," and should be followed by a mild annealing heat treatment, to relieve the metal of any hardening effect due to the cooling process.

In order to temper successfully a piece of steel, great care must be taken both in the process of reheating it and also in cooling it in the bath. In reheating it, the surface metal is apt to expand away from the center and thus cause cracks in the center, as previously explained; and in dropping it into the cold bath the surface metal is apt to contract onto the center to such an extent as to cause cracks in the surface. In order, therefore, to successfully temper a forging, it should be hollow. By taking out the center it can be reheated without danger of cracking, because the center metal is absent, and the heat gets into the interior and expands both it and the exterior together. Also, in dropping it into the cold bath there is no solid center on which the metal is contracted, and in that way the danger of cracking during the cooling process is eliminated.

An annealed forging has its elastic limit somewhat reduced as compared with its tensile strength, but its ductility is increased very considerably, as is shown by its contraction and elongation in test pieces. The elastic limit of an annealed forging is invariably less than one-half of the tensile strength. By "elastic limit" is not meant the point usually determined by the drop of the beam in an ordinary testing machine, but rather the carefully defined point obtained by an electric micrometer, which is from 2,000 to 10,000 pounds lower.

It is very evident that the twisting and other manipulation necessary in the forging of irregular shapes, such as solid forged crankshafts, will leave strains in the metal which, unless relieved by heat treatment as explained above, will be likely to cause failure. The great mortality of this character of forgings is in part due to the fact that they have not received such treatment, either through ignorance or otherwise.

All steel forgings should be finished with good-sized fillets at all corners. In such forgings as connecting rods special care should be taken to have the four corners of the eye in the head well rounded, to resist the tendency to crack at these points should the cross-head or crank-pin heat up and bind in the brasses. In piston rods the taper at the ends should not start from a "set-down" with a sharp angle. — *American Machinist.*

## Steam Boiler Insurance Companies and Steam Users.

[Under the foregoing heading the *Practical Engineer* and *Science and Industry* have published an article by Mr. R. S. Keelor, which is surprisingly fair to the boiler insurance companies. We might perhaps be inclined to modify a few of the statements made, but on the whole we consider the article to be well worthy of a wider circulation, and hence we reprint it below.]

The attitude of insurance companies toward engineers, and the value of the services rendered by these companies to the owners of steam boilers and to the engineers intrusted with their operation, are matters which are not so generally understood as they should be; hence the writer wishes to call attention thereto by way of introduction, since what he shall have to say will be stated from the insurance company's point of view, and it may be assumed that any discussion from such point of view is not without some warrant when it is remembered that the insurance companies of the United States have paid more than one million seven hundred and fifty thousand dollars in losses upon boilers that have exploded.

Insufficient attention is apt to be bestowed on questions that should be carefully considered before a boiler is installed, and where the selection has fallen upon a type of boiler not adapted to the conditions under which it is to be operated, or where the chemical and physical conditions affecting the supply of water to the boiler have not received proper attention, defects must soon develop. That bad management or the subordination of well-settled principles in chemistry and steam engineering to the ordinary notions of economy may quickly ruin a good boiler and cause its explosion is a mat of oft-repeated experience, and the companies whose total risk upon insured boilers the United States amounts to more than four hundred and seven million dollars ha through self-interest, been compelled to develop a corps of specialists known as ste boiler inspectors, whose knowledge is made available not only for the proper safegua ing of the companies' interests but for the advancement of the science of engineering general. The training of these men as inspectors has involved an outlay of more t twenty-two million dollars. The figures here given point in a significant way to value of inspection as applied to steam boilers, but they tell only a part of the st Statistics show that the average life of insured steam boilers is fully fifty per cent. lor than in the case of uninsured boilers, because the insurance company is interested in detection of those hidden defects that cause the boiler to wear out if it does not explo but the service of the insurance company should not stop here. A one hundred ho power boiler, if properly set and kept in good condition, will, under right managem consume 24,000 tons of coal in twenty years, but where these matters do not have pr attention the consumption of coal will be enormously increased. The properly equip insurance company has in its service experts who are qualified to furnish specificat for the construction and setting of boilers adapted to any stated purpose or requ ment, and yet other experts whose duty extends to analyzing the waters with wh boilers are supplied, with a view to the application of antidotes to counteract the b ful effects of bad water. There are a number of harmful acids and mineral mat found in various combinations in different samples of feedwater, and these form a st like incrustation, or in some cases corrode the inside of the boilers or their connecti This, of course, increases the thickness of the surface through which the heat must from the coal, and consequently demands more coal to produce a given result, and t is always danger that the circulation of water within the boiler may be shut off by complete closure of a tube or pipe through the accumulation of such incrustation, then an explosion occurs. As previously stated, the experts in the service of a bo insurance company may save coal for the owner of a boiler and prevent an other certain explosion by making a timely diagnosis in the matter of bad water or incru tion. The application of proper antidotes to feedwaters will promptly affect the tr formation of their contents of mineral matters from hardenable elements into unhar able, simply rotted, inert, earthy oxides, with all of their physical properties, and capa to solidify, completely destroyed. But the more numerous class of men in the ser of these insurance companies are the inspectors who visit the boilers four times a y These are the men who, with candle, hammer, and plastic clay, and with eyes and trained by experience, find their way into many sooty flues; hidden defects that one specially trained would fail to discover are quickly found by these men. The dutie the boiler inspector constitute a hard and thankless task, and, strange to say, his w is often made more difficult by imposing obstacles where coöperation upon the pa the owner of a boiler is dictated by every consideration of safety and real econo The writer has encountered an instance quite recently where the owner of a batter boilers that have been in use some years expressed his regret that he could not take vantage of a lower rate for insurance than he is now paying, because his boilers been in service so long that he feared another insurance company would condemn th thus necessitating a large outlay for new boilers — an outlay which he did not fee could afford at this time.

In the process of rolling the boiler plate local imperfections called "laminati occur. Frequently these laminations cannot be detected when the boiler is construc r steel that has become laminated in the process of rolling is weak at the point ffected, and blisters when put into active service; therefore it becomes still weaker point involved and will not stand the pressure to which a good boiler is sub- , and this is one reason why new boilers sometimes explode. Defective riveting lso lead to rupture or explosion of a comparatively new boiler.

he ordinary inspection made before a new boiler leaves the shop is known as the static test, and consists in subjecting the boiler to the strain of water under pres- ffected by a force pump. This same test is used by city, county, and state inspect- iere boiler inspection is regulated by law, and is frequently relied upon as a suf- test for boilers that have been in use. The boiler about to be tested in this way filled with water and the pressure is then gradually increased. *Experience teaches boiler that is capable of standing this gradual increase of pressure may explode under pressure*, as was the case at the Baldwin Locomotive Works in Philadelphia re- , when a water tube ruptured, bringing death to four employees. A similar acci- ccurred at Baeder & Adamson's Works in Philadelphia in December, 1899, result- the death of two employees. These two accidents very forcibly illustrate the fact ibular boilers are not entitled to be called "safety boilers," if by such designation eant to convey the idea that they will not rupture or explode, and that they are ble of doing harm.

oilers properly constructed and made of good iron or steel sometimes become d" internally from chemical action or corrosion after they have been in use. *This ces a hidden source of danger*, because pitting may extend a considerable distance h the thickness of the boiler sheet and reduce the strength of the boiler propor- ly, and cause the material to rupture at the point thus affected; but, as in the defective riveting or a laminated boiler sheet, the gradual increase of pressure ed in the hydrostatic test may fail to detect the weakness.

ore than $1,750,000 has been paid by insurance companies of the United States ses upon boilers that have exploded or ruptured, and these same companies have out $21,875,000 to a body of men whom they have trained as experts, to inspect ured boilers and reduce the risk of explosion to a minimum. *Where inspection prevent an explosion insurance pays the loss.*

out four thousand boilers have exploded in the United States within a period of years, resulting in the death of five thousand persons and the injury of eight id more. The cost of insurance is merely nominal when compared with the ad- es gained by the owner of the boiler. The risk of an explosion which may cause life and serious damage to property is reduced to a minimum, the life of the s prolonged, and the saving in fuel amounts to more than the insurance costs.

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ss Cooper relates that a French translator of J. Fenimore Cooper's novels was uzzled by the sentence, "He tied his horse to a locust." The Frenchman had heard of a locust tree, and so, after deep thought, he translated the word t" into the French word "sauterelle" (which means "grasshopper"), and a footnote to the effect that in America grasshoppers grew to an enormous size, at it was the custom to place one, stuffed, before the door of each house, as a g-post."—*Hartford Courant.*

# The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XXIII. HARTFORD, CONN., OCTOBER, 1902. No. 10.

## On Firing with Soft Coal.

Thirteen years ago this month we printed, in The Locomotive, an article on the management of soft coal fires, which met with very favorable reception, and appeared to fill a real want on the part of firemen who had not given much attention to the philosophy of combustion. There has been so much agitation in recent times on the smoke question, particularly in the western part of the country, that we have thought it wise to reproduce the article in question, in the hope that it may prove useful to a new and wider circle of readers. We print it, therefore, below.

It is too generally assumed, in firing steam boilers, that the fuel is burned under conditions over which the fireman or engineer has little or no control; and that any man

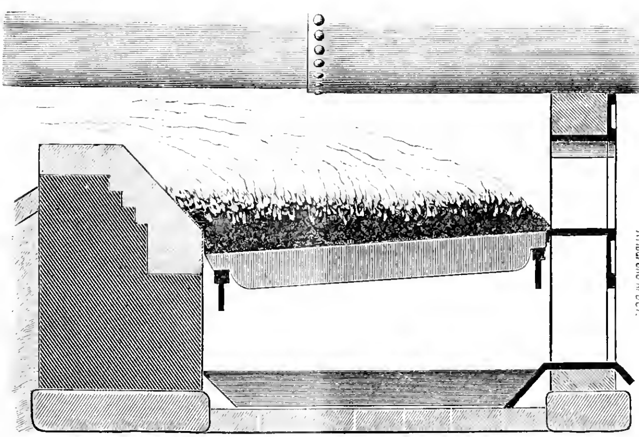


Fig. 1.—A Good Fire.

who can keep up a proper supply of steam is equally good with any other man. That such an opinion is very erroneous is fully shown by many almost daily observations; and one case in point will be enough to illustrate the fact. In a certain plant of three or four hundred horsepower the water for the boilers was passed through a meter, the coal was carefully weighed, and the fireroom log was kept by a competent man. In this way it was easily shown that Mr. A. evaporated less than eight pounds of water per pound of fuel, while Mr. B., apparently just the same kind of a man, evaporated over nine pounds, the difference between the two results being exactly two pounds of water per pound of coal in favor of Mr. B.

It is also a fact that much of the waste generally attributed to the steam engine is in reality due to lack of knowledge and skill in the boiler-room. That a certain quantity of air is necessary in order to secure perfect combustion, is well known; that too much air detracts from the economy and injures the boiler, is also well known; and the skilled and experienced engineer needs no anemometer to tell him when he has reached the delicate point where the air supply is just right. A glance at his fires, a knowledge of his chimney draft, a look at his dampers, and an understanding of the work his boilers are doing, are sufficient to guide him. But there are boilers and boilers, not all of which are cared for or fired in this manner; and it is to those that are not that our illustrations apply.

In Fig. 1 a bituminous coal fire is shown, from six to nine inches thick. It is kept thicker at the back end and along the furnace walls and in the corners, because the heat radiated from the side walls and the bridge causes the coal in these places to burn faster than that on the rest of the grate. It is kept solid and in form by quickly sprinkling a thin uniform layer of coal on alternate sides of the furnace at frequent intervals, and by filling in such parts as may burn hollow. If the fire is neglected for a short time it is morally certain to burn hollow, and holes will develop, through which the cool air in

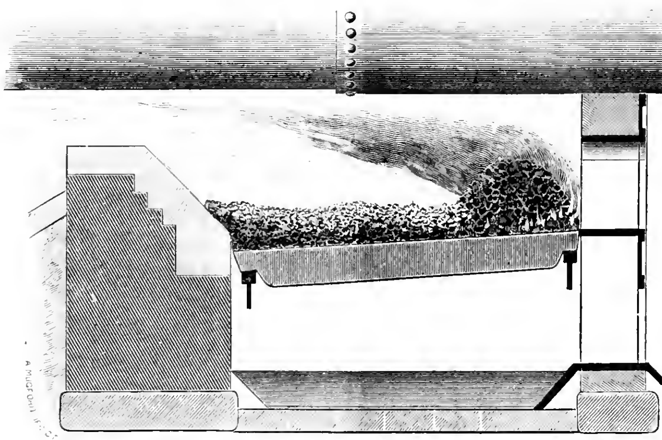

FIG. 2.—COKE-FIRING WITH SOFT COAL.

the ash-pit will pour up freely, chilling the hot gases of combustion and materially lessening the efficiency of the boiler.

Fig. 2 illustrates what is called coke firing. The grate is covered with incandescent fuel as in Fig. 1, except near the doors, where a windrow eighteen inches wide, and built of fresh coal, extends entirely across the front of the furnace. The heat to which this windrow is exposed causes it to coke as it would in a retort in a gas works, and to give off the inflammable gases that it contains, which are burned as they pass back over the incandescent bed of fuel. When fresh fuel is required this mass of coke is broken up and distributed evenly over the grate, bearing in mind the necessity of keeping a good supply on those portions of the fire which tend to burn the fastest. When the fire has again become incandescent, fresh coal is put to coke, and so the firing continues. In this method of running a fire it is still all-important to prevent holes from burning through, and admitting undue quantities of air into the furnace.

Other methods of firing are often seen. One is, to fire only at considerable intervals, throwing on coal so heavily as to almost shut off the draft for a time. Fires run in this way and then left to themselves burn hollow, and air rushes through the holes, burning the fuel away around the edges of them, and thus constantly enlarging them until after a time a strong current of cool air passes unchecked up through the grates, along the side walls and the bridge, and the hot gases coming from the coal are so chilled by it that it is almost impossible to make steam. The same result follows when the coal is heaped upon the center of the grate like a haycock, as shown in Figs. 3 and 4; and in both cases the invariable result is a hard-worked fireman, laboring manfully

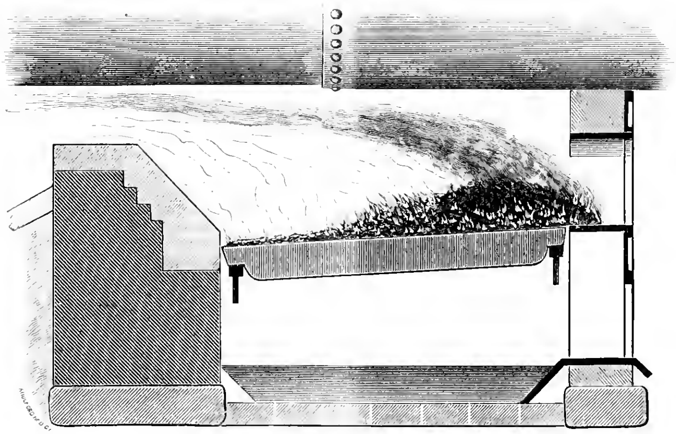

Fig. 3. — Bad Firing: Side View of Furnace.

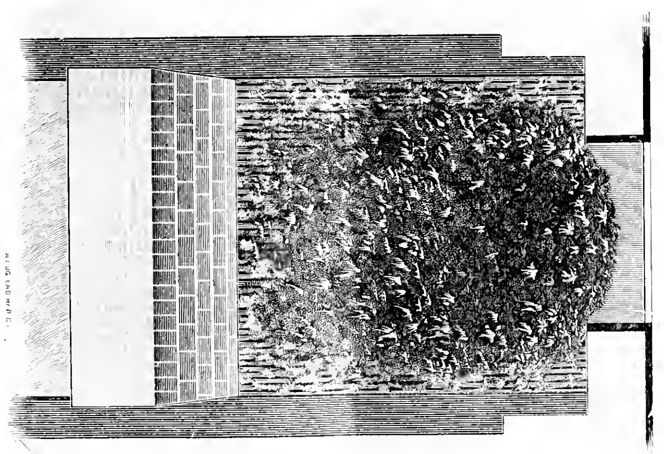

Fig. 4. — Bad Firing: Plan View of Furnace.

to keep up steam, and a bitter complaint from the office at the cost of the fuel consumed. The cold air that passes up through the empty places on the grate, and which must be heated and passed out at the chimney, puts a constant drain upon the coal piles and a constant effort upon the muscles of the fireman, who punches and works away, fretting at the poor steaming qualities of the boilers and at his inability to keep the pressure up to the desired point.

To burn bituminous coal without smoke has long been the hope of inventors and engineers, for it is generally admitted that an enormous waste occurs when any considerable amount of smoke issues from the chimney. It is true that smoke is a sure indication of imperfect combustion, but the vapor ordinarily seen coming from the chimney is not all smoke. The dense black smoke sometimes seen consists almost entirely of unconsumed carbon, but the composition of the lighter smoke is very different. Most coal contains a considerable quantity of moisture, especially bituminous coal; and this moisture is, of course, evaporated by the heat of the fire, and driven off as steam, in company with other products of combustion, giving the light vapor usually seen issuing from the chimneys. Even the densest smoke contains but a small quantity of unconsumed carbon, as measured in pounds, though of course it is likely to contain a considerable quantity of invisible gases that would have been burned and utilized had the combustion been more perfect. The black smoke is usually given off when long flames of a yellowish or reddish hue lap along the whole length of the boiler and perhaps pass into the flues. When the damper is right, and the draft good, and the fires well laid, so that all parts of the grate are evenly covered, the lazy smoky flame is changed to a short flame of intense brightness.

Too much air is as capable of producing smoke as too little; for by its chilling action, previously explained, it makes perfect combustion impossible, and causes the same dense cloud to appear at the stack.

In charging fresh coal it is a good plan to leave the furnace door ajar slightly until the fire has burned up a little so as to admit an extra supply of air, that which passes up through the grate being checked for a few moments by the fresh fuel. If the door is kept *wide open* the boiler will be cooled down and may be severely strained, and a big column of cold air will pass right over the fire in a body, and up the chimney; but if the door is kept half or three-quarters of an inch ajar the air that is admitted will distribute itself through the furnace pretty uniformly, and will consume the gases given off by the fresh coal. As soon as these gases burn off the door should again be tightly shut.

## Inspectors' Report.

MARCH, 1902.

During this month our inspectors made 12,169 inspection trips, visited 22,344 boilers, inspected 8,355 both internally and externally, and subjected 925 to hydrostatic pressure. The whole number of defects reported reached 12,592, of which 1,052 were considered dangerous; 76 boilers were regarded unsafe for further use. Our usual summary is given below:

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment. | 1,152 | 70 |
| Cases of incrustation and scale, | 3,369 | 66 |
| Cases of internal grooving, | 166 | 9 |
| Cases of internal corrosion, | 768 | 40 |
| Cases of external corrosion, | 589 | 31 |
| Broken and loose braces and stays, | 237 | 65 |
| Settings defective, | 443 | 35 |
| Furnaces out of shape, | 407 | 20 |

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Fractured plates, | 263 | 35 |
| Burned plates, | 436 | 37 |
| Blistered plates, | 97 | 6 |
| Cases of defective riveting, | 377 | 39 |
| Defective heads, | 70 | 22 |
| Serious leakage around tube ends, | 2,621 | 357 |
| Serious leakage at seams, | 589 | 16 |
| Defective water-gauges, | 248 | 51 |
| Defective blow-offs, | 182 | 56 |
| Cases of deficiency of water, | 12 | 6 |
| Safety-valves overloaded, | 50 | 13 |
| Safety-valves defective in construction, | 67 | 26 |
| Pressure-gauges defective, | 434 | 37 |
| Boilers without pressure-gauges, | 15 | 15 |
| Unclassified defects, | 15 | 2 |
| Total, | 12,607 | 1,054 |

## Boiler Explosions.

May, 1902.

(136.) — A boiler exploded, on May 1st, at the mines at Sopris, near Trinidad, Colorado. John Harris, a fireman, was fearfully scalded and burned, and was also injured by flying débris. (He died on May 15th.)

(137.) — The town of Hobbs, near Tipton, Ind., was visited by a disastrous fire on May 1st, during the course of which a boiler exploded at the Ford sorghum factory. The explosion did considerable damage, but we have no further particulars.

(138.) — On May 2d a boiler exploded in the Wallers-Rayfield roller mill, at Golconda, Ill. Engineer Philip Draper was fatally scalded, and Charles Rayfield and Amos Stills were scalded seriously, but will recover. The mill was almost totally wrecked. (Mr. Stills' father was killed in a similar accident, about two years ago.)

(139.) — A boiler exploded, on May 2d, in Frank Bundrock's shop, at Gasport, near Lockport, N. Y. Mr. Bundrock was struck on the head by a piece of iron, and was seriously and probably fatally injured.

(140.) — On May 2d a small boiler exploded in Andrews' mill, at Littleton, N. H. John Baker was terribly scalded by hot water and steam, but will probably recover. The damage to the mill was not great.

(141.) — A boiler exploded, on May 3d, in a mill at Allsboro, Ala. John Sutton, a prominent resident of the place, was fatally injured. We have not learned further particulars.

(142.) — Shortly after midnight, on the morning of May 3d, a rotary pulp boiler exploded in the Champion paper mill, at Lawrence, Mass. Fortunately nobody was injured, and from the account that we have received it does not appear that any great damage was done.

(143.) — Sylvester Cole, of South Olean, N. Y., was seriously and perhaps fatally injured, on May 3d, by the explosion of a boiler on the Ramsey Oil Lease, on Indian Creek, where he was employed as a field man. The boiler had just been repaired, and Mr. Cole was getting up steam on it when the explosion occurred.

(144.) — On May 6th a boiler exploded at the Bluff City Lumber company's plant at Clio, near Rison, Ark. One man was killed and another was seriously injured. The boiler was thrown more than a quarter of a mile.

(145.) — A small steam boiler belonging to Mr. Walter Oliver, and used for roasting peanuts, exploded, on May 8th, at Cleburne, Tex. Mr. Oliver was standing near the apparatus at the time, and the head of the boiler passed within a few inches of him, but fortunately he escaped injury.

(146.) — A boiler gave way, on May 12th, in the A. W. Darling satinet mill, on the Worcester and Leicester line, near Worcester, Mass. The report that we have received states that the night watchman started a fire under the boiler and then discovered that the water was low in it. He began pumping feed water into it, and the over heated boiler gave way in several places. The damage was practically confined to the boiler, which was almost ruined. Nobody was injured.

(147.) — Mr. G. W. Shartle and two assistants were severely injured, on May 13th, by the explosion of the boiler of a traction engine that they were testing at Osborn, near Greenville, Ohio. Mr. Shartle, who was standing in the cab, was hurled to a distance of 150 feet, but although he was badly hurt, it is believed that he will recover. His assistants were injured internally, but they will also recover.

(148.) — On May 14th a boiler exploded in Walter Stayzer's sawmill, one mile east of Perry Station, near Welland, N. Y. Engineer George Deaveaux and assistant sawyer Everett were killed, and head sawyer W. Gillian was seriously injured. The boiler was blown to fragments, but we have seen no estimate of the property loss.

(149.) — On May 14th a boiler exploded at Packer Colliery No. 5, operated by the Lehigh Valley Coal Company, at Shenandoah, Pa. Patrick Kelly, John McMichael, and Joseph Bartrich were killed, and George Brenack and John Kelly (a brother of Patrick) were injured. It is said that the men had observed that the boiler was leaking badly, just before the explosion, and that they had started to run when the explosion came.

(150.) — A boiler used for drilling an oil well exploded, on May 15th, on the David Phillips farm, at Rising Sun, Ohio. Fortunately nobody was hurt. The lease and tools are owned by John Onset, of Fostoria. The tool dresser had just left the boiler and gone into the derrick when the explosion occurred.

(151.) — A small boiler exploded, on May 16th, in the laundry of the German Students' home, at Rochester, N. Y. The explosion occurred at 6.30 in the morning, before the girls that work in the laundry had assembled, and nobody was seriously injured. The laundry is a one-story annex to the main part of the building. The south wall of the building was partly blown down, and the roof was lifted off, and completely wrecked. This explosion affords a curious instance of the exceeding ingenuity of those who try to account for such catastrophes without knowing much about them. Thus, one of the accounts that we have received says: "The cause of the explosion is a complete mystery. One theory entertained by the plumbers is that there was a defective spot in the pipe connecting the hot water boiler with the heater, and that the circulation of the steam was impeded, thus causing a vacuum to be formed, which may have resulted in the bursting of the boiler." How a vacuum is going to produce pressure enough to burst a boiler is not explained.

(152.) — One of the boilers at the water works at Homestead, Pa., exploded on May 20th, destroying the brickwork and part of the foundation of the engine room. Fireman John Thomas was slightly injured. The property loss is estimated at about $5,000.

(153.) — The boiler of locomotive No. 601, on the Santa Fé line, between Monmouth and Chicago, exploded, on May 21st, at Corwith, Ill. Engineer George Gorham and fireman Harry Phillips were seriously scalded and otherwise injured. The accident consisted in the failure of a flue.

(154.) — A flue burst on May 22d, on helper locomotive No. 35, of the Northern Pacific railroad, at East Helena, Mont. Engineer Morrissy and fireman Styes were seriously burned, and it is feared that the fireman may die.

(155.) — A boiler used in connection with a steam drill at Ottawa, Ont., exploded on May 22d. John Masson and two boys whose names we have not learned were badly scalded. The boiler was thrown 30 or 40 feet into the air, and passed down through the roof of a neighboring house belonging to George Cairn.

(156.) — On May 23d the mud drum of a boiler exploded in the plant of the Phoenix Iron Works, at Phoenixville, Pa. Two Hungarians whose names we do not know were scalded to death.

(157.) — A small boiler that was used for sinking piles exploded, on May 23d, under one of the piers at Atlantic City, N. J. The pier was crowded at the time, and a wild panic resulted. Some fifty persons were knocked down and bruised in the rush to get to the board walk, but the injuries received were all trivial, so far as we are aware.

(158.) — On May 24th a boiler exploded in Henderson Bros. sawmill, at Cason, some ten miles east of Pittsburg, Tex. One man was killed, and three others were seriously injured. One of the injured men will die. The mill was situated in the heart of the town, and débris was scattered over the entire town. One piece of the smokestack fell through the roof of a residence several hundred yards away.

(159.) — On May 24th, while Eton Hoffpauir was getting up steam in a boiler some nine miles south of Rayne, La., the boiler exploded. Fortunately young Hoffpauir was not very near the boiler at the time, so that he escaped serious injury. He was scalded somewhat, however, about the arms and breast.

(160.) — A boiler exploded on May 26th, at the home of John H. Kirby, of Houston, Tex. Mr. Kirby is a wealthy man, and was having a private theater and natatorium built in connection with his residence. The boiler that exploded was being used to sink the artesian well for the natatorium. Engineer Harry Woodward and a helper named Charles Cogburn were instantly killed. The boiler was torn to fragments, and pieces of it were found four or five blocks away.

(161.) — On May 27th the boiler of locomotive No. 60, of the Atlantic Coast Line, exploded at Manchester, Va. Engineer Robert Gwathmey, Fireman John Taylor, and Trainman James Winston were killed, and William Savage and Stephen Basser were seriously hurt. The rock ballast of the road was hurled through houses and fences 200 yards away, tearing the ends completely out of two buildings.

(162.) — On May 28th a boiler exploded in William Wilcox's sawmill, at Mahalasville, some four miles from Martinsville, Ind. Engineer Watson J. Percifield was killed, and Edward Townsend, Roy Lemons, Harry Lowry, and William Wilcox were injured. The mill was destroyed and the dome of the boiler was thrown to a distance of 500 feet.

(163.) — A flue collapsed, on May 29th, in the E. S. Adkins Lumber Company's sawmill, at Plain View, near West Point, Va. Fireman James Redmond was scalded to death.

(164.) — On May 29th a boiler exploded on an oil lease near Venedocia, Ohio.

Charles Eakin was fatally injured, and his little son, nine years old, was badly hurt, though he will recover. We have not learned further particulars.

(165.)—A boiler exploded, on May 29th, in the W. & A. McArthur Co., Ltd., mill at Little Current, near Cheboygan, Mich. We have not learned further particulars, except that nobody was killed.

(166.)—A boiler exploded, on May 29th, in the Farmers' Packing House, at Easton, Md. Manager Leonard S. Fleckinstein and his son, William N. Fleckinstein, were slightly injured. It is said that the boiler was being tested by the manager and his son. It demolished the end of the building in which it was located, went into the air some three hundred feet, and finally came to earth an eighth of a mile from its original position. Hence we presume that the experimenters inferred it to be unsafe.

(167.)—A slight boiler explosion occurred, on May 29th, in S. Wildborg & Sons' box factory, at Cincinnati, Ohio. Nobody was injured, and the property loss was small.

(168.)—A boiler exploded, on May 31st, in the Gress Lumber company's mill at Heartsease, seven miles east of Tifton, Ga. Two men were painfully injured, though they may recover.

## Virtues of the Pineapple.

The partaking of a slice of pineapple after a meal is quite in accordance with physiological indications, because, although it may not be generally known, fresh pineapple juice contains a remarkably active digestive principle similar to the pepsin that is secreted by the human stomach. This digestive principle of the pineapple is called "bromelin," and its action upon proteids (that is, albumen-like substances) is so powerful that it will digest as much as one thousand times its own weight within a few hours. Its digestive activity varies, as might be expected, according to the kind of albuminous material upon which it acts. Fibrin (which is the albuminoid substance that causes blood to coagulate) disappears entirely after a time. With the coagulated albumen of cooked eggs the digestive process is slow. Upon the albumen of lean meat the digestive principle of the pineapple first produces a pulpy, gelatinous mass, which completely dissolves after a short time. When a slice of fresh pineapple is placed upon a raw beefsteak, the surface of the steak gradually becomes gelatinous, owing to the digestive action of the pineapple juice. Of course, it is well known that digestive agents exist in other fruits also, but when it is considered that an average sized pineapple will yield nearly two pints of juice, it will be seen that the digestive power of the whole fruit must be enormous. The activity of this peculiar digestive agent is destroyed by cooking the pineapple, but unless the pineapple is preserved by heat there is no reason why the canned fruit should not retain the digestive power. The active digestive principle may be obtained from the juice by dissolving a large quantity of common salt in it; for under this treatment a precipitate is thrown down which has the remarkable powers described above. Unlike the natural pepsin of the stomach (which will work only in an acid medium), the digestive principle of the pineapple will operate in an acid, neutral, or even alkaline medium, according to the kind of albuminous substance to which it is presented. Therefore it may be presumed that the pineapple principle would not only aid the work of digestion in the stomach (which is normally acid), but would also continue that action in the intestinal tract (which is normally alkaline, and in which, therefore, the activity of the pepsin from the stomach ceases).—Adapted from *The Lancet.*

The Locomotive.

HARTFORD, OCTOBER 15, 1902.

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

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

## The Metric System.

The *American Silk Journal*, in its issue for November, prints an article entitled "The Metric System Coming", the closing paragraph of which reads as follows: "The Hartford Steam Boiler Inspection and Insurance Company publishes a little book which tells all about the metric system. It is entitled *The Metric System*, and is procurable by addressing the company at Hartford, Conn." Now this is all very true, except that we think any reader of the *American Silk Journal* who chanced to see the paragraph in question would be apt to think that the little book in question was issued by this Company as an advertisement, and that it is sent to any applicant, gratis. At all events, whether this is a reasonable interpretation or not, we have received a number of letters in which this view of the case is taken, and we have been put to some trouble in explaining the case, by letter, to such applicants. The fact is that there is no advertising matter at all in the little book in question, and that it is put out by this Company solely in the interest of the general public. As there are a great many tables in the book, the cost of type-setting was large, and when to this item the expense of paper, electrotyping, press-work, and binding is added it will be understood that the total cost of producing the volume was very considerable. We therefore have felt that it was only just that we should make a reasonable charge for it. We publish it in two editions. The ordinary edition is printed upon excellent paper, with red edges, and is bound in sheepskin, with the title in gold. This edition we send prepaid to any address upon receipt of $1.25. In this form the book is neat and durable and convenient to use; but for the benefit of those who desire it in still more substantial form we have prepared an edition that is printed upon bond paper, and bound in heavier leather, with full gilt edges. We can furnish the book in this edition for $1.50. Let us say once more that we have no wish to make money on the little volume; but on the other hand, as it is not issued as advertising matter, our friends cannot reasonably ask us to *lose* money on it. We have contributed, without one cent of expense to the public, the very considerable amount of labor involved in the accurate calculation and proofreading of the 150 pages of tables that the book contains; and in order to make good our actual cash outlay in meeting the printers' bill for composition, electrotyping, printing, and binding, we have set prices for the two editions as noted above, these prices representing, as nearly as possible, the actual cost of the volume to us. Anyone who is genuinely interested in the metric system will find the book well worth what is charged for it, and its usefulness is sufficiently attested by the fact that we have had as many as six or seven orders for it from the same individuals, on separate occasions, since its first publication. It has proved itself of the greatest service to all who desire an intimate knowledge of the metric system.

"It is a little jewel", said one member of the Congressional committee on coinage, weights, and measures; and this opinion is shared by all who have it if we may judge by the duplication of orders, and by the many pleasant letters that have come in, unsolicited, from those who have used it.

## Crude Petroleum as Fuel.

The recent discoveries of petroleum in Texas and neighboring regions have led to a considerable use of this oil as fuel for steam boilers. In the interests of the steam-using public of that section of the country Mr. F. C. Bitgood, of the Hartford Steam Boiler Inspection and Insurance Company, read the following brief paper on the subject before the Southwestern Gas, Electric Light and Power Managers' Convention, at San Antonio, Texas :

"The use of crude oil as fuel, in this territory, began in April, 1901, and our observations cover the period since then. At the outset our inspectors received special instructions concerning the new fuel, and were cautioned to exercise special vigilance to the end that its effects on the boilers under our charge might be ascertained as quickly as possible. Thus far the closest scrutiny has failed to reveal any deleterious effects where proper care was exercised in installing the oil-burning apparatus and in its operation afterward. In some instances tubes have been bent and bagged, and shell plates overheated, by reason of undue concentration of the oil flame upon certain exposed portions of the boilers; but these troubles have uniformly disappeared when the faulty conditions were rectified. Some apprehension was felt, at first, lest the amount of sulphur contained in the crude oil might be sufficient to cause more rapid deterioration from pitting and corrosion than had been experienced with coal. This fear has so far proved groundless, no extraordinary pitting of tubes and shells having been noted since the introduction of oil as fuel. This may be accounted for by the fact that the amount of sulphur liberated per thousand heat units is less with oil than with coal.

"The wear and tear upon the boiler structure is probably less with oil than with coal. Much of this wear and tear with coal is due to strains produced by the sudden and frequent inrushes of cold air against the hot plates and heads while furnace doors are open for firing, resulting often in leakage at seams and tube ends and small fractures of the boiler plates. These are almost entirely avoided by using oil for fuel — the doors are never opened, and, the temperature remaining practically even, there are no injurious contractions. In some cases, where constant trouble had been experienced with coal from the above-mentioned causes, there was a marked improvement when oil was introduced. The annoying leakages and fractures ceased, thereby lessening repair bills and the frequency of stoppages.

"It will be seen from the foregoing that this company's experience with oil would indicate that it is an ideal fuel, if used with proper precaution. There should always be such number and arrangement of burners as will secure thorough diffusion of the heat over the entire fire surfaces of the boilers. Each plant is a separate proposition, and should be treated as such. The placing of the apparatus in position is in itself a simple matter, but making it fulfill all requirements of safety and economy is quite another thing, and requires expert knowledge and care. Once an installation is properly made, its operation is quite simple. Probably the association will appreciate a word of warning on one or two points in particular — one of these is the haste in raising steam from cold or cool boilers. Oil is rich in heat units, and a large amount of it can be burned in a furnace in a short time. This makes it easy to get up steam quickly; it is no more work for the fireman to get his pressure up quickly than it is to get it up slowly, and therefore nobody complains except the boiler, which cannot make itself understood all at once, but will be likely to do so later on, when frequent abuse in this respect has sapped its vital powers. Another danger lies in forcing the boilers too much. Oil lends itself readily to forcing the boilers away beyond their rated capacity, and there are frequent temptations to do this. Much caution will have to be exercised in these respects if undue wear and tear are to be avoided, to say nothing of the liability to dangerous explosions."

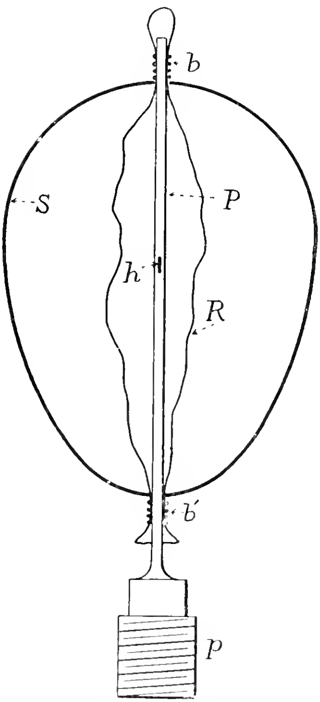
## The Strength of an Egg Shell.

We have all probably tried, at some time of life, to break an egg by compressing it strongly, endwise, in the hand, and we all know that the shell is astonishingly strong. But so far as we are aware, nobody ever tried to get any accurate measurements of the strength of an egg shell, until Mr. Albert E. Guy undertook the job, quite recently. His results, and the means of attaining them, are reported in the issue of the *American Machinist* for August 28, 1902. We cannot undertake to do Mr. Guy full justice in this brief account, but we heartily commend the original article to the earnest attention of anyone who may be interested in work of this kind. The methods of experimenting are as ingenious as the results are astonishing.

In testing the resistance of the shell to internal pressure, the contents of the shell were first removed by the familiar process of "blowing," a small hole being carefully drilled in each end of the shell for this purpose. The difficulties then to be overcome, and the way in which they were surmounted, are thus indicated by Mr. Guy: "The material of the shell is very porous, in the first place, and then a small pipe had to be introduced inside to convey the fluid pressure, and a tight joint made at the opening. It was deemed out of the question to make this joint with cement, glue, shellac, or any other substance which might weaken or strengthen the shell. After much tinkering a very simple scheme was imagined, tried, and found successful. In the diagram, $S$ is the shell; $R$ is a toy balloon made of very thin rubber; $P$ is a piece of brass bushing wire, $\frac{1}{16}$ inch in diameter outside, and $\frac{1}{32}$ inch, scant, on the inside. It is plugged at the upper end, and soldered to a hollow $\frac{1}{8}$ inch pipe plug, $p$, at the lower end. The balloon is tied to the wire at the top and bottom by means of a strong cotton thread, $bb'$, in such a way that the shell may be slightly but freely moved up and down on the wire. A small hole, $h$, cut into the hollow wire, admits the fluid under pressure inside the balloon. When inflated, the balloon presses uniformly against the internal surface of the shell, and obviates the difficulty arising from the porous nature of the shell. It was necessary to have the two holes axially opposite, in order to preserve the balance of the internal pressure. It is worthy of notice that great care must be exercised in cutting the holes. A milling tool, 0.06″ in diameter, was used at first, and then another, 0.13″ in diameter, for finishing. If the operation is not carefully done, very fire fissures are apt to be formed, and as soon as pressure is applied, the shell breaks at once at the ends."

Omitting one shell out of the dozen tested (because it was found to be cracked), the tests showed that the average shell was able to withstand an internal pressure of slightly more than 48 pounds to the square inch, before fracturing! One shell did not fail until the pressure rose to 65 pounds per square inch, and two others did not fracture until a pressure of 60 pounds was attained.

In testing the resistance of the shell to external pressure, the blown shell was enveloped in thin sheet rubber, similar to that used in the earlier experiments, thicker pieces being laid over the holes at the ends, to prevent the rubber envelope from being forced into the shell by the external pressure. The whole was then placed in a brass vessel, which was filled with water, and attached to a pump for producing a hydrostatic pressure. The strength of the shell greatly exceeded the experimenter's expectations. "With the first shell tried," he says, "the gauge on the pump reading from 0 to 320 pounds per square inch, the limit pressure was soon attained and the shell was still intact. Pressure being again applied two or three times more slowly, with care, gave a similar negative result, and the operator began to think that something or someone was, in shop parlance, putting up a job on him. Disconnecting the gauge, the pressure was applied suddenly, and the shell gave way with a loud report. A second shell was tried in the same manner, with identical results. The experiments were then stopped in order to test the gauge anew, for I firmly believed that something was amiss. The pressure gauge was found to be practically correct, however, but had to be discarded for one reading to 1,000 pounds per square inch. The third shell broke under a pressure of 675 pounds per square inch, a really astonishing fact, when one considers that the thickness is so small, the diameter relatively considerable, and the material exceedingly fragile."



Testing for Bursting Pressure.

Eight shells were tested for crushing strength, in addition to the two mentioned as tried with the inadequate gauge; and the average hydrostatic pressure that produced failure was 550 pounds per square inch. Two shells collapsed at 675 pounds per square inch, and one at 625 pounds, and the smallest observed collapsing pressure was 400 pounds to the square inch.

The thickness of the shell was measured in every case, and the average thickness of all was found to be about 0.0134″. Taking account of the dimensions of the several eggs, it was found that the average tensile strength of the shells was 1,540 pounds per square inch of sectional area, and that the average resistance to crushing was no less than 16,550 pounds per square inch of sectional area. The crushing resistance of limestone is variously estimated at from 4,000 to 16,000 per square inch of sectional area, so that the crushing strength of the tested shells may be said to have exceeded that of the best limestone.

"I feel so perfectly astounded at the results of the tests," says Mr. Guy, "that I do not hesitate to proclaim that the egg should be placed at the head of the seven wonders of the world. How insignificant seem the twelve feats of Hercules when we state that an egg shell can stand an internal pressure of 65 pounds per square inch, and an external pressure of 675 pounds per square inch! Although, as a direct consequence of the investigation conducted — science, alas! has its martyrdom — the writer has been constrained for two long weeks to endure, on the dining table, the presence in variegated attires, and to absorb, the contents of the shells tested, he nevertheless feels much honored at being able to make known, for the first time, the measure of the resistance of the frail envelope of a hen's egg."

## The Conservation of Weight in Chemical Reactions.

At a recent meeting of the British Association the question was again raised as to whether or not the weight of a chemical compound is always precisely equal to the sum of the weights of the substances composing it, after all possible allowances have been made for errors of every sort. The great Belgian chemist Stas investigated this point with much care, and came to the conclusion that there is no measurable difference; but notwithstanding his evidence this chemical specter can hardly yet be said to be laid beyond resurrection. "It has long been suspected" (we quote from *Engineering*) "that something is lost when substances interact chemically — that is to say, that certain weights of sodium and chlorine do not give quite as much sodium chloride as the sum of the weights represent. The apparent loss is very small; in some cases, indeed, the compound has appeared to be heavier than the constituents. But the balance of the evidence points to some loss which seems to exceed the limits of experimental error. Landolt and Heydweiller have recently, each on his own account, taken up the problem again, which has chiefly been investigated by German chemists, and Lord Rayleigh had proposed a discussion of the question in the hope of meeting these chemists at Belfast (where the meeting of the Association was held). They did not come, as they are not yet satisfied with their results. Speaking from memory Lord Rayleigh stated that discrepancies of one part in a million had been observed. If there is any loss of weight, what does it signify? A change of weight need not necessarily imply a change of mass. Newton believed in the proportionality of mass and weight, yet he investigated the point by comparing pendulums of different materials. He found no difference in their oscillation periods, nor did Bessel in similar experiments." Lord Rayleigh then pointed out that, if we admit the reality of the phenomenon, it is possible that a violation of the principle of the conservation of energy is implied.

In connection with this subject the following extract from a treatise entitled *Molecules and the Molecular Theory of Matter*, which was published in 1895 by the associate editor of THE LOCOMOTIVE, may be of interest: "The idea that matter is not really of seventy kinds or so, but that it consists of only one fundamental kind, is quite ancient; but in 1815, soon after Dalton's atomic theory had met with general recognition, Prout brought forward the view that the primordial matter of which all elements are composed is *hydrogen*, and that consequently the atomic weights of all the other elements are simple multiples of the atomic weight of that substance. This hypothesis has provoked much discussion, and since it was first proposed it has been attacked and defended by many distinguished chemists; and, although it is rather in disfavor at present, I think we cannot yet say that it has been finally laid to rest. One can hardly glance at a table of atomic weights without being impressed by the close approach of these quantities to integral values. Of course there are conspicuous exceptions — chlorine, for example — to Prout's hypothesis in its original form, and to reconcile these it has been assumed that the various elements are composed, not of hydrogen, but of some unknown and still simpler substance whose atomic weight is $\frac{1}{2}$ or $\frac{1}{4}$ that of hydrogen; but this seems like a very artificial extension of the hypothesis, because by a further extension of the same kind we could easily account for any exceptions whatever. The fact that many atomic weights are *nearly* integral demands some sort of an explanation, however, for it can hardly be accidental. When chemical science was in a less developed condition it was easy to believe that the atomic weight of nitrogen (for example) is 14.00 instead of 14.02 as indicated by experiment, and that the atomic weight of carbon is 12.00 instead of 11.97; but we can no longer entertain any such hypothesis. This point was strongly emphasized by Stas's magnificent researches, for his results are apparently of such extraordinary accuracy that an error of one-tenth of one per cent. is quite out of the question in them. 'It is possible,' says Dr. Lothar Meyer, 'that the atoms of all or many of the elements chiefly consist of smaller particles of matter of one distinct primordial form, perhaps hydrogen, and that the weights of the atoms do not bear a simple relation to one another because the atoms contain, in addition to the particles of this primordial matter, varying quantities of the matter which fills space and is known as the luminiferous ether, which is perhaps not quite devoid of weight. This appears to be the only permissible hypothesis.' Dr. Meyer's surmise may possibly be correct, although certain grave difficulties would have to be overcome before we could accept it. If you will bear in mind what I said a few moments ago about all these points being purely speculative, I will offer another hypothesis, which may not be better than Dr. Meyer's, but which appears to be at least as good, and quite as defensible. There is no harm in letting one's fancy loose in this way, any more than there is in reading a fairy tale; but it is of the first importance, in either case, that we should carefully remember what we are doing, so that *possibility* may not be confused with *probability*.

"There is one point which is everywhere taken to be self-evident by writers on chemistry, but which is not so to me, by any means. I cannot see what warrant there is for assuming that when an atom whose weight is $A$ combines with another atom whose weight is $B$ the weight of the resulting molecule is universally and necessarily $A+B$. This principle, instead of being a truism, must receive a most exact explanation by the final molecular theory. It appears to be true in such reactions as we can observe, but as we have never split up an element into its constituent hydrogen atoms (if indeed it contains such atoms!) there is no evidence that in such a case the 'law of conservation of weight' would still hold true. When we know more about the nature of gravitation we shall be in a better position to discuss this point; but at present I think we may say that it is just *possible* that there may be cases in which an atom of weight $A$, when combining with another of weight $B$, does *not* produce a molecule of weight $A+B$. I am well aware that this would make perpetual motion possible, for if the weight of the given substances happened to be *greater* in the combined state than in the uncombined one we should only have to let them fall some convenient distance while they are combined, and raise them again while they are uncombined, and we should gain a little energy every time the cycle was repeated: while if combination should cause a *loss* of weight, instead of a gain, we could attain the same end by performing the cycle in the opposite direction. Now I am sure that nobody has greater faith in the conservation of energy than I have, and yet we should remember that that grand principle, the discovery of which will cause the nineteenth century to be remembered forever, is nevertheless merely an abstraction from our *experience;* and that it teaches us nothing except that we have never *known* energy to be created or destroyed, and that *with the means at our command* we cannot create it nor destroy it. If it be true, therefore, that matter is composed of some fundamental substance combined with itself in varying degrees of complexity, then whenever the law of the conservation of weight would be violated upon splitting a body up into its constituents, or in forming it from them, the means at our disposal can never enable us to effect either the separation or the combination; and so far as we are concerned such a body would forever remain an element. On the other hand, whenever the law of conservation of weight would *not* be violated upon splitting a body up, the body in question is not an element, but a *compound;* and we can reasonably hope to effect its separation into two or more simpler bodies. This hypothesis explains both the existence of 'elements' and the slight deviations from integral values that we find in their atomic weights. I offer it for what it is worth, and have nothing further to say in defense of it."

If it can indeed be established beyond question, by means of suitably devised experiments, that the weight of a compound is either greater or less than the combined weights of its constituents, even in a single case, we shall probably be in a position to learn something about the nature of gravitative attraction. As we said in THE LOCOMOTIVE in May, 1901: "The main difficulty in the way of learning something about the real *nature* of gravitation is that there does not appear to be any starting point from which we can begin our investigations. If we could only find some little peculiarity or apparent irregularity of gravitative action we should have a foothold at once, and we could then begin a series of experimental researches into the nature of this peculiarity or irregularity, which might end in our learning something about the nature of gravitative action. . . . The main trouble appears to be that there is no visible joint in nature's armor, into which the physicist can insinuate his experimental lever. In all probability, if such a joint could be found, the shell of the mystery would soon be pried open."

It may be that the apparent slight deviations from exact conservation of weight in chemical reactions may prove to be the crack into which the wedge of investigation can be driven; but, as a belief in the exact conservation of weight in all chemical reactions underlies all the work that has been done in chemistry, the scientific world will be slow to accept any but the most positive proof of its falsity. We venture to hazard the opinion that, even if the time-honored belief should be overthrown, some way will be found for explaining the apparent violation of the principle of the conservation of energy that is pointed out in the passage quoted above; for that principle has stood so many severe tests that it is hard to believe that it is not rigorously true, or that it is not true, at least, up to the very limit of precision that human measurements can attain.

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HE BOILED IT DOWN.—The following story is told of the editor of an enterprising London evening newspaper, who, in the eternal rushing to press to get ahead of the opposition, was constantly impressing upon his reporters the necessity for condensing all news. A terrific boiler explosion had taken place on board a big ship lying at Portsmouth. "Get down there as quickly as you can," he said to one of his men. "If you catch the 11.40 from London bridge you'll be there soon after 2 and can just wire us something for the fifth edition, but boil it down, *boil it down!*" And the reporter went. Soon after 3 o'clock that afternoon they got a wire from him:—"Terrific explosion. Man-o'-war. Boiler empty. Engineer full. Funeral to-morrow."—*London Tit-Bits.*

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"DON'T be a slave to habit, but make your habits be *your* slaves. The more good ones you have working for you, the more work you can do, and the easier it will be to do the work." — *W. Osborne.*

# The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XXIII. HARTFORD, CONN., NOVEMBER, 1902. No. 11.

## Concerning Naval Boilers.

The special committee that was appointed some two years ago by the British Admiralty, to investigate the matter of boilers for use in the British navy, has made a *Report*, the substance of which, so far as it relates to boilers, is given below. The Belleville water tube boiler had been used to a considerable extent in the British navy, and

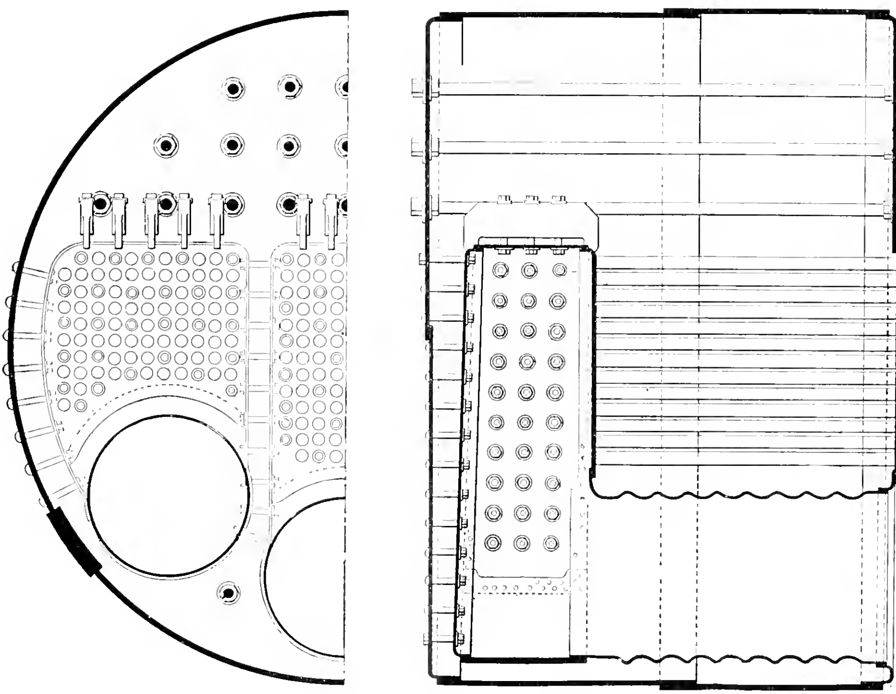

Fig. 1. — The "Scotch", or Cylindrical, Marine Boiler.

the criticisms that had been made upon the performance of that type of boiler were largely responsible for the appointment of the Commission; but the Commission was empowered to make a general investigation of the entire subject of water tube boilers for naval use, and it gave a certain amount of attention to no less than thirty-six different kinds of such boilers.

As some of the types that are referred to are probably not familiar to our readers, we have thought it well to preface the *Report* by a short illustrated account of each of the principal types that are mentioned in it. Further information may be had from Mr. B. H. Thwaite's excellent articles on "The Application of Water-Tube Steam Generators for Naval Service," in the *Engineering Magazine* for November, 1900 (page 199), and December, 1900 (page 331), to which articles we desire to express our own indebtedness. Reference may also be made to Mr. W. D. Wansbrough's "Recent Practice in Steam Boilers in Great Britain," in Cassier's Magazine for November, 1899 (page 33), to which we are indebted for the first cut in the present article.

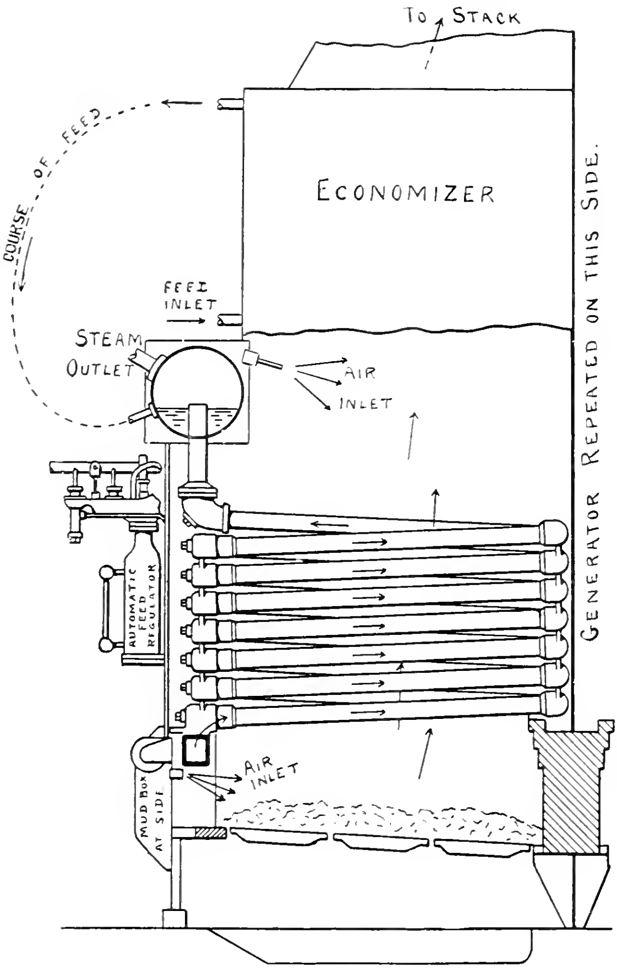


FIG. 2. — THE BELLEVILLE BOILER.

The Scotch boiler, which is shown in Fig. 1, is the type of marine boiler most commonly met with, and is the one referred to in the *Report* as the "cylindrical boiler." It is internally fired, and contains several furnaces (three in the illustration), which are commonly corrugated. The furnace gases pass from these back into combustion chambers, from which they return to the front end of the boiler through banks of tubes, as will be seen from the cut.

The Belleville boiler is shown in Fig. 2. The following description of this boiler is practically in Mr. Thwaite's words: In the most advanced, or "economizer," type of Belleville boiler, the generating tubes are only slightly inclined from the horizontal ($2\frac{1}{2}°$), and are made of solid drawn steel. Twenty of these tubes (say 7 feet 6 inches long) complete a tube group, technically known as an element. The ends of the tubes screw into malleable iron collector boxes. The tubes constituting an element provide for a continuous passage from bottom to top for water and steam. Each tube-group or element is connected at its lower end to a water chamber, and the top of each element is connected to the steam-and-water drum, this connection in every instance being located on the front end. In the Belleville boiler the feed water is introduced at a higher pressure than that of the steam, at the center of the upper drum collector, by

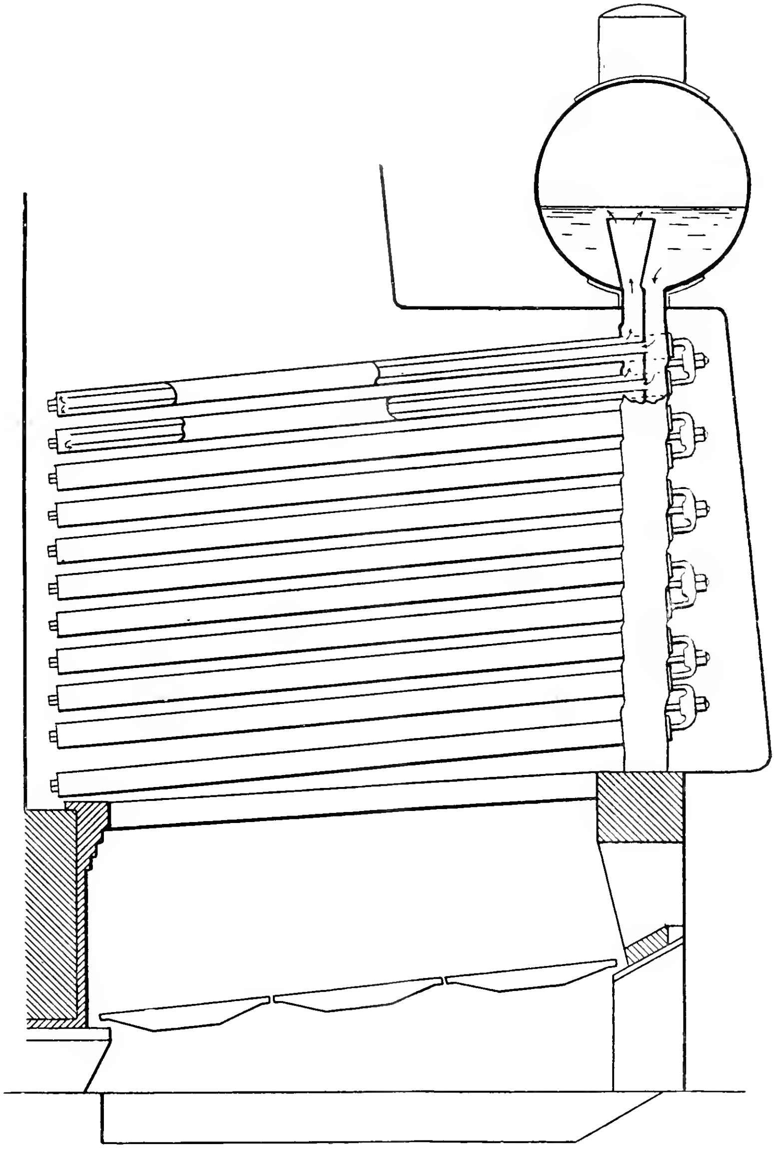

FIG. 3.—THE NICLAUSSE BOILER.

means of a small non-return valve. The introduction of the feed naturally lowers the temperature of the water in the drum, and it is obviously inadvisable that the water, thus cooled, should be allowed to enter any of the tube groups or elements; to prevent this the tops of the latter are caused to project at least eight inches above the bottom of the drum. As the water flows from the drum down the return pipes, its temperature is gradually raised until it deposits such of its soluble solids as are precipitable by heat, and a mud box is provided, at the side of the boiler, to receive the deposit so thrown down. In order to keep the water level at the right point, an automatic feed device is provided. This device is indicated in the cut, but it will not be necessary for us to describe it in detail. Mr. Thwaite gives a good sectional view of it on page 334 of his second article in the *Engineering Magazine*. As will be understood from an inspection of the engraving, the tube-groups of this boiler discharge a mixture of steam and water into the upper drum. These are supposed to be separated here, and, to assist the separation, an ingenious system of baffle plates is provided, which we have not shown in the engraving. An economizer is placed in the stack above the boiler, the construction of the economizer being similar to that of the boiler itself, except that the pipes composing the elements are smaller.

The Niclausse boiler is shown in Fig. 3. The tubes in this boiler are of the duplex

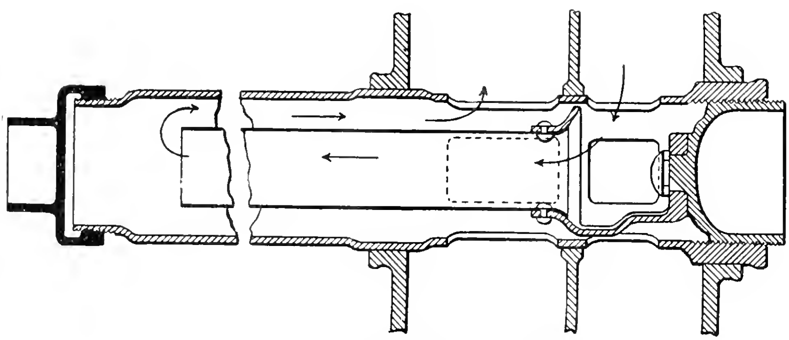

FIG. 4.—DETAIL VIEW OF NICLAUSSE TUBE.

type, and are set at an angle of six degrees to the horizontal. The front header is divided by a vertical partition, as will be seen, and the water in the drum passes down on the front side of the partition, through the entire length of the inner tube, then back through the outer tube to the header, and finally up into the drum again. (The Niclausse boiler is well described in *Marine Engineering* for January, 1900, page 28, and in London *Engineering* for December 13, 1895, page 749, to which articles we would refer those desiring detailed information concerning it.) A detailed view of the tube of one of these boilers is given in Fig. 4. The tube has a conical bearing in the front and back walls of the header, and it is held in place by a dog and studbolt. The back ends of the tubes are of course properly supported in the actual boiler, although the supports have been omitted from the cut in the interests of clearness. It is particularly claimed for this boiler that repairs may be very quickly made. To renew a tube the dog is loosened and the tube is withdrawn through the header. A new tube is then inserted, and the dog is set in position once more. As there are no joints to be expanded, this change can be very readily effected. Baffle plates, to regulate the course of the furnace gases through the tubes, are used in this boiler as well as in the other water tube boilers here described, but they have been omitted in the cuts because they would tend to confuse the eye and draw the attention away from those points that constitute the essential features of the boilers.

The Dürr boiler is similar in construction to the Niclausse, so that at first sight one might suppose that the two were alike. There are essential differences in detail, however. By reference to Fig. 5 it will be seen that the mode of attachment of the duplex tube to the header is quite different from that which is used in the Niclausse boiler. In

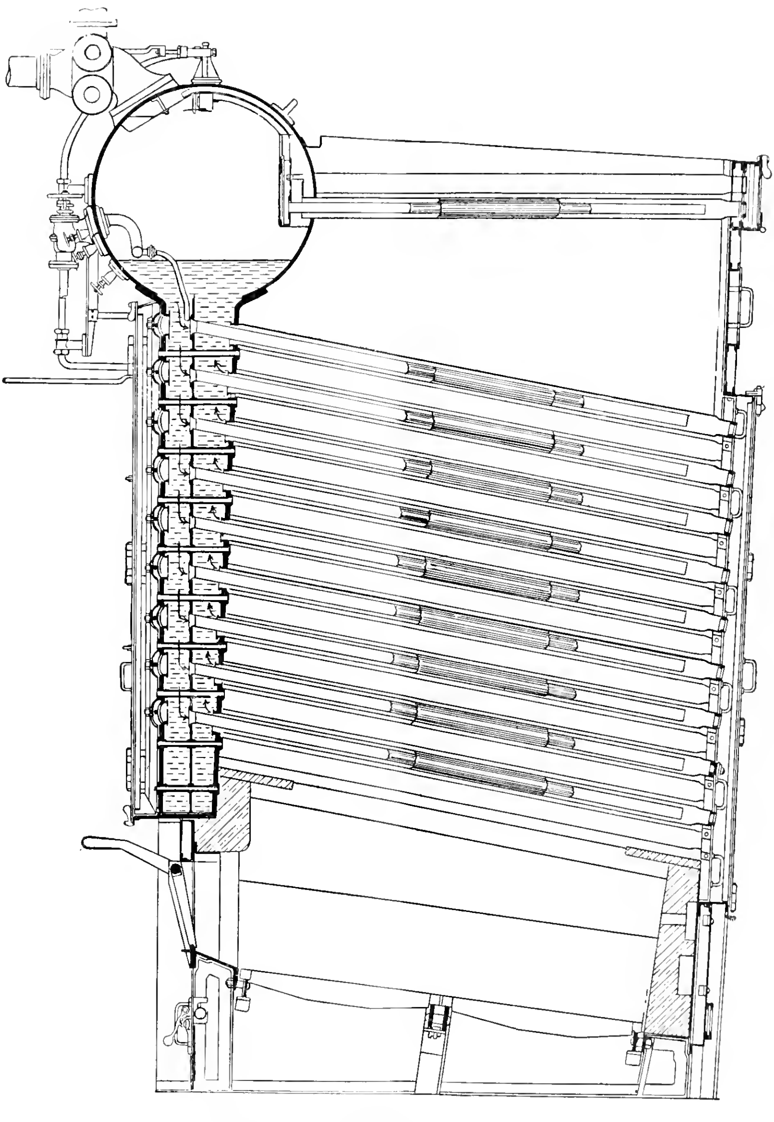

Fig. 5.—The Dürr Boiler.

the Dürr type the outer member of the duplex tube is expanded into the rear surface of the header, while the inner member is secured to the central partition of the header. In the Niclausse type the header is made in sections, each section being just wide enough to take two vertical rows of tubes. In the Dürr boiler, on the other hand, the tubes are built into a single-front collector or header. Owing to these differences in construction, it is necessary to use staybolts to unite the two surfaces of the header or collector in the

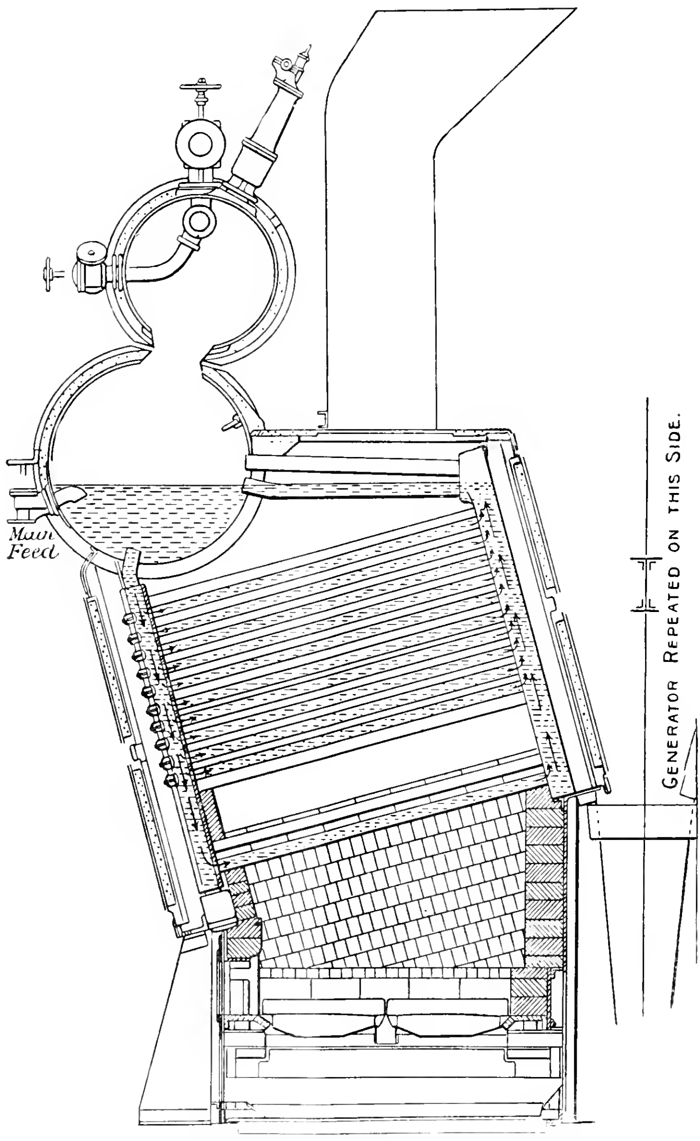


FIG. 6. — THE BABCOCK AND WILCOX BOILER (MARINE TYPE).

Dürr boiler, while no such bolts are necessary in the Niclausse boiler. (The Dürr boiler is described at considerable length in a paper entitled "The Constructive Development of the Dürr Boiler in the German Navy," by Von Buchholtz, in London *Engineering* for July 19, 1901, page 80.)

The Babcock and Wilcox boiler, which is the fourth of the principal water tube types referred to in the *Report*, is represented in Fig. 6. This boiler need not be described in detail, because its general construction, as applied to land purposes, is probably familiar to all of our readers. It will be observed that the marine type has the tubes inclined upward from the front of the boiler toward the back, this being done in order to secure compactness in the construction. The particular boiler shown in the engraving is from the steamship *Martello*, which was one of the ships examined by the Commission.

The construction of all of these sectional boilers necessarily varies to a certain extent, from ship to ship, and all we have attempted to do is to show them well enough to make the following extracts from the Committee's *Report* intelligible.

### The Work and the Conclusions of the Committee.

The committee investigated the behavior of water tube boilers in the British navy, and also in other navies and in mercantile vessels, by visiting many ships in these services, and by obtaining evidence from admiralty and dock yard officers, from a representative of the Board of Trade, from superintending engineers who have had experience with the design and maintenance of such boilers, from the makers of these boilers, and from officers entrusted with the care of them. Trials were also made on his majesty's ships *Europa*, *Diadem*, *Minerva*, *Hyacinth*, *Sheldrake*, *Espiègle*, *Fantôme*, and *Seagull*, and on the Cunard steamship *Saxonia*. Some thirty-six different types of water tube boilers were considered, and in cases where water tube boilers of types intended for use on shipboard were under steam on shore, inspections of them were made, and their behavior was investigated. The engine-room registers of fifteen of his majesty's ships fitted with Belleville boilers, and of eleven fitted with cylindrical boilers, were examined for a period of nine months, in order to ascertain the relative efficiency of these boilers in actual service. They have made arrangements for putting in new boilers and for making other necessary alterations in the *Medea* and the *Medusa*, for the purpose of testing two types of boilers, namely the Yarrow large tube compound boiler and the Dürr, which had not been previously used in his majesty's navy.

The committee was especially directed to "ascertain practically and experimentally the relative advantages and disadvantages of the Belleville boiler for naval purposes, as compared with the cylindrical." In order to comply with this part of their instructions, the committee examined the boilers of many of his majesty's ships, inspected many boiler tubes removed from ships at the home dock yards, received evidence from engineer officers, and considered the defect lists received from ships. An exhaustive series of trials between the *Hyacinth* with Belleville boilers, and the *Minerva* with cylindrical boilers, was also carried out under their directions. [Some account of the twenty-four hour trial between these vessels will be found in THE LOCOMOTIVE for September, 1891, page 134.]

The committee state that "the advantages of water tube boilers for naval purposes are so great, chiefly from a military point of view, that, *providing a satisfactory type* of water tube boiler be adopted, it would be more suitable for use in his majesty's navy than the cylindrical type of boiler." But they add that "the Belleville boiler has no such advantages over other types of water tube boilers as to lead us to recommend it as the best type to be adopted in his majesty's navy." In fact, although they were requested to "authoritatively recommend a standard for the use of his majesty's navy", they state that they are not in a position to do so, even after completing the elaborate investigation outlined above. The water tube boiler, for naval use, certainly has the advantage that it can be gotten under steam more quickly than the cylindrical type, and this, at times, would be of the utmost importance; but we take it that after exhaustive investigations, the committee was unable to find any type of boiler, for naval use, that did not have some serious shortcoming: and we shall presently see that they recommend cylindrical boilers for the ordinary operation of the ship, and water tube boilers in addition, for emergencies.

The committee fully recognized that the Belleville boiler, when new and in good condition, is a good steam generator, but they considered that its rapid loss of efficiency in ordinary work in commissioned ships, the serious character of the defects which have been developed in it, and the great care required in its manipulation, render it undesirable to install any more boilers of this type in the British navy.

"The disadvantages of the Belleville boiler," says the committee, "are as follows:

"(1) The circulation of water is defective and uncertain, and the gages do not indicate the amount of water in the boiler. These causes have led to serious accidents.

"(2) An automatic feeding apparatus of a delicate and complicated kind is necessary, in order to make the safe working of the boiler possible.

"(3) A great excess of pressure over that in the boiler is required in the feed pipes and pumps.

"(4) A considerable excess of boiler pressure over the working pressure at the engines is necessary.

"(5) The quantity of water varies at different rates of combustion, although the same level may be shown on the water gages.

"(6) Separators with automatic blowout valves on the main steam pipe are required in order to take care of water thrown out of the boilers when the rate of combustion or the speed of the engines is suddenly increased.

"(7) A constant and excessive loss of feed water.

"(8) The upper generator tubes are liable to fail by pitting or corrosion, and, in boilers provided with economizers, the economizer tubes are still more liable to fail from the same cause. The trouble from this cause has diminished recently, but the liability of these parts to corrosion still exists, and must be regarded as a serious disadvantage.

"(9) The maintenance of Belleville boilers has proved to be exceedingly costly, whereas that of cylindrical boilers is trifling; and this disproportion is likely to materially increase with the age of the boilers. On account of the necessity for more repairs, ships with Belleville boilers will be laid up more frequently, and for much longer periods, than similar ships with cylindrical boilers.

"(10) The additional evaporating plant required with Belleville boilers, and the greater coal consumption of this type on ordinary service as compared with cylindrical boilers, has hitherto nullified, to a great extent, the saving of weight effected by their adoption, and in considering the radius of action of ships fitted with them no real advantage has been gained by their use. The committee cannot say, however, whether this may not apply to other types of water tube boilers. This can be determined only by extended experience."

As compared with the cylindrical boiler, a satisfactory water tube boiler should possess the following advantages:

"(1) Less delay in steam raising.

"(2) Less liability to damage if the boiler be struck by a projectile.

"(3) Greater ease of repair and renewal of parts.

"(4) Less weight for the power generated, considering the weight of the boiler installation only.

"(5) Ability to carry a higher steam pressure.

"(6) Greater fire grate area for the same floor area, with consequent less forcing for full power.

"To a considerable extent these advantages are possessed by the Belleville boiler, but the committee consider that they are more than counterbalanced by the disadvantages enumerated above."

"The principal defects that have arisen in the ordinary working of Belleville boilers on board his majesty's ships are:

"(1) Corrosive decay of the baffles in the steam collectors, and of generator and economizer tubes. This has been caused by the intermittent character of the circulation of the water in the boiler, by which surfaces exposed to heat are alternately wetted and dried, and by the presence of air in the feed water, which experience has shown to be particularly injurious to feed water heaters placed in the uptakes of marine boilers. Lack of the proper preservative treatments has also contributed to the deterioration of these parts until recently. The rate of decay has now been reduced by the use of lime and zinc, but great care has to be taken in order to prevent choking of the water gage connections, in consequence of this necessary free use of lime. Belleville boilers, having undrowned generator tubes and a very large amount of feed water heater surface in the uptakes, are more liable to injury by corrosion than any of the four types of water tube boilers which are named by the committee as suitable for trial.

"(2) The rapid wear of the working parts of the automatic feed apparatus and of the check valves in the downtake pipes.

"(3) The burning and warping of the uptakes, boiler casings, and boiler supports, with consequent falling off in efficiency owing to the leakage of air into the uptakes. Serious injury to the boilers has, in some instances, resulted from this cause. The burning of boiler casings and supports can be reduced to a minimum by special design, and to some extent by skillful firing; but it is probable that this will always remain a more or less serious working defect in this and other types of marine water tube boilers.

"(4) The melting of fusible plugs, owing to the defective and uncertain character of the circulation of the water. This defect has been a very general source of trouble, but, as these plugs are necessary for the safe working of the boilers, their melting in particular elements cannot be avoided when the rate of combustion under them is varied to any considerable extent.

"(5) Deposit in the tubes about the water line, especially in the wing elements. This occurs when the feed water is not pure and a sufficiently active circulation is not being maintained. It is a serious defect, and has been the cause of tubes failing in several instances.

"(6) Leaky nipple joints. These have given great trouble.

"(7) The deterioration and fracture of the pipes connecting the float chambers and the water gage fittings to the elements. This has been due mainly to the use of unsuitable material.

"(8) The excessive expenditure of coal and of fresh water for boiler feed make-up, as compared with similar vessels fitted with cylindrical boilers. The expenditure of coal in ships fitted with Belleville boilers has been very high, both for auxiliary purposes in harbor and for propelling purposes. The loss of water, up to the present, has been an unsatisfactory feature in the working of Belleville boilers, notwithstanding all the care that has been taken to guard against it.

"Of the foregoing defects, the first, second, fourth, and fifth are inherent in the Belleville system. With reference to the eighth defect, it is considered that the loss of water is also inherent in the system."

The committee, in its letter of instruction, was requested "to report on the advantages and disadvantages of Niclausse and Babcock & Wilcox boilers compared with Belleville, as far as the means at the disposal of the committee permit; and also to report whether any other description of boiler has sufficient advantages over the Belleville, or the other two types mentioned above, as a boiler for large cruisers and battleships, to make it advisable to fit it in any of His Majesty's ships for trial." The committee, in an interim report, mentioned four different types of large straight-tube boilers, viz.: (a) Babcox & Wilcox: (b) Niclausse: (c) Dürr; and (d) Yarrow large tube: which they thought sufficiently promising for use in His Majesty's navy, and they are still of this opinion.

"These types have few of the disadvantages of the Belleville type, with most of its advantages. They all have 'drowned' tubes, and the water level as shown by the gages is practically the level of the water in the boiler; they do not require a much higher pressure to be maintained in the feed pumps than in the boilers, nor in the boilers than at the engines; the use of automatic feed regulators of an extremely delicate type is not necessary: the circulation is fairly well defined, and is much freer than in the Belleville; from such experience and evidence as the committee have had before them, the loss of water will be much less with these types than with the Belleville; and, finally, they appear to be much more likely than the Belleville to be free from accident under ordinary conditions of service."

It is worthy of notice, however, that the committee does not feel that its labors have placed it in a position to "authoritatively recommend" any particular type of boiler as a standard boiler for the use of His Majesty's navy. The committee did not consider that any type of water tube boiler yet devised is as satisfactory for general service as the cylindrical boiler, for naval use; but it recommended that water tube boilers be installed for use in emergencies. "From the evidence before the committee," says the report, "it appears that no type of water tube boiler at present in use is, on general service, as economical as the cylindrical boiler; also, that a large percentage of the coal used is expended for auxiliary purposes in harbor. Until a thoroughly satisfactory type of water tube boiler is obtained, the committee therefore recommend that in large cruisers and battleships cylindrical boilers of sufficient power to work the auxiliary machinery, and to drive the ship at her ordinary cruising speed, should be fitted; the steam pressure should be the same for the water tube and cylindrical boilers, and may conveniently be 210 pounds per square inch, so as to give 200 pounds at the engines. By this means considerable saving in coal will be effected, with a corresponding increase in the radius of action and general usefulness of the vessel. The water tube boilers could be kept clean and perfectly efficient, as they need only be used for driving the ship at high speeds, when economy of coal relatively is not so important."

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MR. JAMES WIMSHURST, F.R.S., late chief shipwright surveyor to the Board of Trade, calls our attention to the fact that the working of steam turbines, even in connection with a condenser, is not nearly so modern a thing as readers might possibly be led to suppose. He quotes from his personal experience of over fifty years ago, when he says he "witnessed in a warehouse at the head of the Grand Surrey Canal, London, a steam turbine of 11 feet diameter working in vacuum and driving a spare propeller of the steamship *Archimedes* at five revolutions greater speed than the engines of the *Archimedes* had driven it, although the turbine boiler was of less heating surface." Although he cannot give detailed particulars, he adds: "The speed of the turbine was great, and gearing to reduce the speed was fitted between the air pump, the screw, and the turbine. Moreover, there was a governor to check the speed of the turbine if, and when, necessary." Possibly some of our readers may be able to give further facts relating to the working of this early steam turbine; for such facts would certainly be deserving of record, and they would probably be as new to most of our readers as they are to us."—*The Mechanical Engineer* (London).

# The Locomotive.

HARTFORD, NOVEMBER 15, 1902.

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

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

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

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


THE issue of *The American Machinist* for November 6th is a special number, issued in celebration of the twenty-fifth anniversary of the first appearance of that excellent journal. It is unusually large, and unusually good; and that is saying a great deal, because the *Machinist* is always in the very front rank of technical journals, as everybody knows. The present issue contains many instructive articles tracing the progress of machinery and the machinist's art during the past quarter of a century. It is fully illustrated, and reflects the highest credit upon its editors and publishers. The price is ten cents, as usual.

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WE desire to compliment The Cassier Magazine Company upon the issue of *Cassier's Magazine* for November, 1902. This issue takes the form of a special "machine shop number," and is filled with matter of interest to machinists and mechanical engineers generally. It is impossible to give any adequate idea of such a magazine in a few words, but we may say that it contains no less than 270 pages of matter, exclusive of advertisements, and we should estimate that running through these pages there are at least 250 excellent engravings, mostly half-tones, illustrating pretty much everything that is new in the machine shop line. The price of this special number, to non-subscribers, is fifty cents; and the progressive mechanic really cannot afford to be without it.

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PROFESSOR John Perry is a good, hard-headed mechanical engineer, who has a sound knowledge of science, both pure and applied, and plenty of old-fashioned horse-sense in addition. His recent address before the British Association on the subject of technical education has therefore attracted wide attention. We shall print an abstract of it in our next issue, under the heading "Modern Mechanical Engineering," and we commend it to the attention of our readers. It recalls an article that was printed in THE LOCOMOTIVE for November, 1894, entitled, "A Remedy for Education," and although it was intended primarily for Englishmen, it contains many hints that ought to be of equal service to ourselves. We should like to correct him on one point that he makes, however. He says: "New countries like America . . . are starting without having to scrap any old machines or old ideas." Now the fact is, that the wonderful advance that the United States has made has been due, in large measure, to the fact that we are "scrapping" old machines and old ideas all the time. Perhaps they do not look old to Professor Perry, who may possibly want to see moss and other cryptogamic vegetation on a machine before he admits its antiquity; but we throw them away all the same, when they have outlived their usefulness, and we consider them "old," even if they still retain their original polish, provided we know that something distinctly better has been invented since we bought them.

## Precision in Measurements.*

It has been prophesied by many high authorities that in the future all discoveries of great moment will prove to be the outcome of exact measurements. Engineers have always attached great importance to accurate measurements, and are constantly introducing words in their specifications insisting upon the same, although they know quite well that exactitude is unattainable, and that the vagueness of the meaning of the provisions for accuracy in contract documents often leads to costly litigation. It would be well for the latter reason alone, apart from other considerations, if the Institution of Civil Engineers could define authoritatively what interpretation should be given to such words as "accurate", or "perfectly true to dimensions", which in practice must necessarily vary in meaning, according to the class of work to which they refer. If, for example, a qualified engineer were asked what constitutes a correct survey, he would reply by another question, What is the survey for? If it be to produce a plan from which measurements are to be subsequently taken by scale, it would be obviously useless to adopt refinement of observations in the survey which would be beyond the power of the draftsman to record on the plan, and a "correct" survey in that instance would mean one in which the error did not exceed, say, $\frac{1}{2000}$ of the length, a degree of accuracy attainable by chaining. If, on the other hand, the object of the survey were to obtain data for the calculation of the exact spans of such a structure as the Forth Bridge, a very different interpretation would be given to the word "correct", and the mode of procedure would be wholly different. In the case referred to, the first action of the engineers was to recover from the Ordnance Survey Department the original trigonometrical stations in the neighborhood, and the calculated lengths of lines, of which General Clarke said that it was "unlikely that the error in their lengths would amount to three inches in a mile, or about $\frac{1}{20000}$ of the length, and that it could not exceed six inches." The next step was for the engineers to measure their own base line with standard rods and take fresh angles many times over, with a final result that in a length of 4,000 feet the actual difference and presumable error in the Ordnance Local Survey proved to be 0.2 foot, or $\frac{1}{20000}$ of the length.

For all ordinary engineering purposes, such a degree of accuracy would entitle a survey to be characterized as "correct". In the case of a metallic structure, for example, the deviation would be equivalent to that arising from a change of temperature of but seven degrees. If, however, the measurement were for the base line of a great trigonometrical survey, a final error of $\frac{1}{20000}$ would imply inexcusable negligence on the part of the engineers. The Prussian engineers claimed that their measurements of the $3\frac{1}{4}$ mile base line at Gottingen, and the triangulations connected therewith were so accurate that the error in the 36 mile diagonal could not exceed $5\frac{1}{2}$ inches, or say, $\frac{1}{400000}$ of the length.

The same elastic interpretation of the "correct" applies to angles, the admissible error in which may range from two minutes to three-tenths of a second, according to the object of the survey.

But although the vagueness of the word "correct", as applied to a survey, occasionally leads to no little difficulty, it is in the carrying out of works that expressions of the kind constitute an ever-present cause of differences between the engineer and contractor, and of endless litigation and expense. Ten per cent. and more can readily be thrown away on the cost of works, if the engineer, either from inexperience or obstinacy,

* Extract from a Presidential Address, by Sir Benjamin Baker, before the British Institution of Civil Engineers.

insists upon a reading of such an expression as "exact to dimensions", reasonable enough in some classes of work, but too strict for the particular class in dispute. It is much to be regretted that some general rules as to limits are not authoritatively laid down for different classes of earthwork, masonry, timber, and steel work. Of course, in many instances, in machined work a limit of so many thousandths of an inch is specified, or a part is considered "exact to dimensions", if it passes a gage test. So long ago as 1850 the late Sir Joseph Whitworth exhibited at this Institution a measuring machine for determining minute differences in length. When a standard yard measure, made of steel $\frac{3}{4}$ inch square, was placed in the machine, it was claimed that by means of the micrometer a variation of but $\frac{1}{1000000}$ inch could be read. Mechanical measurements of this minuteness are, of course, not required in workshop practice. Probably the nearest approach to such a refinement is in the preliminary operations of "figuring" or polishing the lenses of telescopes. By means of the "spherometer", which is a little instrument on three legs to support it on the glass, and a central micrometer screw to measure the curvature of the lens, it is easy, according to Sir Howard Grubb, to get determinate measures of $\frac{1}{50000}$ inch, and by adopting special precautions, even of $\frac{1}{150000}$ inch, which latter has been found to be practically the limit of accuracy of mechanical contact. In anything else but a lens this might well be accepted as complying with the specification of "true to dimensions"; but in that special case such an error would be quite inadmissible, and indirect tests of much greater refinement, such as infinitesimally increasing the local convexity of the lens by the momentary application of the warm hand, and testing the optical consequences of the same, have to be resorted to. Fortunately, as the practical working of many branches of the industrial arts depends for success upon the accurate estimation of quantities much smaller than the preceding, there are often indirect ways of attaining refinements which direct mechanical measurements could not pretend to approach. Thus in the spectroscopic analysis of mere traces of different elements, fractional wave lengths are read to the $\frac{1}{2500000000}$ inch. Again, Professor Dewar in his researches on liquid air attained a vacuum of $\frac{1}{2500000000}$ of an atmosphere, by filling a vessel with mercurial vapor and exposing it to a very low temperature, and Professor Boys, with the simplest possible arrangement of quartz fiber, torsion balance, and mirror, claims to have been able to just detect an attractive force of the $\frac{1}{200000000000}$ of a grain.

It is difficult to realize the minuteness of measurements like the preceding. The smallest gold coin of the realm (England), if drawn out into a wire $\frac{1}{2500000000}$ of an inch in diameter would be long enough to stretch to the sun and back again ten thousand times, and yet the fundamental mystery of the constitution of atoms and molecules would be locked up in every infinitesimal portion of the length of that minute wire.

## Boiler Explosions.

JUNE, 1902.

(169.)—On June 2d a boiler exploded in the Watson Wagon Company's Works, at Canastota, N. Y. Engineer George E. Gallaway was killed, and Owen Thomas was scalded so badly that he died shortly afterwards. The boiler-house was raised four feet from its foundation by the explosion, and was badly wrecked.

(170.)—The boiler of locomotive No. 1,797, on the Baltimore & Ohio railroad, exploded, on June 4th, near Piedmont, W. Va. Brakeman Robert Graham and a man named Smith were instantly killed. Engineer W. G. Lynn was badly burned and otherwise injured, and brakemen Charles Powell and W. R. L. Wenner were severely injured. At last accounts it was doubtful if Powell could live. The locomotive was totally wrecked, and considerable damage was done to the tracks.

(171.) — On June 6th a locomotive boiler exploded at Aqua, on the Richmond, Fredericksburg & Potomac railroad, in Rockbridge county, Va. Engineer John L. Pumphrey and fireman C. G. Saunders were badly injured. The engine was drawing a special train bearing the "Liberty Bell" escort party from Philadelphia to the Charleston Exposition. One Pullman sleeper and a combined parlor and baggage car were derailed, but the passengers escaped unharmed, except for a severe shaking up. The locomotive was destroyed, and the tracks were torn up for a considerable distance.

(172.) — On June 6th a boiler exploded in Cockrell's sawmill, near Heathsville, Va. Nobody was injured. We have not learned further particulars.

(173.)—On June 7th a boiler exploded in Duffy Brothers' sawmill at Valley Church, on the Chillicothe and McArthur road, in Harrison township, near Chillicothe, Ohio. Three men were seriously injured, and it is believed that one of them, Clinton Duffy, one of the owners of the plant, will die. The mill was wrecked.

(174.) — On June 8th a heating boiler exploded in G. L. Graham's greenhouse, at East Bradford, N. Y. The building was wrecked and considerable damage was done. The explosion occurred in the night, and nobody was injured. It is said that the property loss was about $2,000.

(175.) — On June 12th a boiler exploded at an oil well at Hambden, near Painesville, Ohio. Nobody was injured.

(176.) — A boiler exploded, on June 13th, at Berthoud, Col. It was used in boring the Alderman oil well. Nobody was injured.

(177.) — On June 13th the boiler of a threshing outfit exploded on Dr. J. A. Avant's farm, two miles west of Weston, Texas. Engineer George Anderson was fataliy injured, and Orval Hix was injured seriously.

(178.) — A small boiler exploded, on June 17th, in the basement of No. 22 Engine House, at the corner of O'Donnell and Patuxent streets, Baltimore, Md. We have not learned further details.

(179.)— On June 17th the boiler of a traction engine, operated by John Brinkley, exploded while used to operate a hay packer near Greencastle, Pa. Mr. Brinkley was badly scalded and bruised.

(180.) — On June 18th a boiler exploded in the tomato and berry cannery of Garner Brothers, at Union Village, near Heathsville, Va. We have not learned further particulars, except that nobody was injured.

(181.) — A boiler exploded, on June 20th, in a stone quarry in the outskirts of Marseilles, Ohio. Nobody was injured.

(182.) — A boiler used for heating water exploded, on June 21st, in J. W. Riley's bathrooms, at Marshalltown, Iowa. The explosion caused considerable damage to the building, but we have not learned of any personal injuries.

(183.) — A boiler exploded, on June 23d, some five miles west of Mt. Vernon, Ill. George W. Rowe, and his son, Homer Rowe, were killed, and George Rowe was fatally injured. John Thomas and two other persons whose names we have not learned were seriously injured.

(184.) — A boiler exploded, on June 27th, in the Palestine Packing Company's plant, Palestine, Texas. Nobody was injured, but the building in which the explosion occurred was considerably damaged.

(185.) — On June 29th a slight explosion occurred in the electric light plant at Clarksburg, W. Va. We have not learned further particulars, except that nobody was injured.

## Inspectors' Reports.

April, 1901.

During this month our inspectors made 11,684 inspection trips, visited 21,654 boilers, inspected 8,665 both internally and externally, and subjected 953 to hydrostatic pressure. The whole number of defects reported reached 11,538, of which 919 were considered dangerous; 83 boilers were regarded unsafe for further use. Our usual summary is given below:

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment, | 1,203 | 35 |
| Cases of incrustation and scale, | 3,216 | 67 |
| Cases of internal grooving, | 284 | 48 |
| Cases of internal corrosion, | 1,054 | 71 |
| Cases of external corrosion, | 670 | 42 |
| Broken or loose braces and stays, | 296 | 71 |
| Settings defective, | 413 | 39 |
| Furnaces out of shape, | 389 | 26 |
| Fractured plates, | 392 | 51 |
| Burned plates, | 282 | 34 |
| Blistered plates, | 100 | 3 |
| Cases of defective riveting, | 254 | 57 |
| Defective heads, | 84 | 7 |
| Serious leakage around tube ends, | 1,426 | 119 |
| Serious leakage at seams, | 449 | 17 |
| Defective water-gauges, | 244 | 45 |
| Defective blow-offs, | 226 | 67 |
| Cases of deficiency of water, | 18 | 3 |
| Safety-valves overloaded, | 51 | 17 |
| Safety-valves defective in construction, | 66 | 30 |
| Pressure-gauges defective, | 376 | 37 |
| Boilers without pressure-gauges, | 20 | 20 |
| Unclassified defects, | 25 | 13 |
| Total, | 11,538 | 919 |

We have previously referred to the proposed trilingual dictionary of technical words that is to be gotten out by the Germans. The *Engineering Magazine* now says that Dr. Alfred Müller, of 150 Nassau St., New York, has been authorized by the German Society of Engineers to arrange for collaboration in the preparation of the German-English-French technical dictionary which this society has undertaken to publish. He will supply collaborators with specially arranged notebooks, and will gladly furnish further information concerning the work.

# The Locomotive.

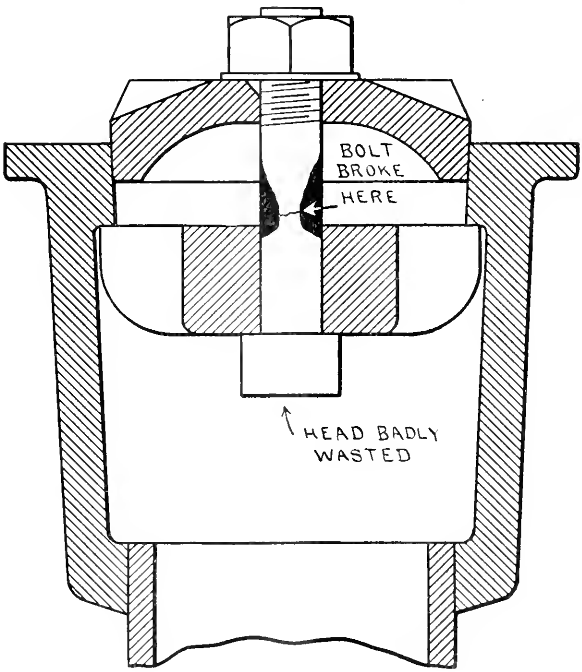
PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XXIII. HARTFORD, CONN., DECEMBER, 1902. No. 12.

## Accident to an Economizer.

The London *Engineer* gives an illustrated account of an accident to an economizer in England some months ago; and as the accident ought to be as instructive on this side of the Atlantic as on the other, we reprint the article below:

"An explosion occurred from a Green economizer at Stalybridge some time ago," says the journal from which we quote, "resulting in the death of two men. It is de-




Showing the Bolt as Weakened by Corrosion

sirable that our readers should be in possession of the principal facts of the case, because there are important lessons to be learned from them. The economizer was made in 1888 by E. Green & Sons, Ltd., and it was (by arrangement with the owners) inspected four times a year by them,—three times while in operation, and once 'thoroughly.' The economizer consists of 384 vertical, cast-iron tubes, $4\frac{9}{16}$ in. in diameter, externally, the upper ends of which are expanded into cast-iron boxes, and closed by covers secured by one bolt. [This is the statement as made by the *Engineer;* but we are of the opinion that the tubes in question are made on a very slight taper, and forced into the boxes hydraulically. At all events, that is the way they are secured in this country.] The 'thorough' inspection consisted in dividing the pipes roughly into groups of 100 each, and removing two caps from each group, and examining the tubes inside. The last time that this was done, previous to the accident, was in August, 1901, and the inspector found the economizer generally in good condition. On February 10th of the present year some of the caps leaked, and two men went to attend to them with a wrench and a piece of piping three feet long. Soon afterwards the bodies of the men were found near the door of the economizer room, and the cap of one of the tubes was found on the floor. The engraving of the bolt and cap, which is presented herewith, tells everything else that is needed. The bolt was badly wasted where shown, the portion that had been lost by corrosion being indicated by the irregular, heavy black patches; and it broke under the strain of tightening up.

"The obvious lessons to be learned from this unfortunate accident are: (1) That the inspection was inadequate. If we do not go as far as the commissioners, from whose report we take the facts and who are of the opinion that every cap should be removed once a year, we nevertheless have no doubt whatever but that more than *two per cent.* of them should be inspected. The fact that many other bolts were subsequently found to be defective confirms us in this view. (2) The danger of interfering with bolts under pressure is again impressed upon us. This practice is always inadvisable [we should put the case far stronger than that, and condemn it altogether], and it is absolutely dangerous when a joint which has been good, possibly for months, gives out without visible cause. When, moreover, the joint is metal to metal, as in the present case, it is bordering on madness. The fact that the joint is blowing, in such a case, is an indication that the bolt is not doing its work. Mark it, therefore, and examine it when the pressure is off. (3) If you are going to do a dangerous thing, make sure of your way of retreat. If these unfortunate men had left the door open, they might possibly have escaped. They reached it, but were apparently too overcome by that time to open it."

We have had many accidents of this general nature in our own practice, and we have endeavored, on all occasions, to emphasize the extreme danger of tightening up nuts under pressure, or of doing repair work of any kind without first shutting the boiler down. We know how great the temptation is, when a little leak is seen, to fall to work upon it at once and fix it. Putting the boiler out of service often seems to be an unnecessary precaution, to which none but an over-timid man would resort; and usually, too, the leak is observed at a time when it is very inconvenient to put a boiler out of use. But in our extended experience we have seen so many serious results from trifling with boilers and steam pipes while under pressure, that we feel called upon to condemn the practice universally, and as positively and emphatically as we can. The engineer or fireman will have to judge, in each separate case, whether it is necessary or advisable to shut down at once, or whether he can safely run the boiler until a more convenient time for giving the leak his attention. But in any case, he should not try to stop it while the pressure is on. The lesson, simple as it is, is a hard one to learn; but the man who does not learn it is always in danger of going, by rapid transit, to another and a better world, and giving his family a chance to realize on his life insurance.

## Inspectors' Reports.

MAY, 1902.

During this month our inspectors made 11,764 inspection trips, visited 21,751 boilers, inspected 9,604 both internally and externally, and subjected 981 to hydrostatic pressure. The whole number of defects reported reached 12,390, of which 907 were considered dangerous; 90 boilers were regarded unsafe for further use. Our usual summary is given below:

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment, | 1,365 | 58 |
| Cases of incrustation and scale, | 3,516 | 85 |
| Cases of internal grooving, | 179 | 28 |
| Cases of internal corrosion, | 1,014 | 57 |
| Cases of external corrosion, | 654 | 62 |
| Broken or loose braces and stays, | 129 | 21 |
| Settings defective, | 506 | 35 |
| Furnaces out of shape, | 461 | 26 |
| Fractured plates, | 360 | 38 |
| Burned plates, | 377 | 39 |
| Blistered plates, | 139 | 8 |
| Cases of defective riveting, | 226 | 15 |
| Defective heads, | 86 | 15 |
| Serious leakage around tube ends, | 1,678 | 169 |
| Serious leakage at seams, | 448 | 23 |
| Defective water-gauges, | 284 | 75 |
| Defective blow-offs, | 264 | 62 |
| Cases of deficiency of water, | 18 | 8 |
| Safety-valves overloaded, | 93 | 24 |
| Safety-valves defective in construction, | 73 | 12 |
| Pressure-gauges defective, | 494 | 29 |
| Boilers without pressure-gauges, | 11 | 11 |
| Unclassified defects, | 15 | 7 |
| Total, | 12,390 | 907 |

JUNE, 1902.

During this month our inspectors made 11,440 inspection trips, visited 20,460 boilers, inspected 9,881 both internally and externally, and subjected 1,032 to hydrostatic pressure. The whole number of defects reported reached 13,487, of which 1,310 were considered dangerous; 93 boilers were regarded unsafe for further use. Our usual summary is given below:

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Cases of deposit of sediment, | 1,303 | 41 |
| Cases of incrustation and scale, | 3,374 | 98 |
| Cases of internal grooving, | 253 | 12 |
| Cases of internal corrosion, | 1,189 | 48 |
| Cases of external corrosion, | 921 | 79 |
| Broken or loose braces and stays, | 299 | 150 |

| Nature of Defects. | Whole Number. | Dangerous. |
|---|---|---|
| Settings defective, | 449 | 65 |
| Furnaces out of shape, | 511 | 30 |
| Fractured plates, | 320 | 51 |
| Burned plates, | 475 | 48 |
| Blistered plates, | 136 | 1 |
| Cases of defective riveting, | 345 | 30 |
| Defective heads, | 110 | 22 |
| Serious leakage around tube ends, | 1,962 | 294 |
| Serious leakage at seams, | 548 | 38 |
| Defective water-gauges, | 272 | 59 |
| Defective blow-offs, | 328 | 112 |
| Cases of deficiency of water, | 11 | 4 |
| Safety-valves overloaded, | 116 | 29 |
| Safety-valves defective in construction, | 66 | 28 |
| Pressure-gauges defective, | 468 | 42 |
| Boilers without pressure-gauges, | 28 | 28 |
| Unclassified defects, | 3 | 1 |
| Total, | 13,487 | 1,310 |

## Boiler Explosions.

JULY, 1902.

(186.) — The boiler of John H. Keaton's sawmill exploded, on July 1st, at Atwood, some three miles east of Milan, Tenn. Fireman Luke Dalton was fatally injured, his skull being fractured by a flying fragment of the boiler. William Bonner and Thomas Bolton were also seriously hurt. The mill was destroyed, and débris was scattered all about to considerable distances.

(187.) — The boiler of a locomotive exploded, on July 2d, on the Rock Island railroad, near White City, Kansas. Fireman W. C. McNabb was scalded to death, and engineer Myers was scalded seriously, though not fatally. We have not learned further particulars.

(188.) — On July 3d a boiler exploded in Ranger & Broadbrook's planing mills, at Attica, N. Y. The sides of the building in which the boiler stood were blown out, but nobody was injured, as the employees had just left the mill.

(189.) — On July 5th the boiler of J. H. Vaughan's threshing outfit exploded, some two miles west of Gainesville, Tex. John Wisdom and James Carter were scalded so badly that they died a few hours later.

(190.) — A boiler exploded, on July 7th, at the Eagle Mills, Woonsocket, R. I. Watchman Irving A. Briggs, who was tending the fires at the time, was hurled through a door, and was badly injured. Two of his ribs were fractured, and he also received serious cuts and bruises about the body. The stone building in which the boiler stood was destroyed, and the property loss is said to have been $12,000.

(191.) — Edward Beatty was badly injured, on July 7th, by the explosion of a boiler in the Sand Fork oil field, near Bealls Mills, Lewis county, W. Va. He was burned so badly that it was thought, at first, that he could not possibly recover. Later advices, however, indicate that his injuries did not prove fatal.

(192.) — On July 8th the boiler of John Doerksen's threshing outfit exploded, about seven miles northwest of Burrton, Kansas. The front head of the boiler blew out. Abraham Doerksen was injured fatally, and some five other persons received lesser injuries.

(193.) — A boiler exploded, on July 9th, in the Cuahuatemoc brewery, at Monterey, Mex. One man was killed, and two others were injured. Fire followed the explosion, and the combined damage from the explosion and the fire is estimated at $60,000.

(194.) — The boiler of Anderson & Wilson's threshing outfit exploded, on July 9th, at New Albany, eight miles west of Fredonia, Kansas. Leo Anderson was fatally injured, and a flying piece of wreckage cut one of William Wilson's legs squarely off. Several other persons were also injured to a lesser extent.

(195.) — Elijah Coombs was instantly killed, on July 10th, by the explosion of a boiler in Ollinger & Hobbs' sawmill, near Beattyville, Ky. Robert D. Ollinger's legs were lacerated so badly as to necessitate the amputation of both. Bonaparte Pritchard was also badly scalded. The mill was demolished.

(196.) — On July 11th the boiler of John Davis' threshing outfit exploded on the outskirts of Moundridge, Kansas. Anson Crippen was thrown fully a hundred feet, and received injuries from which he died on the following day. John Friesen and Charles Mippleton were also seriously injured.

(197.) — A boiler exploded, on July 12th, in Curtis Jannell's sawmill, at Williamsville, near Brattleboro, Vt. Nobody was injured. The main portion of the boiler was thrown to a distance of over 1,000 feet.

(198.) — On July 17th a boiler exploded in Mr. J. H. Bennett's sawmill, in Marlboro county, near Cheraw, S. C. Mr. Bennett was instantly killed, and his fireman was badly injured. The boiler house was completely destroyed.

(199.) — The boiler of locomotive No. 58, on the T., St. L. & W. railroad (commonly known as the "Clover Leaf") exploded, on July 17th, while the locomotive was backing on the side track at Continental, Ohio. Engineer Charles Major and fireman J. C. Smith were instantly killed, and a considerable amount of damage was done to the train, the track, and adjacent property. The fireman's body was thrown to a distance of an eighth of a mile.

(200.) — A boiler exploded, on July 18th, in Robert Collins' bakery, on East Sixty-fourth street, New York City. The property loss was about $1,000, but nobody was injured, although sixteen men were working, at the time, in the basement where the explosion occurred.

(201.) — On July 18th the boiler of a threshing outfit exploded, at Fairfield, N. C. Engineer Henry Morris was thrown sixty yards and instantly killed. Two young men named Simmons were also badly hurt.

(202.) — A boiler exploded, on July 19th, in Pridmore & Reese's sawmill, at McCreary, Miss., a station on the Mobile & Ohio railroad, ten miles east of Columbus, Miss. Both of the owners of the plant, together with an employee named Taylor, were killed, and Mr. Pridmore's brother was injured so badly that he may not recover. The mill was totally wrecked, everything being literally torn to pieces.

(203.) — A boiler explosion occurred, on July 19th, on the steam yacht *Duquesne*, owned by James G. Butler, of St. Louis, Mo. The accident occurred off the Norwalk Islands, in Long Island Sound, while the *Duquesne* was on her way from Black Rock to New York. J. B. Allen, Hiram Farnham, and Isaac Farnham were painfully scalded, but all three recovered. The men were rescued by the oyster steamer *Commander*.

(204.) — A boiler explosion, similar to the one just recorded, occurred, on July 20th, on the steamer *City of Lawrence*, at North Beach, Long Island. We have not learned further particulars.

(205.) — A boiler tube burst, on July 21st, on the steam yacht *Harold*, while she was lying in the Delaware river, opposite Torresdale, Pa. Warren Stanger was thrown overboard and drowned, and engineer J. W. Van Winkle was fatally scalded. The launch belongs to W. D. Stanger, of Pensauken, N. J.

(206.) — The boiler of a Baltimore & Ohio freight locomotive exploded near Olney, Ill., on July 22d. Engineer Conaty was instantly killed, and fireman Michael Muster was fatally injured. Fifteen cars were wrecked.

(207.) — On July 22d a boiler exploded at the St. Louis Vitrified and Fire Brick works, at Maryland Heights, St. Louis county, Mo. One of the buildings of the plant was demolished. We have not learned further particulars.

(208.) — On July 22d a boiler exploded in the Rapid City Lumber Company's plant, at Rapid City, S. Dak. Nobody was injured, although there were eight persons in the immediate vicinity of the boiler.

(209.) — The boiler of freight locomotive No. 1944, on the Baltimore & Ohio railroad, exploded, on July 23d, at the railway station at Ravenna, Ohio. Engineer J. R. Barnes was instantly killed, and fireman C. H. Cabbin and brakeman Charles M. Jones were painfully scalded. The locomotive was demolished. The boiler cleared the trucks, shot ahead sixty feet, and then plowed into the ground fully four feet.

(210.) — A boiler exploded, on July 24th, in William Mooman's blacksmith shop, at Pierson, Ill. Mr. Mooman was operating the boiler at the time, and he and six children, who were looking on, were badly scalded and bruised. One of the children was also seriously crushed about the chest, head, and arms. The building was destroyed. The walls were blown out and the roof fell upon the persons within.

(211.) — On July 25th a boiler exploded in Dr. T. C. Robinson's boiler house, at Turtle Creek, near Pittsburg, Pa. We have not learned of any personal injuries. The building in which the wrecked boiler stood is a private pumping station for furnishing water to about 100 houses. The building was destroyed.

(212.) — Two boilers exploded, on July 26th, in the electric light and ice plant of William Curry's Sons, at Key West, Fla. The entire island was shaken, the electric light and ice plants were demolished, and the Knight building, adjoining the Curry plant, was wrecked. Thomas Webb and William Hendry were killed. Patrick Andrews, Thomas Yates, Thomas Symonette, Eugene Knight, and Charles Lloyd were badly injured, and twenty other persons received injuries of less severity. A fragment of one of the boilers, weighing 4,000 pounds, was thrown 500 feet into a fish market. Another, weighing 100 pounds, went through the roof of the offices of the Peninsular & Occidental steamship line, falling among the clerks at work, and injuring several. The property loss is estimated at $150,000.

(213.) — The boiler of the Pittsburg & Western railroad's locomotive No. 86 exploded, on July 26th, at Hickman, a station on the Baltimore & Ohio railroad, near Connellsville, Pa. J R. Smith, a brakeman, was fatally injured, but the engineer and fireman escaped unharmed. The locomotive was entirely wrecked.

(214.) — The Narragansett electric light plant, at Providence, R. I., was visited by a slight boiler explosion on July 28th. Nobody was seriously injured. We have not learned further particulars.

(215.) — On July 29th a boiler exploded in Strong & Grinestaff's sawmill, at Moss, Tenn. Fireman James Coulter was instantly killed and several others were scalded and otherwise injured.

(216.) — A boiler exploded, on July 29th, in the flouring mill of Hull & Draper, at Salem, near Centralia, Ill. Engineer P. E. Lefter was killed, and Robert Messer, Roy Sills, John Sills, Ardery Lawrence, and Donald Phelps were injured. The boiler house was completely wrecked and the main walls of the mill were badly cracked, so that the loss to these buildings will amount to about $10,000. Serious damage was also done to a Baltimore & Ohio Southern passenger train that had just pulled into the station, which is near the mill. One Pullman sleeping car on this train was almost destroyed, and its single occupant had a wonderfully narrow escape from death.

(217.) — On July 31st a boiler exploded in Joseph Hardesty's sawmill, situated in the village of Platform, some four miles back of Crown City, Gallia county, Ohio. Mr. Hardesty (the owner of the mill) was instantly killed, and his son received serious injuries from which he may not recover.

(218.) — A boiler exploded, on July 31st, in Charles Suppes' sawmill, near Newcastle, Monroe county, Ohio. John Shaw was instantly killed and George Wheeler was hurt so badly that he lived only a short time. A son of Mr. Suppes was also injured so severely that it is thought he cannot recover. The mill was destroyed.

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The Size of Alaska. — In the *Popular Science Monthly* for December, 1902, Mr. George B. Hollister gives a map of Alaska, superposed upon one of the United States, in order to illustrate the enormous size of our northern possession in a popular and forcible manner. In describing the map he says: "When Point Barrow, the most northerly extremity of Alaska, is placed upon the Canadian border in northern Minnesota, Mt. St. Elias falls near the Ohio river between western Kentucky and Indiana, and the main portion of the territory covers almost the entire area of the Great Plains and Mississippi Valley as far south as Arkansas. The extreme southeasterly portion of the narrow strip of Alaska, upon which Sitka and Juneau are situated, would extend to the Atlantic Ocean at Georgia; the celebrated Nome district would fall in western South Dakota near the Wyoming line; and the most westerly of the Aleutian Island group would lie upon the Pacific coast line near Los Angeles, the intermediate islands touching the Mexican border in Arizona and New Mexico. In other words, the territory of Alaska is sufficient in geographical extent to reach from the Atlantic to the Pacific, and from Canada to Mexico. Placed on the United States in the position described above, Alaska would cover, wholly or in part, twenty-three states and territories, and the western third of Lake Superior." It is evident that there must be many parts of this vast region that have not yet been visited by white men.

# The Locomotive.

HARTFORD, DECEMBER 15, 1902.

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

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

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

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



THE index and title page to the volume of THE LOCOMOTIVE that ends with the present issue are in preparation, and will be mailed free to those that preserve their copies for binding, upon application, by mail, to the Hartford office of this company.

## Mr. John Fritz.

The dinner that was given, at the Waldorf-Astoria hotel in New York on the evening of October 31st, to celebrate the eightieth birthday of the veteran iron manufacturer Mr. John Fritz, was very generally noticed in the daily papers, and many very pleasant and well-deserved compliments were paid to Mr. Fritz. The decorations of the dining room and of the tables were symbolic of the iron and steel industry. "A model blast furnace was in one corner," says the *Engineering News*, "and an open hearth furnace in another. Table pieces were made representing ships of war, guns, bridges, locomotives, and the like, and sherbet was served in boxes made to look like short sections of steel rails. The menu was contained in a large pamphlet, bound in metal-coated paper, held together by bolts and rivets, and embossed with a representation of a blast furnace. Within, on parchment paper, it contained an engraving in sepia tint showing the Bethlehem works, a blast furnace and a rolling mill, and also an excellent photograph of Mr. Fritz with his autograph signature, as well as the menu card proper and a poem by Dr. R. W. Raymond."

We should like to say a few words in explanation of the services that Mr. Fritz has rendered to the iron manufacturing business, and perhaps we cannot do better than quote the following anecdote which Mr. Charles T. Porter contributes to the *American Machinist*, as this not only tells what Mr. Fritz's main service was, but also illustrates the fact that his achievements have not been nearly as well known as one might reasonably expect them to be.

"One Sunday afternoon, some three or four years ago," says Mr. Porter, "I received a call from Mr. Henry C. Meyer of the *Engineering Record*, who was a fellow townsman of mine in Montclair. He told me that Mr. Rockefeller had been building a fleet of twenty-one steamers for the transportation of ore on the lakes; that he had formed a plan to name these vessels after the great leaders in metallurgical and engineering science and art, and that he had committed the selection of these names to his confidential agent, Mr. F. T. Gates, who was also a resident of Montclair. Mr. Meyer told me further that twenty of these vessels had already been launched and named, and that the last one was approaching completion. He added that a few of the admirers of Mr. Fritz, who knew of this proceeding, were anxious that this last one should bear his name, and a committee of their number had waited on Mr. Gates and urged upon him this selection. Mr. Meyer said that for some reason which they could not divine Mr. Gates had hesitated about the matter, and that the gentlemen were obliged to leave without any positive assurance on the subject, and that it had occurred to him that I might be able to say something to Mr. Gates that would incline him favorably, and he wanted me to see him for this purpose.

"I replied that I was a stranger to Mr. Gates, and, moreover, did not imagine that I could add anything to what had probably been said already. He urged me to go, however, so we went. We did not find Mr. Gates at home at the first call, but later I called alone, introduced myself, and told the purpose for which I had been requested to see him.

"I found that Mr. Gates' view was of a very definite and practical character. He told me that the intention was to honor the men who had done the most to promote the use of iron and steel in the world; that he had been greatly interested and impressed by what the gentlemen had told him respecting the important part borne by Mr. Fritz in the development of the iron and steel industries in this country, and was very anxious to meet their wishes and name the boat for him, but this difficulty seemed to be in the way: Each one of the men whose names had been selected had done some *one* particular thing of importance in increasing the consumption of iron and steel, and these gentlemen had failed to point out any one particular thing that Mr. Fritz had done, and that had made him hesitate; but he would be very glad if this difficulty could be removed.

"I replied that I was surprised to hear his statement, and that I felt sure that his very proper requirement could be fully complied with. I then told him that Mr. Fritz was the inventor of the three-high train of rolls, which had revolutionized the rolling-mill business, being now used universally except for rolling armor plate, where the train was stopped and reversed at every pass. As he had no knowledge on the subject, I was obliged to explain to him that previous to this invention iron and steel were rolled between two rolls, and after every pass the bar was returned idly on the top roll to pass through again, and that the use of the train was quite limited, because thin sections cooled and cracked along the edges, and at each successive pass these cracks opened wider and the bar would be ruined. I told him that in the three-high train the bar is reduced on the back pass also, doubling the production of the train; that its heat is kept up to the end of the operation, heat being added mechanically as fast as it is lost by radiation; and, most important of all, the passes being alternately in reverse directions, cracks opening up on one pass were welded up on the next one, so that any sections whatever could be rolled with the certainty of sound edges, thus enlarging the usefulness of the train indefinitely.

"I told him that not only did Mr. Fritz make this invention, but by his force of character and his indomitable will he compelled its trial against opposition that would have crushed any ordinary man. All experts who would commit themselves gave an adverse opinion. Every one in the business denounced it as the height of folly. His friends implored him not to wreck his prospects in life by insisting on a chimerical scheme that was sure to fail. And finally the directors of the Cambria Iron Company passed a resolution ordering him, then their superintendent, to build the proposed train in accordance with the established usage. Mr. Fritz met this last move by promptly sending in his resignation. This brought them to their senses, and they finally permitted him to try his experiment.

"'Why,' exclaimed Mr. Gates, when I had finished, 'this is precisely what I want. But why was I not told this at first?' I replied that I could not answer that question; it puzzled me as much as it did him, but he might rely on the correctness of my statements. This he evidently did, for the next morning we chanced to meet on the way to New York, and Mr. Gates hailed me from a little distance and said, 'I have named the boat *John Fritz.*'"

The following extract from the *Engineering Magazine* may also be found of interest in connection with the foregoing:

"Born in 1822, Mr. Fritz has been engaged, during his long life, entirely in the development of the iron and steel industry of the United States. Such a career covers practically all the developments in iron manufacture since Cort invented the puddling furnace, and all of the tremendous expansion in the manufacture and use of steel which followed the epoch-making inventions of Bessemer, Siemens, Martin, Gilchrist, and Thomas.

"Mr. Fritz's work has been mainly that of a developer of processes which, while they may have had their origin elsewhere, have found their fullest fruition in the mills, forges, and machine shops of the United States. It was he who, with the lamented Holley and with his brother George Fritz, practically initiated America into the possibilities of the Bessemer process, and it is in his footsteps that the men who have since carried on the work have trod. Under his masterful, conservative, comprehensive guidance there have grown up in the United States such works as those at Johnstown and at Bethlehem, with all the development of the modern three-high rolling mill, the hydraulic forging press, the nickel-steel armor plant, gun-forgings, structural-steel production, and the whole transformation of modern materials of engineering; and today he stands as the concrete representative of modern engineering in all its highest achievements.

"Mr. Fritz has had the rare privilege of receiving in his lifetime the honors which too often come only when they can no longer be a gratification. He has been successively president of the American Institute of Mining Engineers and of the American Society of Mechanical Engineers. He is an honorary member of the Franklin Institute, and the honored recipient of the Bessemer medal at the hands of the British Iron and Steel Institute.

"Perhaps no better summary of the work in which Mr. Fritz has taken such a controlling part can be made than to quote from his own presidential address before the American Society of Mechanical Engineers, delivered in 1896.

"'The modern practice of steel making,' he said, 'has, in the hands of the mechanical engineer, the metallurgist and the chemist, wrought wonders in producing a material which in quantity, physical qualities and cheapness would have been regarded as utterly impossible half a century ago, when steel rails, beams, angles, and plates were not thought of, and steel was regarded as a luxury among the materials of the working artisan. The labor of the men of iron and steel has so cheapened their products that today we are enabled to use steel for the commonest purposes as well as for the most expensive articles produced by the skill of the mechanic. No article is too humble to be made of it, and no structure so grand and important as to refuse its services; it is demanded in the frying pan as well as in vast bridges and viaducts; as well in the housewife's needle as in the great leviathans which have made the ocean a span of less than a week. Thus we find steel asserting its value through every walk of life, and extending to every clime, linking lands in that bond which grows broader and stronger with the years, till even now we see, if but dimly, on the horizon the promise of the linking of nations in the universal brotherhood of mankind, and bringing the longed for era of eternal peace.'

"And then, at the close of his eloquent address, Mr. Fritz might well have added, had his gentle and characteristic modesty not deterred him, '*Quorum pars magna fui*'" [ "Of which I was a great part" ].

## An "All-Stations" Express Train.

At the recent meeting of the British Association Mr. John Brown explained a scheme that he had evolved for running an express train without stops, and yet enabling passengers to board it and leave it at any station. The idea was illustrated by a model. The train is to be run by electric power, and each car is to have its separate motor. Passengers desiring to leave at any given station would pass into the last car of the train, and this car would be detached at the proper moment, and brought to rest at the station. Passengers desiring to board the train would get into a similar car at the station before the train was due, and the car so loaded would be started off in advance, and the oncoming express would be allowed to overtake it gradually. We have no desire to detract from any glory that may be due to Mr. John Brown, but we have no doubt but that this same idea has occurred, some thousands of times, to mechanics of an imaginative turn of mind. We are of the opinion, however, that the world will not see the new "all-stations express" in active practical operation for some time to come. The editor of THE LOCOMOTIVE is free to confess that when he contemplates the chance of blowing out a fuse, or coming to grief in some other way, at a critical moment, in front of the express that is to pick him up, he would much prefer to take the horse car. Even walking would have its attractions in the face of such a possibility. The scheme is so utterly futile that we should not have mentioned it at all, if it had not been dignified by the official notice of such an august body as the British Association. Sir Frederick Bramwell suggested that the passengers might be transferred by running the train and the trailer (if we may call it so) on parallel tracks, and making the luckless ones "walk the plank," as the pirate kings of the good old days used to do. We guess Sir Frederick was having a little fun with Mr. Brown. It strikes us that the whole scheme could be mightily improved. It would hardly do to pick up the passengers and drop them by the automatic devices that are now used for mail bags, because the shock would be perturbing to the spirits. But why could they not be thrown off the train against suitable piles of mattresses or air cushions? Anybody who wanted to get on the train could easily be fired aboard, out of a specially constructed cannon, loaded with a carefully graduated charge of powder and trained upon a padded receptacle at the rear of the train. We give these ideas to the public without charge, because it has often been said that here in the United States we are reckless in our railroading, and we wish to nail that untruth on the spot by showing that when some foreigner gets up a new scheme for passenger transportation, it is the first instinct of the American to amend and improve that scheme in the interest of public safety.

## Modern Mechanical Engineering.

A change is taking place in England in regard to the best methods to be adopted to educate the coming generation of engineers. The academic curriculum, which has been so long in favor, is looked upon by some of the leading men as inadequate to the requirements of the present day, the argument being that it does not fit young men to deal with commercial mechanical engineering in all that leads to greater economy and increased output in actual barter and sale. This change of front, in the practice of the last decade, is a very great advance, and if it has come at last it is none too soon, for laymen had seen the necessity for a change a good many years ago. Diplomas and degrees amount to nothing unless they carry with them an ability, upon the part of the licentiate, to put hard money into the pockets of manufacturers. What does it profit the latter to have a long report bristling with carbonic oxide, marsh gas, *et al.*, the nature of which he is totally ignorant, when what he actually needs is a specific statement of the reason why he burns so much coal to get so little steam, backed up by an offer from an engineer to remedy the faults complained of for so much money, performance guaranteed thereafter or no payment demanded? This is done daily by men who have taken only workshop degrees and have no sheepskins to vouch for their knowledge of the business; it is true that these last are not able to make reports couched in scientific terms, and in a great majority of cases do not know what they have done, or why it was done, from a professor's point of view, but the result of their labors frequently is that the coal men find fault with the manufacturer because his orders are reduced. That is an aspect of the case which the most illiterate look upon favorably. There is no intention in these remarks to belittle scientific attainments, or deride them as useless; but I must be permitted to say that the best evidence of the possession of knowledge in any branch of business is that it gives positive results.

At the last meeting of the British Association for the Advancement of Science, Prof. John Perry, president, touched upon the subject mentioned in the caption of this article under the title of "Technical Education," but it deals largely with specific issues and departures in engineering purely. In relation to that stumbling-block to the feet of many, who, while possessing great ability as mechanicians, lack the mathematical faculty, so to call it, Professor Perry said:

"A great reform has begun already in the teaching of mathematics, and it seems probable that at the end of five years no boy of 15 will be compelled to undertake abstract reasoning about things of which he knows nothing. He will be versed in *experimental* mathematics, which he may call mensuration. He will use logarithms, and mere multiplication and division will be a joy to him; and algebra, sines, and cosines will be easy. When I insist that a boy should be able to *compute*, this is the sort of computation that I mean. Five years hence it will be called elementary mathematics. The average boy has hitherto been taught as if he intended to become a Newton or a Laplace. He became stupid and learned nothing. What we really want is only a few fundamental ideas about momentum and the transformation of energy, properties of materials, etc., in order that they may become a part of a student's mental equipment that he uses constantly."

Professor Perry went on to say that "labor-saving rules which are soon forgotten should be displaced by one or two ideas which a man's common sense will enable him to apply to any problem, and which cannot be forgotten; upon this a youth of good mathematical attainments may build a superstructure more elaborate than even Rankine, Maxwell, or Kelvin dreamed to be possible. When a man or boy of any age enters a technical college, how should he be taught? Whether he comes from a good or bad school, we approach his intelligence through the experience he already possesses. This involves that the teacher shall take the point of view of the pupil, instead of the reverse. Give the pupil a choice of many directions in which he may study, and let lectures be of such a character as to show him how to teach himself, both by experiment and by the use of books; except for help and direction when asked for, leave him largely to himself. I much prefer to have classes of students with varied previous experiences, because they are more helpful to one another."

Concerning the value of this, as practically applied, Professor Perry said: "In the Finsbury College there were many machines which could be experimented with occasionally; boys were taught to make drawings in pencil only; also tracings and blue prints that would be respected in the shop, instead of drawing-class drawings, which are not respected anywhere; but the most important part of the course was that of the laboratory, in which every student worked, making quantitative experiments. An offer of a 100-ton testing machine was made to the institute, but refused as nonessential. There is very little value in such a machine; the student thinks of the big machine, instead of the tiny specimen he is testing. Young students loaded wires and beams with actual weights and saw exactly what happened; they experimented with an old screw-jack as to its efficiency under certain loads as intently as if no one had ever made such experiments before. An old fly-wheel, bought from a junk dealer, had kinetic energy imparted to it by means of a falling weight, and occupied the attention of four white-headed directors of an electric company for many weeks. At the end of that time they had a most useful knowledge of the important principles of mechanics.

"Perhaps teachers in the larger colleges will smile upon hearing this called laboratory work. True, it was elementary mechanics; but is not every principle which every engineer constantly needs called elementary by superior persons? I find that these very elementary propositions are quite unknown to many who have passed through elaborate mathematical studies of mechanics. Students found out in that laboratory the worth of formulas, and gained courage to make calculations from them, for they had found out the extent of their own ignorance.

"A great difficulty in all laboratory work is to find demonstrators who are both wise and energetic. Through foolishness and laziness combined, the most perfect systems become unmeaning routine; the smoother it works the less educational it is. In England just now the curse of all education is the small amount of money available for salaries of teachers — just enough to attract mediocre men. I have been told (and I can easily imagine it to be true) that such men have one talent overdeveloped — a talent, namely, for making their job softer and softer, until at length they merely sit at a table, maintaining discipline by their presence, and only answering the questions of such students as are inconsiderate enough to come and worry them. In such cases it is absolutely necessary to derange their clock-work routine, and after an artificial earthquake or two, one is reminded of what occurred at the pool of Bethesda, whose waters had their healing virtues restored after an angel had troubled them. To effect a permanent cure of perfunctory service there should be better salaries paid to obtain better men.

"Mathematics, physics, and chemistry, are usually taught in water-tight compartments, as if they had no connection with one another. This is particularly objectionable in an engineering college. The usual teacher thinks the highest of the very parts of mathematics that are useless to engineers who employ mathematics as a tool of their trade; those parts that would be useful to him he never reaches. Luckily the physics professor has a smattering of engineering, sometimes; at any rate he respects it, but he is apt to teach, as mechanics, the pseudo mathematics which forms 90 per cent. of the alleged theory to be found in so many French and German works upon machinery. As pure mathematical exercise work it is meaner than the stupid exercises in school algebras; and as pretended engineering it does much harm, because a student does not find out its futility until he has gone through it, when his enthusiasm for engineering problems has been permanently injured. But how is a poor mathematical professor who dislikes engineering (feeling, doubtless, like Pegasus harnessed to a grocery wagon) to distinguish good from evil? He fails to see how worthless are some of the books on 'Theoretical Mechanics,' written by mathematical coaches to enable students to pass examination; whereas an engineer teaching mathematics would cut out all that is useless and base his reasoning upon the experience already possessed by the student.

"The average man in future will be highly educated; this means very much more personal attention from thoughtful teachers. Is England prepared to pay for it? If not she must be content to see her average men uneducated. The average man looks askance at college trained engineers, and is, in fact, opposed to them; and I think, on the whole, that he has much justification for his opinions, for university degrees are often conferred upon students who follow courses in which they learn little but how to get past the Board of Examiners. What we should strive for is a system which will suit the British boy and man. The former has been called stupid so often that he is in much danger of becoming so, but we may be sure of one thing, that is, he will find some way to escape from the stupefying kind of school work to which the German boy must submit. We must have a British system of education, but it must be one that will commend itself to employers. Employers must certainly co-operate if they want the real article instead of tyros. Much of the training that is needed is in actual commercial shop work, which cannot be given or obtained in any technical college. [It *is* given, however, in some few American technical institutions.— *Editor* THE LOCOMOTIVE.] In Germany and Japan the great unions of manufacturers give the privilege of a year's work in their shops to polytechnic students; but it seems to me that these men are much too old to learn engineering, and a year of practical work is too short a time if the finished product is to be a valuable man.

"No right thinking engineer has been scared by the newspaper writers who tell us [*i. e.*, the English] of our loss of supremacy in manufactures, but I think we all admit the need of reform in some directions in our present methods, especially in the matter of education. I laugh at the idea that there are any better workmen than ours, but I consider education of them to be the corner-stone of prosperity in all lines of engineering manufacture. New countries like America and Germany (?) have their opportunity now; they are starting without having to scrap any old machines or old ideas, yet they will have their turn, too, and the cost of scrapping will look large in their eyes; but in the mean time they have taught us lessons — the greatest of all lessons — that we must realize that other nations are hungry for our trade, jealous of our supremacy; we may, for a time, lose a little of that supremacy. It is only because we have been too confident that manufactures and commerce and skill in engineering — which Napoleon sneered at — would remain with us forever. Many writers have long pointed out the consequences of neglecting education and the loss of prestige attendant upon it which now alarms newspaper writers. Over and over again attention has been called to the fact that the engineer has created what is called modern civilization, giving luxury to the poor and freedom from drudgery to thousands instead of the few. He is doing far more than this in lifting the yoke of superstition from necks that have bowed under it for ages. The study of natural science is alone able to do this, but until quite recently such study has not been possible for the multitude. I say that to engineers the world owes the possibility of the study of natural science becoming general. In our country, nearly all discoveries come from below. Leaders in science, and inventors, receive from thousands of obscure sources the germs of their greatest developments, and when the people generally become more familiar with natural science, leaders will be not only more numerous, but individually greater. The heart-breaking jeremiads of enthusiasts in education would produce but little effect if it were not for the engineer. He has brought peace. He is turning the brown desert into green pasture, and producing that intense competition among the nations of the earth which compels education." — *The Iron Age.*

## The Foucault Pendulum Experiment.

The Minister of Public Instruction of France, with other high dignitaries, presided, during October, at a repetition of Foucault's pendulum experiment in the Pantheon, at Paris. A pendulum some 218 feet long, making a complete swing in 16 seconds, was suspended from the dome of the Pantheon. The plane of oscillation of such a pendulum changes 360° in thirty-one hours and 41 minutes, in the latitude of Paris, on account of the rotation of the earth. Foucault's original experiment was tried about half a century ago. As the plane of oscillation did change just as it should do on the hypothesis that the earth revolves on its axis once in twenty-four hours, the movement of the pendulum was a proof that the hypothesis is correct — a proof, that is, to every one capable of understanding the mathematical demonstrations involved. To common folk the fact of the rising and setting of the sun and stars is the basis of their faith in the earth's rotation.

The recent repetition of the celebrated experiment was attended by several thousand spectators,— not that they had any doubts as to the time of the earth's revolution on its axis, but to see a most interesting spectacle, and to listen to M. Camille Flammarion's address on the subject. From this address a few sentences are given below. They are of interest from several points of view. After explaining the principles involved M. Flammarion went on to say : " In receiving, by this spectacle, the demonstration of the movement of our own planet, we feel that we are inhabiting one of the earths that have received no special privileges ; that our terrestrial fatherland is but a modest province of the universe; that we are citizens of the sky, just as if we were inhabiting Mars or Sirius ; and that we live in the bosom of the infinite and the eternal. Astronomy gives us the sensation — I was about to say the vertigo — of the infinite. Above religions it places Religion; above human gods it venerates God; it discusses miracles and suppresses superstition; for anthropomorphic and teleologic errors it substitutes determinism, justice, harmony. Contemplations like these free our consciences from ancient servitudes, and proclaim the unattackable independence of thought and the worship of truth, and at the same time make us pity the Lilliputian discords engendered on this minute, revolving anthill of ours. They ennoble our minds by inviting us to live in peace in the fruitful study of the true, in the contemplation of the beautiful, in the practice of the good, in the progressive development of the reason, and in the noble exercise of the higher faculties of the intelligence. It is astronomy that brings us light."— *New York Sun.*

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A NUMBER of correspondents have recently asked us to reply to questions in the theory of probabilities. We don't know whether this means that there is some new kind of a lottery on foot, or whether the recent publication, in cheap and convenient form, of Laplace's essay on the subject has led to a legitimate interest in the questions that are there discussed. At all events, we desire to say to the correspondents in question, and to any others who may have had it in mind to favor us with these same questions (or with others of the same tenor), that we shall shortly reply to them all by publishing an article on the theory of probabilities, which will cover the various points that have been raised.