HARTFORD STEAM BOILER
HARTFORD,
CONN.
INSPECTION AND INSURANCE CO.

With compliments of

J. M. Allen *President.*

The Locomotive.

PUBLISHED BY THE

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.
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The Locomotive.

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Boiler Explosions and Failures from Hidden Defects.

The illustrations that we present this month show a mode of failure of steam boilers that has not received attention commensurate with its importance. We refer to the fracture of the plate along the longitudinal joints, either through the rivet holes as shown in Fig. 1, or parallel and adjacent to them, as in Fig. 2. Of these two

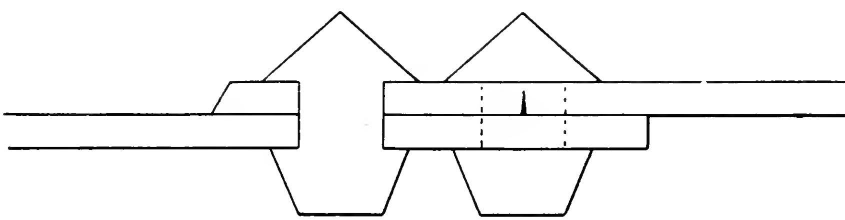

Fig. 1.—A Hidden Crack Passing Through the Rivet Holes.

methods of failure, that shown in Fig. 2 is by far the more common, as a fracture seldom runs from hole to hole, unless the rupture occurs from simple over-pressure, in a sound boiler. The formation of cracks of this kind is by no means uncommon, and in the course of thirty years of experience, with the number of boilers under our charge steadily increasing, until it is now over 62,000, we have had abundant opportunity of studying them.

Figs. 4, 5, and 6 show sections of fractured plates, as cut from boilers at the instance of our inspectors, the cracks in each case being of the kind shown in Fig. 2.

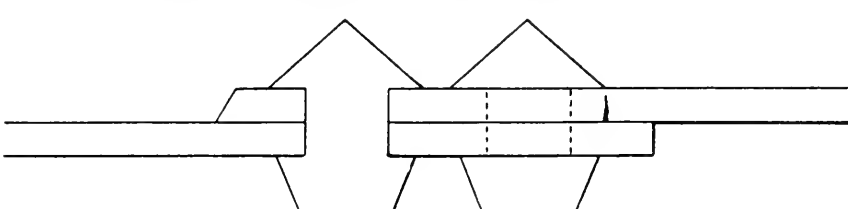

Fig. 2.—A Hidden Crack Under the Outer Edge of the Rivet Heads.

In Figs. 4 and 5 they extended entirely through the plate, and in Fig. 6 the plate was so nearly perforated that it was easily bent back by hand into the shape that is shown. All of these fractures were in that part of the outer plate which is covered up by the "over-lap" of the inner one, and they all started from the *inner* surface of the outside plate, and worked toward the *outer* surface, as indicated in Fig. 2. The difficulty of discovering a crack of this kind is obvious enough, because the crack is entirely out of sight, and as it does not often 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 careful and competent inspector, especially as the joints that

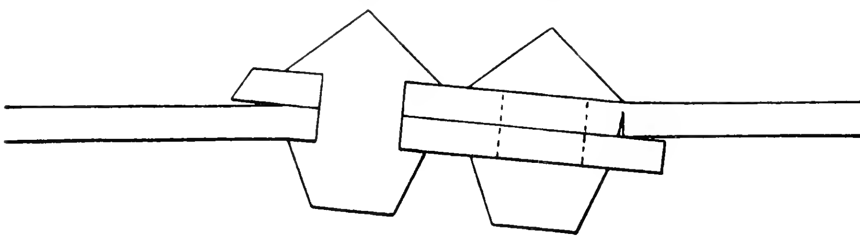

FIG. 3.—ILLUSTRATING THE FLEXURE OF THE PLATE NEAR A LAP-RIVETED JOINT.

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. The dotted lines in Figs. 4, 5, and 6 show where the edge of the inside plate came, in each case.

Numerous explosions have been caused by hidden cracks of this kind, with the most disastrous consequences; and hence it is important to discover their cause, if this be possible, and to take precautions against them. If the plates are hard, or tend

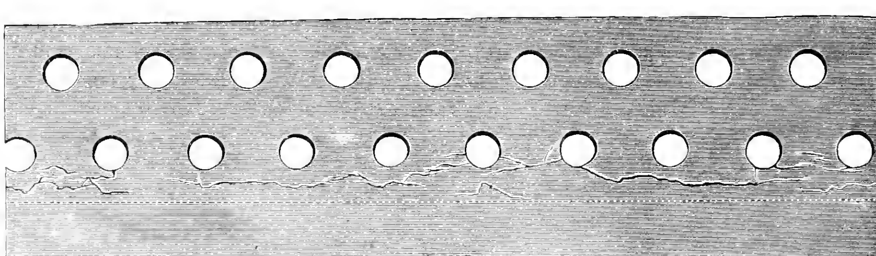

FIG. 4.—A PLATE DESTROYED BY A HIDDEN FRACTURE.

toward 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. Fig. 7 shows the effect of this action, on an exaggerated scale.

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 line lying at, or just beyond, the edge of the rivet heads, as shown in Fig. 2. In the course of time these slight changes of form, when combined with the stress already existing along this line from the cause just described, 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.

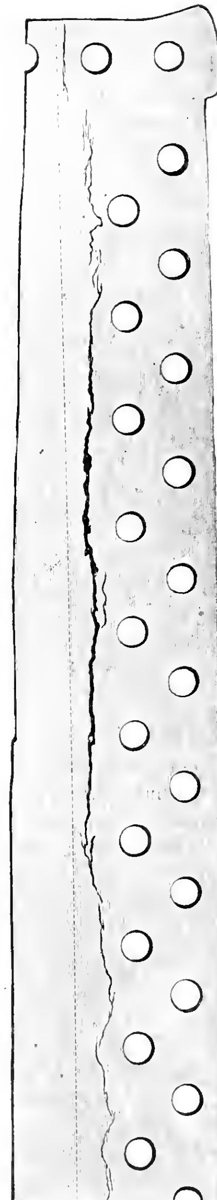

Fig. 5. — Another Case of the Same Sort.

The development of fractures at the joint appears to be confined to the *lap* joint construction, as we have no record of similar failure in joints of the double butt strap type (see The Locomotive for July, 1891, and November, 1896). This is undoubtedly explained by the fact that in this type of joint both of the two causes specified above are reduced to a minimum. Thus it is evident that the wide outside pitch of a triple riveted butt joint does not weaken the plate to anything like the extent that the much closer pitch of the commoner double riveted type does, and hence there is no such marked increase of curvature along this line. Furthermore, the inside strap, in the triple riveted butt strap type, affords so much support to the plate along the rivet-holes that are in *single pitch*, that any considerable amount of bending, under changing temperatures and pressures, can hardly occur at that point. Furthermore, in the lap-riveted joint the two plates do not come in line with each other, and hence the pressure tends to cant the plates up into a shape something like that shown in Fig. 3, so as to bring the line of strain in the two plates as nearly as possible into the same true circle. Every time the pressure in the boiler changes, the angle by which the joint is canted up will vary; and hence there will be a slight but continued bending of the plate back and forth, with the result that a fracture may at any time develop under the edge of the rivet-heads, as indicated in Figs. 2 and 3. In the butt joint this source of weakness is entirely avoided, because the plates come fairly in line with each other, and a change in pressure does not produce any change whatever in the form or position of the joint.

The defect described in this article is possible in all types of boilers that have riveted shells and lap joints. If the plates are thick, and the shells are of small diameter, the liability of flattened joints is increased, and the tendency to distortion in the way shown in Fig. 3 is also increased; so that the remedy is not to be sought in this direction. The best precaution is, for the steam-user to have his boilers constructed of the best material, with butt strap joints, and all holes drilled with the sheets in place: and to see that in building them the best modern appliances are used, for forming the work without leaving local stresses in the plates.

It has been said, occasionally, that we have made riveted joints a sort of hobby, and that we are far too particular about them. That is not the case. We do not give this feature of boiler construction any more attention than it deserves; and if we seem to say a good deal about it, the reason is that our experience with the innumerable boilers that have come under our notice shows that information of this kind is badly needed. Realizing the necessity of improving existing practice in this respect, the President of this company has given much attention to the construction of riveted joints, and early advocated the use of the butt-strap type, especially for high pressures. Many experimental joints have been riveted up under his direction, and submitted to destructive tests for the purpose of comparing their actual strength with the strength as given by computation. The way in which various forms of joint give way in actual practice has also received attention, and is taken into account, so far as possible, in the joints that we design. The defect pointed out in this article is no new thing, but has been observed from time to time almost as long as the company has been doing business. In the early days of our work we were called upon to investigate the cause of failure of a locomotive boiler, and as the trouble was found to be of the sort here described, it was thought best to examine other boilers of the same general type and age, and to remove a section of the joint along one course of plates. These were found to be cracked, as shown in Figs. 4, 5, and 6, along almost the entire length of the joint,

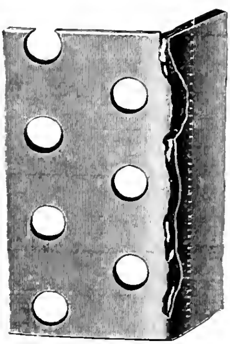

FIG. 6.—A PLATE ALMOST PERFORATED BY A CONCEALED CRACK.

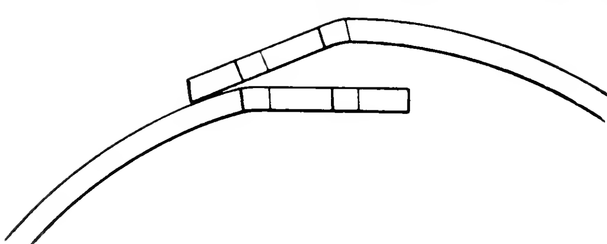

FIG. 7.—SHOWING THE ACTION OF THE ROLLS (EXAGGERATED).

and for more than two-thirds of the thickness of the plate, in some places. Other cases followed, and a strap was finally put on over all the longitudinal joints of the boilers that were similar in construction, and exposed to a high pressure, so as to form what is known as a welt joint. No further failures occurred in these boilers after the welts were added, and in building new ones the form of joint was changed.

The hidden crack is by no means peculiar to American practice. Thus Mr. Lavington E. Fletcher, of the Manchester Steam Users Association, England, at a meeting of the Institution of Mechanical Engineers, at which riveted joints for boiler construction were discussed, said that he had lately had three locomotive boiler explosions brought to his notice, in which the primary rent had occurred just at the edge of the inner lap, along one of the longitudinal joints of the barrel of the boiler, although the plates were of the best quality, and the boilers were built by first-class makers. Engineers were familiar, he said, with the ordinary groove, from which a number of locomotive boilers had exploded; but in this case there was no true groove, but only a fine hair-like crack lurking under the edge of the overlap. To get at the bottom of the matter, he cut up the boiler of a sister engine that had not failed, and upon taking the plates out, and bending back the overlap, they were found to be cracked almost through to the skin in some places, although the crack was so fine that it might easily have escaped detection. He recommended that the longitudinal joints in locomotive barrels be made with double butt straps, so that the boiler might be truly cylindrical, and changes of shape under varying pressures be avoided.

In a discussion on riveted joints, as reported in the *Minutes* of the same society for 1881, Mr. Jeremiah Head spoke of the dangers incident to rolling plates after the holes are punched. His argument is very similar to that advanced above, and conforms with our own experience. The danger of forming a sharp bend along a row of holes is greater in a double-riveted lap joint than in a single-riveted one, and still greater yet in the triple-riveted lap form. "If there were three rows of holes," said Mr. Head, "the third row gave a great additional leverage for the rolls to act with; and certainly the plate would prefer to bend at that row, rather than to bend equally throughout the part between the rolls. He had frequently seen in boiler-makers' works about the country . . . that if the plates were double-riveted, and bent cold after punching, there was a sharp bend to be observed in both plates along the inside row of rivets, which was certainly very bad. In such a case, where a boiler-maker supposed he was getting extra strength by a double row of rivets, he was really making that part a very weak place in the boiler. But that was not the whole question. The effect of bending after punching was to suddenly increase the curvature at each line of rivets; and when the plate came to be brought round with a circle for a small boiler, it was evident that the two ends would come into the position shown (on an exaggerated scale, of course,) in Fig 7. Then, since this joint had to be riveted together, the edges had to be knocked back by some means or other, and very likely in a country shop that would be done very roughly. He thought engineers ought not to forget that weak point."

Many years ago the great Russian chemist, Mendeleieff, said that he could not understand the immense localization of petroleum at Baku and elsewhere, unless it is being continually formed by the decomposition of carbides. The recent work of Moissan and others with the electric furnace gives this view a special interest. For example, it is found that at high temperatures carbon will combine directly with lime, producing the substance called carbide of calcium; and this, in turn, will unite with water or steam to form acetylene gas. Acetylene, when heated, becomes changed to benzene, which is the basis of a vast multitude of oily compounds. Mendeleieff's shrewd guess may therefore be correct, and petroleum may be in process of continuous formation, either in this way or in some similar one, deep in the earth, under the influence of the subterranean heat.

Inspectors' Report.

OCTOBER, 1896.

During this month our inspectors made 10,108 inspection trips, visited 20,295 boilers, inspected 6,572 both internally and externally, and subjected 815 to hydrostatic pressure. The whole number of defects reported reached 11,188, of which 926 were considered dangerous; 40 boilers were regarded unsafe for further use. Our usual summary is given below :

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	923	33
Cases of incrustation and scale,	1,951	46
Cases of internal grooving,	75	3
Cases of internal corrosion,	663	35
Cases of external corrosion,	778	48
Broken and loose braces and stays,	196	27
Settings defective,	295	40
Furnaces out of shape,	425	17
Fractured plates,	284	32
Burned plates,	228	20
Blistered plates,	231	2
Cases of defective riveting,	1,157	44
Defective heads,	121	32
Serious leakage around tube ends,	1,934	356
Serious leakage at seams,	424	18
Defective water gauges,	378	47
Defective blow-offs,	194	44
Cases of deficiency of water,	39	10
Safety-valves overloaded,	117	26
Safety-valves defective in construction,	198	19
Pressure gauges defective,	449	18
Boilers without pressure gauges,	2	2
Unclassified defects,	126	7
Total,	11,188	926

ONE of the new things seen in machine shops is a twist drill that is provided with small tubes passing down the body of the tool from shank to point. Oil is forced into these at the shank end, and by its escape at the bottom of the hole it lubricates the cutting edges of the drill far better than is possible by the older method of squirting the oil into the hole from an oil can. A minor advantage of the tool is, that the oil as it flows outward through the hole assists in the removal of the chips or borings.

WIRED glass, which is merely ordinary rough glass containing a netting of wire, is growing in favor among mill owners, although the operatives object to its use in windows, because it obstructs the view. Its value consists in its resistance to fire, as it remains in place under conditions that would destroy ordinary glass, and make every window a source of oxygen to feed the flames. The wired glass cracks when exposed to heat, but the wires hold the fragments in place, and the whole mass soon softens and melts together again.

Boiler Explosions.

October, 1896.

(256.) — A boiler exploded on October 2d, in Gilbert Bell's mill, at Hillsdale, N. J. One side of the building was blown out, but nobody was hurt.

(257.) — A boiler in Nelson Mills' mill at Novesta, near Kingston, Mich., exploded on October 2d, instantly killing Jeremiah Lewis and Nelson Mills, the proprietor. Ezra Scribner died within two hours, and Ezra Day was injured so badly that he died on October 6th. The mill was completely wrecked.

(258.) — On October 3d, a boiler exploded in a grist mill at Baddertown, a little hamlet near Merlin, in Kent county, Ontario. Solomon Gray was killed, and George Peters was injured. The mill was destroyed.

(259.) — A. F. Lively's mill at Staples, Minn., was destroyed by fire on October 4th, and during the course of the fire the boiler exploded.

(260.) — On October 4th, the boiler of a locomotive attached to a passenger train on the Santa Fe railway, exploded about two miles north of Osage City, Kan. The train, which was in motion, was wrecked. George Strunk, Henry Hollister, William McAdams, Arthur Smith, and two other men whose names are not known, were killed, and William Beckler, a passenger on the train, was temporarily deranged by the disaster, so that he took his own life with a revolver. M. Purcell, J. B. Stone, H. S. Fowler, W. F. Evans, F. A. Tiffany, Mrs. Edna Maxwell, Wilford Burns, and James Coleman, were injured. The explosion was so violent that many believed it to be due to dynamite on the track; but the officials deny this rumor, and admit that it was a boiler explosion, pure and simple.

(261.) — A boiler in Johnson Bros'. mill, near Frostburg, Md., exploded on October 5th, killing Frank Boettner and Charles Winebrenner. The building in which the boiler stood was entirely destroyed.

(262.) — A boiler exploded, on October 5th, in Joseph Bowens' saw-mill, on Carr's Fork, Knott county, near Whitesburg, Ky. Mr. Bowens was fatally hurt, and died shortly afterwards. Another man, whose name we have not learned, was also seriously injured.

(263.) — On October 6th, a boiler exploded on the tug boat *Peter D. Herfhey*, at Watervliet, near Albany, N. Y. The pilot and engineer, who were the only persons on board at the time, were asleep in the stern of the boat, and were not injured. The *Herfhey* was running in opposition to another line of tug boats, and our account states that "the pilot and engineer say that they are confident that some one tampered with the boiler" while they were asleep. This is not in the least likely. Reports of this kind, when investigated, almost invariably prove to be mare's eggs.

(264.) — The boiler of locomotive No. 68, on the N. Y., N. H. & H. railway, exploded, on October 7th, at Meriden, Conn. Engineer Webber and Fireman Bates were slightly injured. The locomotive was badly damaged, and the ground was littered with wreckage. Many pieces of the boiler were hurled several hundred yards, and several buildings were more or less damaged. Eight years ago the boiler of this same locomotive burst near Wallingford, Conn.

(265.) — On October 8th a boiler exploded in the rolling mill of the Reading Iron

Works, at Danville, Pa. John Casselman, Johnson Lovett, Thomas Cromwell, Oliver Cromwell, John Mullen, Sr., and John Mullen, Jr., were killed, and so also was Mary Barron, an infant daughter of Margaret Barron. Among the injured were Clinton Major, Comly Young, Charles Woll, George Lunger, Robert McVeigh, Thomas Miller, Thomas Evans, Jonathan George, Charles Ranier, Robert A. Ried, Rush Yerrick, William Gerringer, George Nevins, Daniel Marks, James Connely, Sr., A. L. Brandt, Joseph Sheppard, W. H. Barnhart, Richard Sheppard, Frank Lehman, Thomas Williams, Henry Mayer, and Margaret Barron. Others, whose names could not be learned, were also injured to a greater or lesser degree. A considerable amount of damage was done to surrounding property. A boiler exploded on the same spot on October 7, 1854, so that the present explosion occurred almost precisely on the forty-second anniversary of the earlier one.

(266.) — A boiler exploded, on October 8th, in William Besch's feed mill, at Buckman, a village 15 miles east of Royalton, Minn. The proprietor was instantly killed, and Theodore Carl died in the course of the day. Peter Oestreicher and his wife, and Jacob Huhn, were also seriously injured, and may not recover.

(267.) — On October 9th a boiler exploded in Edward Ehl's mill, near Sanford, Midland county, Mich. John Brown, the engineer, was instantly killed, and the mill was totally wrecked.

(268.) — A boiler belonging to W. C. Rose, of Lakeside, some sixteen miles southwest of Fort Scott, Kan., exploded on October 15th, doing considerable damage. Nobody was seriously injured.

(269.) — A tube failed, on October 15th, in one of the boilers of the Pacific Mail steamer *San José*, shortly after she had left San Francisco. B. Molloy and John McMurray were painfully scalded. McMurray remained on the *San José*, but Molloy was brought back to San Francisco by the steamer *Acapulco*, of the same line.

(270.) — The Central Georgia Land and Lumber company's mill, at Sibley, Ga., was entirely destroyed, on October 17th, by a boiler explosion. George Collins was killed, Alexander Farmer had both of his legs broken, and several other employes, whose names we have not learned, were painfully injured.

(271.) — The boiler of a threshing machine belonging to Ryall Bros., of Larimore, N. D., exploded on October 18th. John Ryall was seriously injured by a flying fragment of iron. He is likely to die.

(272.) — A boiler exploded on October 20th, at Harrietsville, near Caldwell, Ohio. The engineer, Simon Spangler, was injured so badly that he died shortly afterward.

(273.) — On October 22d a boiler exploded in a mill at Summersville, W. Va. Francis Wiley, owner of the mill, and Bartholomew Fitzwater and William Axline, were instantly killed, and Clement Furr, Peter Turner, and Frank Axline were seriously injured. It is doubtful if Mr. Furr can live. The mill was destroyed.

(274.) — The boiler of the tug boat *William Horre*, which lay at the foot of Smith street, South Brooklyn, N. Y., exploded on October 23d. Alonzo Lewis, owner of the tug, was aboard at the time, and was killed. John Buckley and Patrick Buckley were blown into the water, but were speedily rescued. The tug was destroyed, and the coal-boat *Vim* was sunk. The barges *M. C. Williams* and *Nellie Williams* were also badly damaged. Pieces of the tug were found half a mile from the pier.

(275.) — A boiler exploded, on October 26th, in Mullen & Snider's mill at Loveland, Ohio. Robert Mullen, the senior member of the firm, was fatally injured. His partner, Joseph Snider, and Joseph Schuyler, a workman, were also injured in a lesser degree. The machinery in the mill was badly wrecked, and much damage was done to the building.

(276.) — On October 26th a large saw-mill was wrecked at Westminster, near Lima, Ohio, by the explosion of a boiler. Two men were injured, and five others, who were in the building at the time, were fortunate enough to escape unharmed.

(277.) — The boiler of a threshing machine belonging to Charles Maash, of Wood Lake, Minn., exploded on October 26th. Engineer Frank Maash was hurt badly.

(278.) — A boiler belonging to Thomas Lutz, Sr., exploded, on October 27th, at Washington, near Mansfield, Ohio. George Anderson was instantly killed, and Thomas Lutz, Jr., was fatally scalded.

(279.) — On October 29th a boiler exploded in Atdens & Kennedy's mill, in Chesterfield county, Va. One man was scalded. The machinery in the mill was ruined, and it is said that the dome of the boiler was blown a distance of one mile.

Scientific knowledge is advancing so rapidly, that a comprehensive catalogue of current scientific literature is greatly needed by every professional man who wishes to know what is going on. An international committee, appointed for the purpose, has now arranged for the publication of a catalogue of this sort, to begin with the year 1900. It is to be edited by a central bureau in London, and will include every original paper on pure science, whether published in a periodical, in the transactions of a society, or in book form. Applied science, however, will be excluded, because the undertaking is sufficiently vast without it.

The iron process of purifying water, which is simple, cheap, and effective, is now in successful operation in various cities of Holland, France, Italy, Turkey, and India. The apparatus consists of a horizontal cylinder, partly filled with scraps of iron, which revolves slowly on its axis while the water passes through it from end to end. By this means the iron is brought in contact with every particle of the water, and effectively destroys whatever organic matter it contains. An ordinary sand filter is used to remove the matter precipitated by the iron. Tests made upon water treated in this way are said to prove that more than 99 per cent. of the microbes present are killed.

A recent contribution to the now voluminous literature of X-rays tells of a case in which an attempt was made to locate a bullet in a man's head. The experiment was successful, but within twenty-four hours the hair all fell out from those parts of the head that had been directly exposed to the rays, and a painful ulceration followed. Effects of this kind are now well substantiated, and an exposure of two or three hours is sufficient to render the skin parched and "sun-burned," to cause the hair to fall out as described above, and to kill the nails. The hair will grow again, however, and new nails are also formed. These effects are probably not caused by the X-rays themselves, but are more likely to be due to the direct inductive action of the high-tension electric currents used to operate the Crookes's tube.

The Locomotive.

HARTFORD, JANUARY 15, 1897.

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

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

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

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

THE Sächsisch-Thüringischer Steam Boiler Inspection Association announces the death on October 7th, of Herr Krug, Director-General of the association, and one of its original members and founders.

THE Index and Title page for the volume of THE LOCOMOTIVE that was completed with our last issue, are now ready, and will be sent, upon application, to those who wish to preserve their copies for reference. Bound volumes for the year 1896 will also be ready shortly, and may be had at the usual price of one dollar each.

WE desire to acknowledge the *Annual Report*, for 1896, of the Chief of the Bureau of Steam Engineering of the U. S. Navy. The personnel of the navy has been the subject of much recent discussion, and we note with satisfaction the following reference to it on page 16 of this *Report*: "I feel that it is only necessary to direct your attention to the number of engineer officers who have been retired during the past year for physical incapacity, and to the steadily increasing number of such officers on the retired list, to demonstrate that the physical strain to which the officers of the Engineer Corps are subjected is too great. In former annual reports I have given what I believe to be abundant reasons for an increase in the number of officers of the corps. As time goes on, and the number of ships and their power increase, the necessity for additional officers is intensified, and I feel that I should not be doing my duty if I did not again briefly refer to the matter. The personal element is one which must enter largely into the result of any naval engagement, and if we had the most powerful and the swiftest fleet afloat, it would be valueless to us in time of war if we have not a sufficient number of trained men to see that the machinery of this fleet is in condition for action, and to keep it going in action. The guns will be powerless without the machinery, and, other things being equal, that fleet will give the best account of itself which has the best equipment of trained men in the engine room as well as at the guns. To sacrifice the one is merely inviting disaster to the whole, and no amount of skill on deck can compensate for the lack of it below. It is one thing to design and build machinery, but quite a different thing to keep it in such condition that it may be ready to respond to the calls that may be made upon it under all conditions, and naval machinery is of such a character that it is only by the exercise of constant vigilance and the greatest care that it can be expected to be kept in readiness for such calls. If the number of trained men is not sufficient for this purpose, the efficiency of the ship as a whole is lowered, and the money which has been expended on her construction to produce the very qualities which were considered of paramount importance has been practically wasted."

Loch Katrine, and Corrosion from Pure Water.

To the Editor of THE LOCOMOTIVE.

Sir:—A friend having sent me a few copies of THE LOCOMOTIVE, I have been a good deal interested and instructed thereby. Your issue of last June contains a specially interesting article on the "Corrosive Action of Pure Water." The general conclusions you arrive at I can from experience fully endorse. Your specific reference to Glasgow water, however, is far from accurate. Any one reading it would expect to find boilers here generally badly corroded inside, which is not the case. Apparently you have been misled by the book you refer to. Having been a resident boiler inspector in Glasgow for over six years, I can speak authoritatively from experience of Loch Katrine water. Better water for boilers I never met with. When boilers are regularly worked, under usual conditions, I never yet found it cause even the slightest corrosion; and after working for from six to twelve months regularly, if simply washed out the boilers are as clean as ever. When boilers are worked intermittently, or at low temperatures (say under 220° Fahrenheit), pitting, especially on small tubes, is very common. Tubular boilers worked intermittently generally require to be re-tubed every few years; shell-plates also get pitted, but it is rarely that that is serious. When the feed-water is heated, the pipes also waste rapidly. The water formerly used was taken from the river Clyde, before it got seriously polluted with sewage. Clyde water leaves a good deal of soft scale in boilers, which is not difficult to remove. It is a very good water. In the tidal portion of Glasgow the Clyde water is very polluted, and so leaves a lot of dirt behind; but higher up, where the water was formerly all taken, this is not the case.

As you apparently endeavor to get as accurate information as you can, I thought this would be of service to you, as a return for the information supplied by your paper.

Yours faithfully,

A BOILER INSPECTOR.

GLASGOW, SCOTLAND,
November 24, 1896.

[We print the foregoing letter with pleasure, and extend our thanks to our correspondent for the facts he presents. Our reference, in the June issue of THE LOCOMOTIVE, to the water of Loch Katrine was merely by way of illustration of the action that we had found pure waters to have, in this country, under suitable conditions. Rowan's remarks were quoted because they confirmed our own experience, and because we had found him, in other matters, to be a conservative and careful authority. The change in the water supply of Glasgow, from the Clyde water to that of Loch Katrine, was made, if we remember rightly, in 1859. At that time the high pressures and correspondingly high temperatures that now prevail in boilers were by no means so common. The necessity of providing good circulation in all parts of the boiler was also only partially understood. Now the conditions under which pure waters are most troublesome are (1) when the temperature is not widely different from the atmospheric boiling point, and (2) when the boilers have poor circulation in some of their parts, or when they are occasionally allowed to stand idle, so that the circulation entirely stops. We judge from our correspondent's letter that he is prepared to admit that Loch Katrine water does behave as we represented, when these conditions are fulfilled; and hence we cannot see in what respect his testimony impeaches that given by Rowan. From what he says concerning the necessity of renewing tubes in certain classes of boilers, we even regard his experience as confirmatory of our own. Pure water is certainly not like St. George's dragon, which ate up stones and old iron and whatever came in its way. Its injurious effects are manifested only when the conditions are right; and it is rare to find a case of corrosion or pitting from this cause in a boiler which is run at a high temperature, which is never left idle, and whose contents are always and everywhere in active circulation.— EDITOR.

Iron Stacks, and the Corrosive Action of Pure Water.

A correspondent who has had some experience with the destructive effects of very pure water writes as follows:

"We notice, with much interest, your article in the June LOCOMOTIVE in regard to the corrosive action of pure water. We are to-day putting in a flue, for the fourth time within one year, in a new boiler in our plant. These tubes pit and blister along the top, over their entire length; the action being worst near the center, where holes are soon eaten through. We are using city water, which is considered to be very soft and pure. This action is most marked in the new boiler. We have one tubular boiler which has been in use for about twenty-six years on the same water, and which has never had the tubes renewed. We have often thought that there is a great deal of difference in the iron or steel plate itself, as some of it seems to invite corrosion or pitting, both in boiler tubes and shells, and in smoke stacks. Some stacks, for example, do not seem to have half the wearing capacity that others show under what appear to be similar conditions. We do not entirely approve of the usual practice in building stacks, which is, to put the lightest iron at the top. Our experience has been that a stack with the same thickness the whole length will give out at the top first, and that the bottom third will often outwear two tops."

A Retrospect of the Year 1896.

The most notable event during the year 1896 in the field of engineering, was the opening of the river Danube to navigation. This event formed part of the millennial festivities in Hungary, and, as such, took rank with the great exposition at Buda-Pesth. The undertaking was intrusted to Hungary by the treaty of Berlin, 1878, and work was commenced in 1890, and completed on the last day of 1895. The blasting operations covered a distance of sixty miles. Nine thousand workmen were continuously employed, and the total cost was $10,000,000. The canal now affords an unobstructed outlet from Vienna to the sea for boats drawing ten feet of water. The Chicago Drainage Canal is being pushed with commendable energy. Apart from its magnitude, this work is remarkable for the magnificent excavating machinery which it has called into existence, and the novel methods of handling material which are employed. The preliminary operations connected with the great Simplon Tunnel through the Alps are under way, and the fact that this monumental work is being undertaken conjointly by the Italian and Swiss governments is a pledge of its vigorous prosecution. In this country we have seen the completion of the great dry dock at Port Orchard, 675 feet long, and a similar structure at the Brooklyn Navy Yard, with a length of 670 feet, is within measurable distance of completion. Work has been commenced during the year on the new East River Suspension bridge, New York. This structure will rank as the second longest railroad span in the world, the clear length between towers being 1,600 feet. It will carry six lines of railroad track, two roadways, and two footwalks, and will in every way, except that of beauty, eclipse the existing New York and Brooklyn bridge. Mention should also be made of the completion of the great Cascade Locks on the Columbia river, Oregon, whereby a vast area of the interior of the state is opened up to river navigation.

Electric traction has continued to make steady progress during the year. Its ultimate application to the trunk railroads has been brought a step nearer by the excellent results obtained during the year on the Nantasket branch of the New Haven road, which have been so good that the company has determined to lay a third rail on other branches of its system. The year has seen the opening of the Buda-Pesth electric underground road in Europe, and in this country the Boston Electrical Subway has progressed favorably. The Snæfell Mountain Railway in the Isle of Man has scored a brilliant success for electric traction, in sharp contrast to its unfortunate contemporary across the channel in North Wales, the Mount Snowdon steam rack railway. Much interest attaches to the line opened this year at Lugano, Switzerland, where the three-phase system receives its first application to traction. The cars carry a double trolley, and the rails are utilized as one conductor.

Compressed air, notwithstanding the loss of power inseparable from its compression and expansion, has come to the front this year, especially in this country, where the Hardie and Hoadley patents for railway motors have been extensively tested on the streets of New York city. Both of these attempt to overcome the loss by a system of heating the air previous to its admission to the cylinders. The Hardie motor has given such satisfaction that it is shortly to be applied experimentally to the elevated railroads in this city. Compressed air has also undergone a successful test on the United States monitor *Terror*, where it is applied to the manipulation of the turrets.

The motor car, or horseless carriage, has attracted more attention this year than any other device in the field of mechanical engineering, always, of course, excepting the bicycle. The record of the year proves that the motor car has come to stay, and gives cause to believe that it will enjoy a popularity second only to that of the bicycle itself, and a commercial utility far greater. The greatest performance of the year was that of the winning machine in the Paris-Marseilles race, which covered 1,073 miles at an average speed of over 15 miles per hour. In this country we have had the Cosmopolitan race on Decoration Day, and the track race at the Providence State Fair. At present the oil motors are in almost undisputed possession of the field; but there is every reason to expect that when the steam engineers have had time to develop a suitable form of engine and boiler, this supremacy will be disputed.

The bicycle still continues to enjoy an enormous popularity. It has undergone little or no organic change this year in its construction; the diamond frame, chain-driven machine continuing to be the practically universal type. The weight of the average machine remains at about 23 pounds.

The close of the year 1896 sees no abatement in the craze for naval shipbuilding, which has taken possession of the nations. England, France, and Russia continue to make enormous expenditures on their fleets, and Germany, on a smaller scale, is maintaining her activity of the last few years. Speaking generally of the designs, there is a tendency to sacrifice armor to armament and speed. This is very noticeable in the latest battleships of the English navy, known as the new *Renown* class, which, with a displacement of nearly 13,000 tons, will have only eight inches of armor on the sides, six inches on the bulkheads, and ten inches on the turrets. On the other hand, they will carry nearly 2,000 tons of coal, and steam about nineteen knots. It will thus be seen that the dividing line between battleship and armored cruiser is gradually disappearing. One of the most sensational events of the year was the speed attained by the torpedo boat destroyers *Desperate*, of the British navy, and *Forban*, of the French navy, both of which exceeded thirty-one knots an hour. The naval progress of the United States during the past year has been altogether unprecedented. The most notable fact is the completion of that powerful trio of battleships, the *Indiana*, *Massachusetts*, and *Oregon*, which are universally conceded to be the most powerful fighting machines afloat. Each of them considerably exceeded the contract speed at its trial, the *Oregon* touching seventeen knots an hour. The *Brooklyn* was nearly two knots ahead of its trial speed of twenty knots, and this vessel also enjoys the distinction of being the most effective ship of her class yet constructed. The monitors *Monadnock* and *Terror*, the ram *Katahdin*, and the torpedo boat *Ericsson* have also been accepted. In naval strength, the United States have now moved up to sixth place, and they will eventually be ahead of Germany on the list, if the present activity continues.

The year closes with the Harveyized reforged nickel steel plate and the compressed fluid steel solid shot of American manufacture still in the lead.

In the merchant marine it is gratifying to record that the American liner *St. Paul* has captured the record from Southampton to New York, her time on two successive trips being 6 days, 2 hours, and 24 minutes, and 6 days and 31 minutes, her speed on the latter trip being 21.08 knots per hour. This result from a ship which was designed for only 20 knots, is a distinct tribute to the skill of the shipbuilders. Mention must be made in this connection of the placing of orders by the Japanese government with the Messrs. Cramp, and with the Union Iron Works, for two fast cruisers. It is the first event of its kind, and full of promise for the future. Speaking generally, there has been a tendency the past year to build cargo steamers of unprecedented size, huge carrying capacity, and moderate speed, the *Pennsylvania*, the next largest ship to the *Great Eastern*, and rivaling her in size, being a case in point. The German yards have two vessels in hand for the Atlantic mail service, which are to surpass the *Lucania*, the *Frederick the Great* being 20 feet longer on the water-line, and several hundred tons greater in displacement. The world is watching curiously for the trial trip of the Bazin roller ship.

The geographical world has welcomed home this year from Arctic exploration Dr. Nansen, who failed to drift across the North Pole, but penetrated to latitude 86 degrees 14 minutes, which is 2 degrees and 50 minutes further north than ever before attained. The Jackson-Harmsworth expedition has mapped out an extensive area of Franz Josef Land, and Lieutenant Peary has returned safely from his annual Arctic trip. The voyage of Mr. Borchgrevink to Antarctic regions, and his earnest representations, are likely to result in one or more well equipped expeditions.

Archæology has reaped a rich harvest as the result of the year's explorations. M. De Morgan's discoveries at Dashur in Egypt, the excavations of Dr. Richardson in Corinth and Herr Dorpfeld at Athens, the finding of Trajan's Ship of State in Lake Nemi, and lastly the splendid results of American investigation in Babylonia are only some of the operations of a particularly successful year.

The field of aeronautics is poorer by the loss of Lilienthal, who died a martyr's death, the victim of his devotion to science. The most remarkable performances of the year have been those of Prof. Langley's aerodome, which, carrying its own fuel and water, has soared and returned to earth, and also flown 1,500 yards in a horizontal direction, without losing its equilibrium or receiving any damage. The feat of human flight has been successfully accomplished for varying distances by inventors who have followed in the steps of Lilienthal, who was the first to accomplish it successfully. Experiments in kite-flying have been industriously prosecuted at the Blue Hills Observatory, Boston, and this quondam pastime is likely to be turned to good meteorological account.

By far the most dramatic event in the world of science occurred when the year was yet but a few days old. On January 4th, at the celebration of the semi-centennial of the founding of the Berlin Physical Society, Prof. Roentgen announced his discovery of what are now universally known as the X-rays. A certain form of vacuum tube was shown to be capable of giving out rays which could penetrate opaque substances, and the public incredulity was quickly dissipated when X-ray photographs began to fill the columns of the illustrated press. Following close upon the announcement came the fluoroscope, which enabled the effect of the rays to be seen directly by the eye. If no other event than this one had to be chronicled, the year just closed would stand out as one of the most famous in the history of science. — (Condensed from the *Scientific American.*)

A TERRIBLE accident occurred on the Australian steamer *Wendouree* about July 20th, A boiler flue collapsed, and the steam and boiling water that rushed out of the break cut off the escape of three men who were working in another boiler, across the gangway. Two of the men, James Sinclair and Arthur Pilsborough, were scalded to death, and the third man, Donald Carmichael, was frightfully burned.— One of the boilers of the Merced Gold Mining Co., at Coultersville, Cal., was shut down, on July 28th, to be cleaned and inspected. William Goldsworthy, an employe, went into the boiler, and while there the valve connecting the boiler with the rest of the battery was partially opened in some way. He was severely scalded on the arms, legs, and breast, before he could make his escape, but his injuries fortunately did not prove fatal.— Two explosions occurred, on September 30th, in the Indianapolis Brewing Co.'s plant, at Indianapolis, Ind. The first was due to a leaking valve on one of the ammonia pipes. We have not learned the nature of the second one, which occurred shortly afterward, but we understand that it was of sufficient force to shatter the building and to tear doors from their hinges, blocks away. Sixteen men were injured.— One of the boilers of J. S. Thorn & Co.'s architectural and sheet metal works, in Philadelphia, met with a peculiar accident on October 19th. The boiler had recently been cleaned, and on the day of the explosion Engineer John Herwin filled it and started a fire under it. The explosion occurred a short time afterwards, and Herwin was found to be badly burned. The accident does not appear to have been due to steam, but it is suggested that the engineer may have used kerosene or benzine or some other inflammable substance, in cleaning the boiler, and that the vapors generated from this had in some way taken fire with explosive violence.— A steam pipe bursted in a laundry at Woburn, Mass., on December 12th. The girls who work there were badly frightened, but nobody was injured.— A twelve-inch steam main gave way in the basement of the Savoy hotel, in New York, on December 18th, by the stripping of a thread. Michael Burns received injuries from which he is likely to die, and James McGrath was scalded painfully but not fatally.— An explosion occurred on December 30th in the kitchen of the home of Chief of Police Pilon, of Great Barrington, Mass. Pots and kettles were scattered about the room, and one of the stove lids was blown through the ceiling. Our account says that "a short piece of pipe with a thread on each end was found in the firebox, and it is supposed that some person who had a grievance against the Chief, or his family, were seeking revenge;" but we think it is far more likely that the trouble was that the water-front of the range exploded from over-pressure, and that the mysterious piece of pipe was merely a nipple that belonged somewhere about the piping.

The Locomotive.

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Collapse of a Pair of Corrugated Furnaces.

Our illustrations, this month, represent an accident which recently occurred on the Pacific Coast, and which has several instructive features. It shows, for example, the wonderful amount of deformation that a well-made corrugated furnace can undergo, without leading to a disastrous explosion; and it also conveys the useful lesson that un-

FIG. 1.— COLLAPSED FURNACE OF THE "CITY OF EVERETT."

necessary complications in valves and piping should be carefully avoided, since they are almost sure to result in trouble. at some time or other.

The accident in question took place in one of the four compound marine boilers of the whale-back steamer *City of Everett*, which is used as a freight steamer in the coasting trade between San Diego, Cal., and British Columbia. The *City of Everett* was built of steel in 1894, at Everett, Wash., and is 346 ft. in length, 42 ft. 8 in. in breadth, and 13 ft. 7 in. in depth. She has four compound marine boilers, each 132 inches in diameter and 11 ft. long. The shells are of steel, 0.938 of an inch thick, and of 60,000 pounds tensile strength; and the pressure allowed by the government inspector is 168 pounds per square inch.

Each of the four boilers has two corrugated steel furnaces, 40 in. in diameter and 8 ft. 6 in. long. The furnace shown in Fig. 1, is from the forward starboard boiler, both furnaces of which were burned and bulged down by blowing the water out of the boiler while there was a fire in each of them.

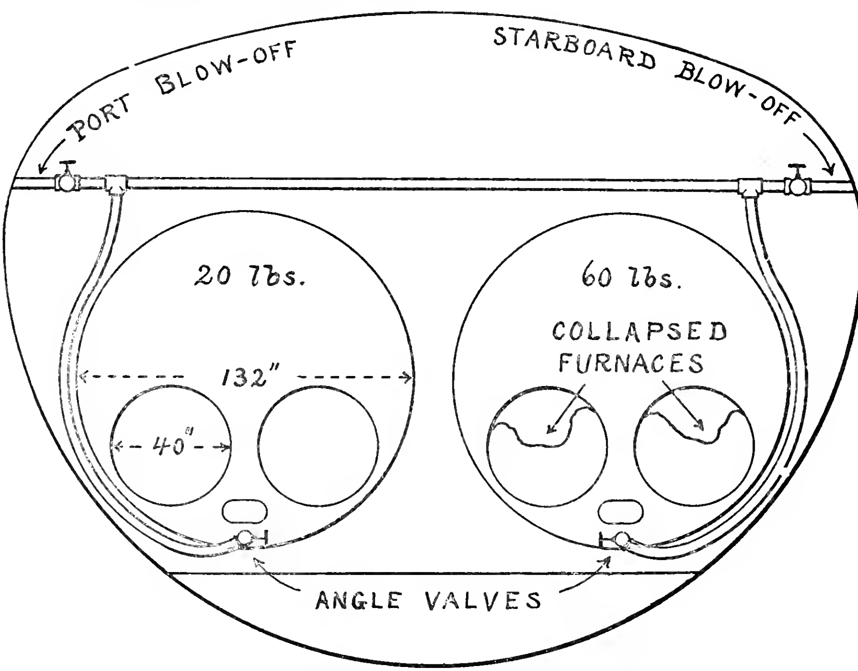

FIG. 2.—CROSS-SECTION OF THE "CITY OF EVERETT," SHOWING THE BLOW-OFF PIPES.

The blow-off pipes from the four boilers are connected into cross, or thwart-ship blow-pipes, which pass over the tops of the boilers as shown in Fig. 2, and are provided with valves on the port and starboard sides of the vessel. It is this arrangement of the blow-pipes which led to the accident under discussion.

It appears that the vessel was loaded in British Columbia with coal, and after leaving Victoria, B. C., and while steaming across the straits of San Juan de Fuca, the engineer in charge ordered the water-tender, or fireman, to blow down three or four inches of water from the forward starboard boiler. In carrying out this order the fireman opened the valve on the front head of the starboard boiler, and also the outboard blow-valve on the starboard side. (This will be understood by reference to Fig. 2.) After blowing down as far as desired, the top outboard valve was closed. This, of course, stopped the blowing at once; but when the man came down from the ladder *he forgot to shut the lower valve, on the head of the boiler.*

When the steamer reached Port Townsend, one of the breeching bolts on the forward port boiler was found to be leaking, and the chief-engineer therefore ordered the pressure to be lowered on that boiler, and that water blown out so that the bolt could be renewed. He also gave orders to wash out the two after boilers, and carry steam only on the forward starboard boiler (*i. e.* the one on the right, in Fig. 2). As the *Everett* was to lie at the dock over night, a slow fire was kept under this boiler, the fires under the other three being hauled. When the steam pressure on the three cooling boilers had been reduced to about 20 pounds, orders were given to open the blow-off valves attached to them, and blow down. This was done, the blow-off valve on the front head of the starboard boiler being open all this time, although it was supposed to be shut.

The result hardly needs to be told. The boilers from which the fires had been drawn were under only 20 pounds of steam, while the forward starboard boiler, with a fire in each furnace, was carrying 60 pounds, so that it emptied itself much more rapidly than any of the others. After some little time one of the firemen opened one of the doors of the forward starboard boiler, and found the furnace red-hot and bulged down, as shown in the engravings. Upon investigation he found the other furnace in this boiler in the same condition. The fires were at once hauled out, and upon examination it was found that the furnaces were down 21 inches, the corrugations being pulled out so that at the bottom of the bulges the furnace was almost smooth; but no signs of fracture could be discovered.

If these furnaces had been poorly made, or if they had been constructed of a material deficient in ductility, it is almost certain that a disastrous explosion would have followed the rough usage to which they were subjected; and this fact ought to satisfy anyone of the paramount importance in boiler construction of having good material and good workmanship. The unwisdom of giving a fireman too many things to remember will also be apparent; for if each boiler had been provided with its own separate blow pipe, discharging directly into the sea without any connection with the other boilers, this accident could not have happened.

Inspectors' Report.

NOVEMBER, 1896.

During this month our inspectors made 8,325 inspection trips, visited 17,269 boilers, inspected 6,397 both internally and externally, and subjected 603 to hydrostatic pressure. The whole number of defects reported reached 11,540, of which 984 were considered dangerous; 54 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	928	49
Cases of incrustation and scale,	2,340	61
Cases of internal grooving,	108	13
Cases of internal corrosion,	634	29
Cases of external corrosion,	676	32
Broken and loose braces and stays,	159	62

Nature of Defects.	Whole Number.	Dangerous.
Settings defective,	326	27
Furnaces out of shape,	435	35
Fractured plates,	280	51
Burned plates,	276	20
Blistered plates,	256	6
Cases of defective riveting,	1,175	29
Defective heads,	138	23
Serious leakage around tube ends,	1,981	308
Serious leakage at seams,	417	31
Defective water-gauges,	288	49
Defective blow-offs,	228	53
Cases of deficiency of water,	12	6
Safety-valves overloaded,	75	25
Safety-valves defective in construction,	103	27
Pressure-gauges defective,	602	32
Boilers without pressure-gauges,	7	7
Unclassified defects,	96	9
Total,	11,540	984

DECEMBER, 1896.

During this month our inspectors made 9,266 inspection trips, visited 18,546 boilers, inspected 6,317 both internally and externally, and subjected 590 to hydrostatic pressure. The whole number of defects reported reached 12,426, of which 988 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,	797	45
Cases of incrustation and scale,	2,069	63
Cases of internal grooving,	91	12
Cases of internal corrosion,	733	26
Cases of external corrosion,	682	27
Broken and loose braces and stays,	577	108
Settings defective,	290	30
Furnaces out of shape,	367	14
Fractured plates,	259	44
Burned plates,	328	71
Blistered plates,	142	7
Cases of defective riveting,	2,264	36
Defective heads,	83	5
Serious leakage around tube ends,	2,066	296
Serious leakage at seams,	455	19
Defective water gauges,	336	65
Defective blow-offs,	180	35
Cases of deficiency of water,	12	8
Safety-valves overloaded,	80	19
Safety-valves defective in construction,	61	24

Nature of Defects.	Whole Number.	Dangerous.
Pressure-gauges defective,	436	30
Boilers without pressure-gauges,	3	3
Unclassified defects,	115	1
Total,	12,426	988

Summary of Inspectors' Reports for the Year 1896.

During the year 1896 our inspectors made 102,911 visits of inspection, examined 205,957 boilers, inspected 78,118 boilers both internally and externally, subjected 8,187 to hydrostatic pressure, and found 663 unsafe for further use. The whole number of defects reported was 143,217, of which 12,988 were considered dangerous. A summary of the work by months is given below, and the usual classification by defects is likewise given :

Summary by Months, for 1896.

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,	10,062	18,713	6,068	645	69	10,925	1,212
February,	7,735	15,808	4,734	525	40	10,215	876
March,	8,641	17,076	5,812	601	50	11,685	1,049
April,	8,841	17,920	6,575	677	84	11,852	1,313
May,	7,947	15,877	7,047	677	83	12,641	1,170
June,	8,366	15,840	7,200	795	50	13,079	1,105
July,	8,025	17,737	8,151	775	47	14,806	1,270
August,	7,489	15,388	6,640	723	59	11,605	1,253
September,	8,106	15,488	6,605	761	40	11,255	842
October,	10,108	20,295	6,572	815	40	11,188	926
November,	8,325	17,269	6,397	603	54	11,540	984
December,	9,266	18,546	6,317	590	47	12,426	988
Totals,	102,911	205,957	78,118	8,187	663	143,217	12,988

Summary, by Defects, for the Year 1896.

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	11,561	598
Cases of incrustation and scale,	25,619	790
Cases of internal grooving,	1,336	129
Cases of internal corrosion,	8,870	422
Cases of external corrosion,	9,076	460
Defective braces and stays,	2,521	892
Settings defective,	4,145	404
Furnaces out of shape,	5,203	240
Fractured plates,	3,385	674
Burned plates,	3,095	327
Blistered plates,	2,791	102

Nature of Defects.	Whole Number.	Dangerous.
Defective rivets,	16,313	878
Defective heads,	1,547	269
Leakage around tubes,	24,791	3,819
Leakage at seams,	5,517	407
Water-gauges defective,	4,660	733
Blow-outs defective,	2,280	582
Cases of deficiency of water,	203	105
Safety-valves overloaded,	900	270
Safety-valves defective,	1,264	326
Pressure-gauges defective,	6,588	478
Boilers without pressure gauges,	57	57
Unclassified defects,	1,495	26
Total,	143,217	12,988

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

COMPARISON OF INSPECTORS' WORK DURING THE YEARS 1895 AND 1896.

	1895.	1896.
Visits of inspection made,	98,349	102,911
Whole number of boilers inspected,	199,096	205,957
Complete internal inspections,	76,744	78,118
Boilers tested by hydrostatic pressure,	8,373	8,187
Total number of defects discovered,	144,857	143,217
" " of dangerous defects,	14,556	12,988
" " of boilers condemned,	799	663

The following table is also of interest. It shows that our inspectors have made over a million visits of inspection, and that they have made more than two million inspections, of which more than three-quarters of a million were complete internal inspections. The hydrostatic test has been applied in over one hundred and twenty-six thousand cases. Of defects, more than a million and a half have been discovered and pointed out to the owners of the boilers; and nearly two hundred thousand of these defects were, in our opinion, dangerous. Over ten 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, 1897.

Visits of inspection made,	1,092,967
Whole number of boilers inspected,	2,177,045
Complete internal inspections,	842,648
Boilers tested by hydrostatic pressure,	126,441
Total number of defects discovered,	1,629,404
" " of dangerous defects,	196,046
" " of boilers condemned,	10,463

We append, also, a summary of the work of the inspectors of this company from 1870 to 1896 inclusive. The years 1876 and 1878 are omitted, because the data that we have at hand for those years is not complete. The figures, so far as we have them, indicate that the work during those years was in good accordance with the regular progression observable in other years. Previous to 1875 it was the custom of the company to publish its reports on the first of September, but in that year the custom was changed and the summaries were made out up to January 1st, so as to agree with the calendar year. The figures given opposite 1875, therefore, are for sixteen months, beginning September 1, 1874, and ending December 31, 1875.

SUMMARY OF INSPECTORS' WORK SINCE 1870.

Year.	Visits of inspection made.	Whole number of boilers inspected.	Complete internal inspections.	Boilers tested by hydrostatic pressure.	Total number of defects discovered.	Total number of dangerous defects discovered.	Boilers condemned.
1870	5,439	10,569	2,585	882	4,686	485	45
1871	6,826	13,476	3,889	1,484	6,253	954	60
1872	10,447	21,066	6,533	2,102	11,176	2,260	155
1873	12,824	24,998	8,511	2,175	11,998	2,892	178
1874	14,368	29,200	9,451	2,078	14,256	3,486	163
1875	22,612	44,763	14,181	3,149	24,040	6,149	216
1877	....	32,975	11,629	2,367	15,964	3,690	133
1879	17,179	36,169	13,045	2,540	16,238	3,816	246
1880	20,939	41,166	16,010	3,490	21,033	5,444	377
1881	22,412	47,245	17,590	4,286	21,110	5,801	363
1882	25,742	55,679	21,428	4,564	33,690	6,867	478
1883	29,324	60,142	24,403	4,275	40,953	7,472	545
1884	34,048	66,695	24,855	4,180	44,900	7,449	493
1885	37,018	71,334	26,637	4,809	47,230	7,325	449
1886	39,777	77,275	30,868	5,252	71,983	9,960	509
1887	46,761	89,994	36,166	5,741	99,642	11,522	622
1888	51,483	102,314	40,240	6,536	91,567	8,967	426
1889	56,752	110,394	44,563	7,187	105,187	8,420	478
1890	61,750	118,098	49,983	7,207	115,821	9,387	402
1891	71,227	137,741	57,312	7,859	127,609	10,858	526
1892	74,830	148,603	59,883	7,585	120,659	11,705	681
1893	81,904	163,328	66,698	7,861	122,893	12,390	597
1894	94,982	191,932	79,000	7,686	135,021	13,753	595
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

The Locomotive.

HARTFORD, FEBRUARY 15, 1897.

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Obituary.

JOHN NELSON SMITH.

We record, with profound regret, the death of Mr. John Nelson Smith, which occurred on January 19th, at his home in Hartford, Conn. Mr. Smith was born in 1830, and served his time as a blacksmith in New London, Conn. He first came to Hartford in 1857, going to work, at that time, for the firm of Woodruff & Beach, boiler-makers, where he remained for eleven years. In 1868 he formed a partnership with P. Ammerman, who was then foreman in Woodruff & Beach's shop, and the new firm continued in the business of making boilers for five years. In 1873 the partnership was dissolved, the business being continued, however, in Mr. Ammerman's name, and Mr. Smith remained in the shop as foreman for several years more. He then went to Norwich, Conn., where he engaged in the manufacture of heating boilers. Several years later he sold his Norwich business and again removed to Hartford, where he renewed his connection with Mr. Ammerman, continuing in that position until he became special inspector for the Hartford Steam Boiler Inspection and Insurance Company, in July, 1890.

Mr. Smith was a man of sterling qualities, and was distinguished alike for his knowledge and experience, for his strict integrity, and for a certain indescribable friendliness of manner in all his social and business relations, which won the respect and the esteem of everyone, and inspired a feeling of the warmest personal regard in all who knew him.

Boiler Explosions.

NOVEMBER, 1896.

(280.) — On October 30th a boiler exploded in Martin Fusier's cannery, near Smith river, Del Norte Co., Cal. The engine-room was wrecked, and two persons were killed. James Wheeler, Clarence Fusier, and seven other men were injured. The boiler was tested hydrostatically, last fall, to eighty pounds, and at the time of the explosion it was carrying only forty-five pounds. [This account was received too late for insertion in the regular October list.—ED.]

(281.)—The boiler in Frank Platt's green-house on Edgewood Avenue, New Haven, Conn., exploded November 1st, and considerable damage was done. The boiler was partially wrecked, and all the glass in the green-house was blown out.

(282.)—William Mann and Abraham Goss were killed on November 4th, by the explosion of a locomotive boiler in the Southern railroad yards, at Atlanta, Ga. James Rodgers was also seriously injured. The locomotive had been thoroughly overhauled and repaired only about ten days before.

(283.)—On November 5th two boilers exploded on Daniel Thomson's Calumet plantation, four miles above Patterson, La. Three men were injured, one of them quite seriously.

(284.)—The building occupied by the Patterson Manufacturing Company, at Toledo, Ont., was wrecked, on November 6th, by the explosion of a boiler. Two men were injured so seriously that they are not likely to recover. One newspaper says that the explosion was "like unto the crack of doom for magnitude, but scarcely as disastrous." If the editor of that paper looks forward to the crack of doom as a *disaster*, we should advise him to mend his ways right off.

(285.)—On Saturday, November 7th, a boiler of the locomotive type, used to run Capt. B. P. Brown's cotton-gin near the Southern railway, at Davidson, N. C., exploded with terrific force. Fortunately, nobody was hurt, and the damage to property was not great, as the flight of the boiler was away from the main buildings. Capt. Brown, the owner, had left the boiler only a few minutes before, and gone up to the ginnery. A negro, who was near by, said that he noticed that the steam gauge registered 170 pounds, and that he started to go and open the furnace doors when the boiler jumped out, end over end, and landed some 300 feet away, across the railroad tracks, and by the side of a public roadway. The safety-valve in this case had probably been neglected, so that it had stuck fast to its seat, allowing the pressure to mount upwards until it became so great that the boiler could no longer hold it.

(286.)—The boiler of a large saw-mill at Peniel, near Spencer, W. Va., exploded with terrible results on November 7th. L. C. Ingram and two other men, named Sheets and Milhoan, were almost instantly killed.

(287.)—One of a nest of sixteen boilers in the Centralia Colliery, at Centralia, Pa., exploded on November 7th. Andrew Monchok was instantly killed, and John Ganthey and Joseph Kubick died later in the day. Matthew Lescher was fearfully burned, and died two days later. John Bolinski was also badly scalded, but it is believed that he will recover. The exploding boiler was hurled about 500 yards, and all the other boilers in the battery were more or less displaced, four being blown entirely from their settings. The boiler-house was entirely destroyed. The property loss was probably above $8,000.

(288.)—On November 9th a boiler exploded in Roderick Baker's saw-mill in Perry county, near Lexington, Ky. John Francis and Roderick Baker were killed, and James Crow, Bud Harper, Richard Marrs, David Crowder, Mason Failen, Samuel Clark, and three other men were scalded and otherwise injured.

(289.)—A boiler exploded on November 10th in William Spencer's mill at Waverly, near Scranton, Pa. Frederick Smith, the fireman, was badly burned and scalded. He will lose his eyesight, and he may not recover. Another man, named Tripp, was also scalded to a lesser degree.

(290.)—On November 12th a boiler exploded at Thomson, Ga., in the McDuffie mills, owned and operated by I. W. Shields. The engine and boiler-house was completely demolished, and fragments of brick and iron were scattered about for a quarter of a mile in all directions. Engineer Gordon E. Wall and his fireman (whose name we have not learned) were painfully injured, but it is believed that they will recover. A little child who was sitting near by, was killed, and the African Methodist church, a large building recently erected, was completely demolished, and transformed into a heap of ruins.

(291.) — A boiler exploded on November 12th in the South Brooklyn copper works, at South Brooklyn, Ohio. F. H. Baldwin was thrown to the ground by the explosion, and was badly scalded, but he will recover.

(292.) — On November 15th a boiler exploded on the Davis plantation, in St. James' Parish, La., severely scalding John Arba and Moses Robertson.

(293.) — A boiler exploded, on November 16th, in a mill belonging to Robinson Bros., of Park Hill, Ont. A little girl, the daughter of J. H. Cunningham, was instantly killed. Edward Robinson also received injuries from which he afterwards died, and his father, Thomas Robinson, was severely injured. Mrs. Cunningham was also slightly injured. The boiler is said to have been old and badly constructed, and had no re-enforcement about the man-hole. The feed-water used was taken from a ditch, and was unfit for use. The dome of the boiler (which was the heaviest piece remaining, after the explosion), was blown to a great distance, narrowly missing a boy on the way. The mill itself was completely destroyed.

(294.) — A boiler in A. F. Hansen's blacksmith shop, at Table Rock, Neb., exploded on November 16th, injuring Louis Fellers very badly. He was still living, some ten days after the accident, but his condition was critical, and the chances were greatly against his recovery.

(295.) — On November 17th, a boiler exploded in Moore & Gay's mill, some eight miles from Cuthbert, Ga. One man was killed instantly, and several others were injured. The machinery in the mill was badly damaged.

(296.) — A boiler exploded, on November 17th, in a mill belonging to Reno Bros., in Saline county, near Sedalia, Mo. John Reno was killed, and Edward Reno was badly scalded.

(297.) — William Sullivan, a fireman in the East End electric light plant, Pittsburgh, Pa., was seriously injured, on November 17th, by the explosion of a boiler. The head of the boiler blew out, and struck Sullivan on the body, crushing several ribs.

(298.) — A boiler belonging to the Hope Furnace, at Pomeroy, Ohio, exploded on November 19th. Fortunately nobody was injured, but the boiler-house was blown to atoms.

(299.) — A boiler exploded, on November 19th, in a feed mill belonging to Ira Johnson & Sons, of Asbury Park, N. J. Engineer Daniel Van Arsdale, who was standing in front of the boiler, was hurled backwards against a wall, and pinned fast by the wreckage. He was horribly scalded by the escaping steam and hot water, but it is thought that he may recover. The engine-room was entirely demolished.

(300.) — A boiler in one of the mills of Mizell & Brother, King's Ferry, Fla., blew up, on November 20th, doing much damage to the mill, and scalding several workmen, most of whom will die.

(301.) — A boiler exploded in the Dover Boiler Works, Dover, Del., on November

21st, while it was being tested. Henry Linderman was badly hurt about the head. Edward Hicks was badly bruised and scalded, and Frank Langdon was severely injured by a flying fragment of iron.

(302.) — The boiler of Sivard's saw-mill at Rush Run, Jefferson county, W. Va., exploded on November 21st, scattering a portion of the plant to the winds. The engineer left the building a few minutes before the accident, and thus saved his life.

(303.) — The boiler on the steam launch *Pilot* exploded near Cairo, Ill., on November 23d. J. M. Mitchell and C. Bryan, who were aboard at the time, were severely injured, and Mr. Mitchell will die.

(304.) — Joseph Green and Michael Inhofer were instantly killed on November 24th, by the explosion of a threshing machine boiler at West Newton, a small place about eleven miles north of New Ulm, Minn.

(305.) — A boiler exploded on November 26th, in the bagasse burner on the Esperenza plantation, three miles below Hahnville, La. Four men were severely injured, and one of them died within a short time. The explosion was heard five miles away. The place is owned by Wogan Bros., and the property loss is estimated at about $15,000. The rear portion of the sugar house was totally demolished.

(306.) — By the explosion of a boiler in the W. Dewees Wood company's rolling-mill at McKeesport, Pa., on November 28th, David C. Hall, a fireman, was killed, and Thomas Baldwin, an engineer, received injuries from which he is not likely to recover. One side of the mill is totally wrecked, the damage to the building being about $5,000.

(307.) — Miller's barber shop, at Brightwood, near Indianapolis, Ind., was badly damaged, on November 30th, by the explosion of a small boiler used for heating water. The shop is in the Miner block, and the building was badly damaged. The front and rear walls were thrown a foot out from their foundations.

December, 1896.

(308.) — A boiler exploded on December 1st in Isaac Smith's mill, at Montgomery, near Brookhaven, Miss. Alexander Spencer, the fireman, was instantly killed.

(309.) — A boiler exploded on December 1st on the Wilbert oil lease, at Petroleum Center, near Oil City, Pa. Oliver Cosper was struck by a piece of the boiler and injured so badly that he cannot recover. The building in which the boiler stood was wrecked.

(310.) — On December 2d a boiler exploded in Held's meat market, at Boone, Iowa. Henry Held, a son of the owner of the market, was fearfully injured, and will probably die. The building in which the boiler stood was blown to pieces, and fragments of it were found five blocks away. An adjoining building was also damaged to a lesser extent.

(311.) — On December 4th a locomotive boiler exploded near Mansfield, Conn., on the Central Vermont railroad. Engineer Otis Hall, Fireman Benjamin Hall, and Head Brakeman W. P. Thomas were killed.

(312.) — A boiler belonging to Forbes & Hall, in the Creamery building at Boulder, Cal., exploded on December 5th. Nobody was near at the time, but Mr. A. E. Bowen, of Bowen's Hotel, was somewhat injured by a flying fragment of the debris.

(313.) — A boiler exploded on December 7th near Brunswick, Ga., killing Mr. Thayles Pyles, and seriously scalding two other men.

(314.) — On December 7th a boiler exploded in the Gray Lumber Company's No. 1 mill, at Leliaton, Ga., killing the ten-year old son of Mr. Henry Moncrief, and hurling the power house roof a long distance. The boiler itself was thrown 750 feet.

(315.) — A small boiler exploded on December 7th in the building adjoining the old hotel at Uxbridge, Mass. Nobody was injured.

(316.) — On December 8th a boiler exploded at Seville, in Wilcox County, Ga., in one of the largest and most modern machine plants of the Wilcox Lumber Company. S. Spiland, Patrick Houston, Hanso Frazier, Brown Daniels, Thomas Ellis, Henry Busbee, Arthur Barton, and Joseph Oxendine were killed. The entire plant was reduced to a mass of ruins, and the Atlanta *Constitution* says that "fragments of the structure and pieces of machinery were scattered over the country for miles around."

(317.) — On December 9th a boiler exploded in the electric light plant at Orange, Texas. The roof was torn from the boiler-house, and the property loss is said to have been about $5,000. Happily, nobody was hurt.

(318.) — The boiler of a threshing machine exploded on December 9th on the farm of Archibald Ferguson, in Yarmouth township, near St. Thomas, Ont. Alexander Forbes was struck by a piece of the boiler and instantly killed. Three other men were injured more or less severely.

(319.) — A boiler exploded on December 10th in Jones and Ferguson's saw-mill, near Baskerville, eight miles east of Boydton, W. Va. John H. Lett and James Blackford were instantly killed.

(320.) — A threshing machine boiler, belonging to Nathan Mason of Point au Roche, near Plattsburg, N. Y., exploded on December 11th. We have not learned of any serious consequences, except that reported by the Plattsburg *Press*, which says that the explosion "allowed the scalding steam and water to permeate the atmosphere for a considerable distance."

(321.) — A boiler in the basement of Engine House No. 3, of the fire department of Bridgeport, Conn., exploded with considerable violence on December 13th. Fortunately, nobody was in the basement at the time, and the only person injured was George Rutherford, a hoseman.

(322.) — On December 14th a boiler exploded in Wiser Adkins' saw-mill, at Denton, Ky. Asa Kitchen was instantly killed, and four other men were badly injured.

(323.) — A boiler exploded on December 14th in Forsyth Bros.' coal works, near Finleyville, Pa. Andrew Forsyth was injured so badly that he cannot recover.

(324.) — On December 19th a boiler exploded in the Kent Woolen Company's mill at Centerville, R. I. Sylvanus Brault, Mrs. Brault, and Arthur Fisher were instantly killed, and D. I. Baker received injuries from which he subsequently died. Benoni Houle, Arthur Grevais, Ellen Levar, Annie Monahan, and a Mr. Chrisholm were also injured to a lesser degree. Mrs. Brault had gone to the mill with her husband's breakfast, and had hardly entered the boiler-room when the explosion occurred. A particularly sad feature of this explosion lies in the fact that the Braults leave a family of five small children. The mill was much damaged, the property loss being estimated at about $12,000.

(325.) — The boiler of locomotive No. 591, on the Iron Mountain railroad, exploded on December 19th at Gad's Hill, Mo. Engineer P. H. Fitzgerald and Brakeman J. S. Isby were killed, and Fireman Brady was seriously injured. The locomotive was totally wrecked.

(326.) — A boiler belonging to William Craiglow, of Hocking township, near Lancaster, Ohio, exploded on December 19th. Nobody was near it at the time.

(327.) — On December 21st, a boiler exploded at Newkirk, Okla., twelve miles south of Arkansas City, Kan. Fireman John Reeves was killed, and Mr. Williams, the owner of the mill, was seriously injured. The mill was badly damaged.

(328.) — On December 22d, a boiler exploded at Jacksonville Mine No. 4, near Athens, Ohio. Jesse Walters, a fireman, was thrown fully fifty yards, receiving bruises and scalds from which it is doubtful if he can recover. We have seen no estimate of the property loss except that it is several thousand dollars.

(329.) — A boiler exploded, on December 25th, in a saw-mill on the Chariton River, near Unionville, Mo. Alonzo Currant was killed. Currant's son and a man named John Cooper were also severely scalded and otherwise injured.

(330.) — While ascending Wolf Summit, seven miles west of Clarksburg, W. Va., on December 27th, freight engine No. 1,342, of the Baltimore & Ohio Railroad, bursted her boiler. Fireman Dolan was painfully injured.

(331.) — On December 27th, a boiler exploded in a cotton gin on Joseph Walker's place, at Cornerstone, Ark., near Pine Bluff. Fireman Clay Thomas was killed, and two other men were badly injured. The building in which the boiler stood was wreckage, and the machinery was ruined. Timbers and pieces of iron were blown across a neighboring bayou, and were found on the Richardson plantation, 500 yards away.

(332.) — A boiler used at the Medical Lake Insane Asylum, near Spokane, Wash., exploded on December 28th, completely demolishing the boiler-house and damaging a portion of the rear wing of the asylum. Fireman Fritz Theilman was thrown against a brick wall and fatally injured. A panic ensued among the patients, but none of them were seriously hurt. The property loss was probably about $25,000.

(333.) — A boiler exploded, on December 30th, in Granville Fyke's mill, about ten miles northeast of Mount Vernon, Ill. Mrs. Fyke was killed, and William Padgett, William Purdue, and Granville Fyke were seriously injured. Purdue is not expected to live. The mill was totally wrecked. The explosion was heard five miles away.

A MAN fell overboard in New York harbor the other day, and his cries drew two Polish "beach-combers," who took away from him the plank to which he was clinging, and left the man in the water. They knew a good plank when they saw it. The drowning man was rescued by somebody else, and at last accounts he was on the war-path for two Polish scalps.

THE steam-chest of a 500 horse-power engine in Ashly & Bailey's silk mills, at Columbia, Pa., exploded on October 28th. John Allison, the engineer, Ralph Hale, fireman, and Frederick G. Erfin, the purchasing agent of the company, were in the mill at the time, and were all severely injured and burned by the steam. The damage amounts to about $5,000.

Boiler Explosions during 1896.

We present, in the accompanying table, a summary of the boiler explosions that occurred in the United States during the year 1896, together with the number of persons killed and injured by them.

It is difficult to make out accurate lists of explosions, because the accounts of them that we receive are often unsatisfactory. We have spared no pains, however, to make this summary as nearly correct as possible. In making out the monthly lists from

SUMMARY OF BOILER EXPLOSIONS FOR 1896.

MONTH.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January,	35	40	99	139
February,	30	32	28	60
March,	28	19	36	55
April,	24	28	34	62
May,	24	51	44	95
June,	24	29	18	47
July,	24	15	25	40
August,	42	48	67	115
September,	36	28	46	74
October,	25	35	66	101
November,	28	24	40	64
December,	26	33	26	59
Totals,	346	382	529	911

which it is extracted (and which are published from month to month in THE LOCOMOTIVE) it is our custom to obtain a large number of accounts of each explosion, and 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 1896. 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 1896 was 346, against 355 in 1895, 361 in 1894, and 316 in 1893. In a few cases more than one boiler has exploded at the same time. When this has happened, we have counted each boiler separately, as heretofore, believing that in this way a fairer idea of the amount of damage may be had.

The number of persons killed in 1896 was 382, against 374 in 1895, 331 in 1894, and 327 in 1893; and the number of persons injured (but not killed) in 1896 was 529, against 519 in 1895, 472 in 1894, and 385 in 1893.

It will be seen from these figures that during the year just elapsed there was, on an average, nearly one boiler explosion a day. The figures in the table show that the average of the deaths and injuries during 1896, when compared with the number of explosions, was as follows: The number of persons killed per explosion was 1.10; the number of persons injured (but not killed) per explosion was 1.53; and the total number of killed *and* injured, per explosion, was 2.63.

The year 1896 was not distinguished by any such dramatic explosions as those of the Gumry Hotel, at Denver, and the Detroit *Evening Journal*, which we had to record in 1895. If we consider the number of persons killed and injured, the most notable explosions of the year, in this country, were probably the following: On January 2d, there were 9 persons killed and 31 injured in St. Louis, Mo.; on January 30th, 5 persons were killed and 17 were injured in an iron works at Hollidaysburg, Pa.; on June 18th, 14 persons were killed and 4 were injured by a boiler explosion on the steamer *Hon. Titus Sheard*, near Little Falls, N. Y.; and on October 8th, an explosion in a rolling mill at Danville, Pa., killed 7 persons and injured 26 others. If, on the other hand, we regard the property loss as an index of severity, the worst explosions were probably as follows: The W. P. Orr Linseed Oil Co., at Piqua, Ohio, on April 5th, with a loss of about $60,000; the tow-boat *Harry Brown*, near Vicksburg, Miss., on May 10th, with a list of 12 killed and 5 injured, and a property loss of $50,000; and the Michigan Salt Works, near Marine City, Mich., with a loss of about $60,000. We may also mention the boiler explosion in Danbury, Conn., on March 3d, where the ruins took fire, the combined loss from explosion and fire being estimated at $200,000.

Miscellaneous Accidents from the Use of Steam.

On November 29th, a boiler exploded in a carbon factory at Nanterre, seven miles northwest of Paris, France. The property loss was about $100,000. The factory is owned by M. Hademard, the father-in-law of Capt. Dreyfus, who was sentenced to life imprisonment a short time ago for selling military secrets to Germany.

The blow-off pipe of a boiler in the water-works at Fernandina, Fla., bursted, on November 30th, and Assistant-Engineer F. J. Williams had a narrow escape from death.

One of the boilers of the French steamer *Saghalien* exploded on December 2d, while the vessel was off the Chinese coast, bound from Singapore to Hong Kong. Eleven of the stokers and one of the engineers were killed by the explosion or by the escaping steam. The chief stoker was so badly injured that he died a few hours afterwards, and four other firemen died the next day, as a result of their burns. The vessel was crowded with passengers, and, for a time, there was the wildest confusion on board. Letters brought by the *Rio De Janeiro* from the Orient, give the details of the disaster. The passengers had just assembled in the saloon for dinner, when there was a loud report like that of a cannon. The deck beams were torn up. Gratings were sent flying in the air, and the steamer trembled from stem to stern. As soon as the steam had cleared way, men were sent below in the stoke-hold. Seven of the Lascar firemen lay about the floor before the ruined boiler, dead or nearly so, from the fearful bath of superheated steam into which the explosion had plunged them. The chief stoker, a Frenchman, was among them. He died in the most frightful agony a few moments after he had been carried on deck. Ten other firemen who were in the stoke-hold were also badly burned, and four of them died during the night following the explosion. Among the passengers were three engineers and twenty stokers of the French navy, who volunteered their services to remedy the damage done. Within a day they had the engine so far repaired that the vessel was able to run about six miles an hour, and a few days later she dropped her anchor at Sankow. The dead firemen and engineers were buried at sea.

The Locomotive.

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Construction and Care of Steam Boilers as a Preventive of Steam-Boiler Explosions.*

By J. M. Allen.

Steam boilers are so extensively used in all the great industries of the world, including railroad, locomotive, and marine boilers, that profound study and investigation have been given to their construction, setting, and management, with a view to the greatest safety and economy. Until within the last fifteen or twenty years stationary steam boilers were rarely run at a pressure exceeding 100 pounds per square inch, the

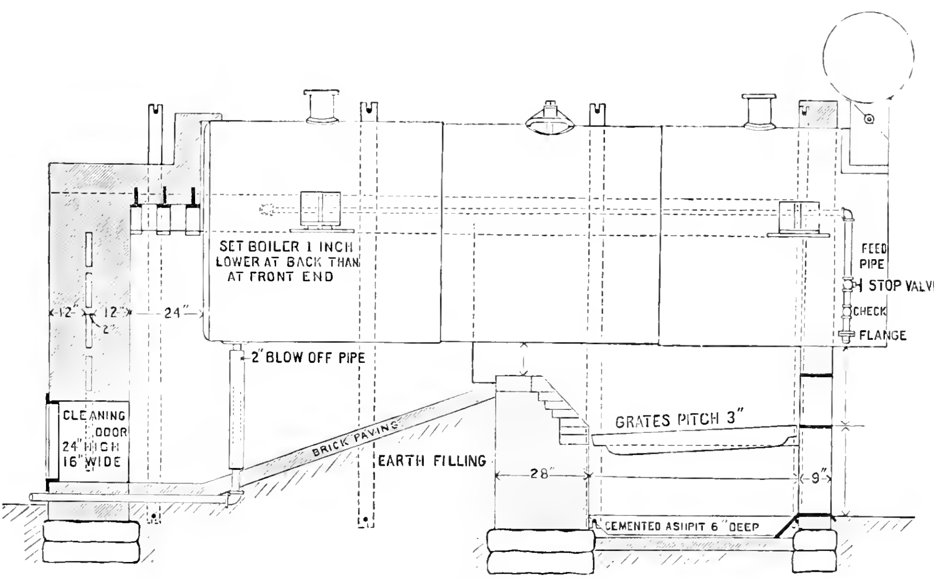

Fig. 1. — Side Elevation of Setting.

usual pressure being from 75 to 85 pounds. But with the improved steam engines of the compound, triple, and quadruple expansion types, a demand was created for boilers capable of carrying 150 to 175 pounds pressure per square inch. To meet this demand, a very serious and important problem was forced upon the boiler-makers. Old methods had to be abandoned, and old machinery and tools replaced by more modern appliances. The

* This paper was read at the annual meeting of the Southern Ice Exchange, held in Charleston, S. C., Februrary 23d, 24th, and 25th.

boilers in use twenty or twenty-five years ago were wrought-iron shell boilers, of the plain cylinder, flue, or return tubular types, and to this day the return tubular boiler is more extensively used in this country than any other type of boiler. It is cheaper in first cost, easily managed and repaired, should repairs be required, and, if properly constructed, that is, rightly proportioned as to grate area and heating surface, with first-class material and workmanship, will show an economy in evaporative efficiency equal to any boiler in use. Under good management, with a good quality of water, such a boiler, not overworked, should last for fifteen years at least. The question will no doubt be asked, How should such a boiler be constructed, and what is meant by evaporative efficiency as bearing on economy? First, then, iron plates for the construction of boilers have of late years been almost entirely superseded by homogeneous steel plates, which have a greater tensile strength than iron plates, and a greater elasticity and duc-

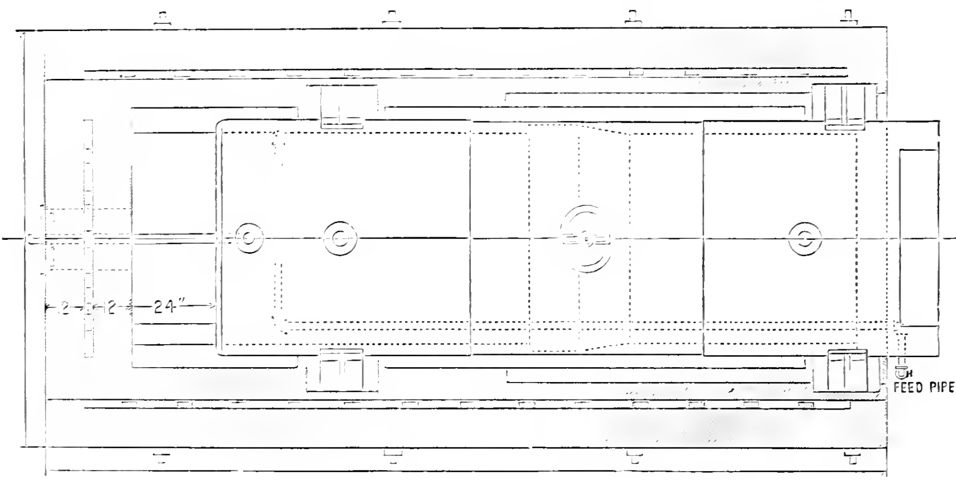

FIG. 2.—PLAN VIEW: SECTION THROUGH CENTER OF BOILER.

tility. The standard tests now require a tensile strength of from 55,000 to 60,000 pounds per square inch. That is, the quality of the steel plate must be such that a bar one inch square would require a force of 60,000 pounds to pull it asunder, and in the process the ductility of the steel would cause it to stretch somewhat, so that at the point of fracture there would be a marked reduction of area in the bar. The amount of reduction of area at this point of fracture decides in a great measure the quality of the steel as adapted to boiler construction. In making specifications for boilers, especially for high pressures, we require that the steel plates shall be of a tensile strength of from 55,000 to 60,000 pounds per square inch, and that the reduction of area at point of fracture under test (as described above) shall be not less than 56 per cent., that is, the metal stretched under the test, or strain, so that when it broke it was less than half the original area of the bar. Such tests determine the quality and ability of the steel plates when made up into a boiler, to adjust themselves to the expansion and contraction of the metal caused by the varying temperatures to which the boiler is subjected when it is set up and put in use. This is a very important point, and is liable to be overlooked by boiler-makers if they and their works are not abreast of the times. If the plates of which the boiler is constructed are hard and brittle, they will give endless trouble from a want of ductility to enable them to yield to the varying strains to which they are subjected. Parties purchasing boilers, especially for high pressures, should insist, in their contracts, that these tests be faithfully made by competent persons, either at the mill where the plate is made, or at some laboratory where tests are made by disinterested parties. The latter would probably be better. The question may be asked, if the tensile strength of the material should be 60,000 pounds per square inch, how is the proper strength estimated for the various thickness of plates as $\frac{3}{8}$ inch, $\frac{5}{16}$ inch, $\frac{1}{4}$ inch, etc.? If the plate is $\frac{1}{4}$ inch thick, we take $\frac{1}{4}$ of 60,000, or 15,000; if $\frac{3}{8}$ inch inch thick, $\frac{3}{8}$ of 60,000, or 22,500, etc., and these amounts are used in the problem of calculating the safe working pressure of the boiler, as will be shown further on.

Another point, and one most important, is the riveted joint. Some of the old boiler-makers used to say that the more rivets they drove in the joint the stronger it was. Now, if we examine this matter carefully, we shall see that for every rivet driven there must be a hole in the plate, and the more holes there are, the weaker the plate, for much of the metal has been cut out. Then, again, if the rivets are too small, or are pitched too wide, they will shear off, and that will be a source of danger. By pitch of rivets is meant their distance apart from center to center. Now, in laying out a joint, the size of the rivets, and the pitch of rivets, depend upon the thickness of plate.

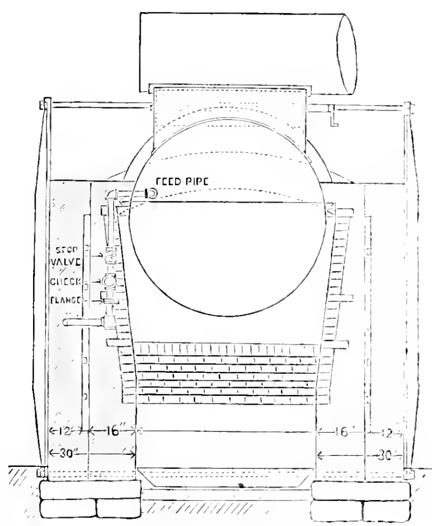

FIG. 3. — SECTION THROUGH FURNACE.

Hence in the present demand for high pressures, the old methods of construction with one size and pitch of rivets for all diameters of boilers and pressure will not answer. Such construction to-day has the element of serious danger in it, and may result in destructive explosion. But if the joint is properly laid out and constructed, with a good factor of safety, and with good care and management, no trouble need be apprehended. You will inquire, What is a factor of safety? When a boiler is constructed and ready for use, by ascertaining the tensile strength of the plates (which is generally found stamped on each plate by first-class plate-makers), the diameter of the boiler, and the construction of the joint, also the bracing, it is an easy problem to calculate the bursting pressure of the boiler, that is, what pressure would be required to burst the boiler asunder. We then divide this by 5, and the quotient will be the safe working pressure, that is, we take $\frac{1}{5}$ the bursting pressure for the safe working pressure. If the calculation showed that 500 pounds per square inch would burst the boiler, we should say 100 pounds was a safe working pressure, and that would be running on a factor of safety of 5. Many boilers are run on as low a factor as 4, and 3.7, but the margin is too narrow, especially the latter. Another fallacy in the old methods of construction was the tendency to crowd the boiler with tubes, thus leaving little space comparatively for water. The object was to increase heating surface, but it was done at the expense of good circulation of the water, and oftentimes at the expense of economy in fuel.

The proper bracing of the heads of the boiler is also important. The area of unstayed portion above the tubes must be calculated, and the proper number of braces provided for. I enclose blue prints and copies of our monthly paper, The Locomotive, illustrating the various points discussed.

Now, to illustrate the method of calculating the bursting and safe working pressure of a boiler, I will assume that the boiler is 60 inches in diameter, 16 feet long, constructed of the best quality of steel plate, $\frac{3}{8}$ inch thick, tensile strength 60,000 pounds per square inch. $60,000 \times \frac{3}{8}$ inches $= 22,500$, tensile strength of steel plate $\frac{3}{8}$ inch thick.

The joint is to be riveted with rivets $\frac{7}{8}$ inch in diameter. The rivet holes should be $\frac{15}{16}$ inch in diameter, $\frac{1}{16}$ inch larger than the diameter of rivet, so that the rivet will easily enter the hole; but when the rivet is driven, it is assumed if the work is

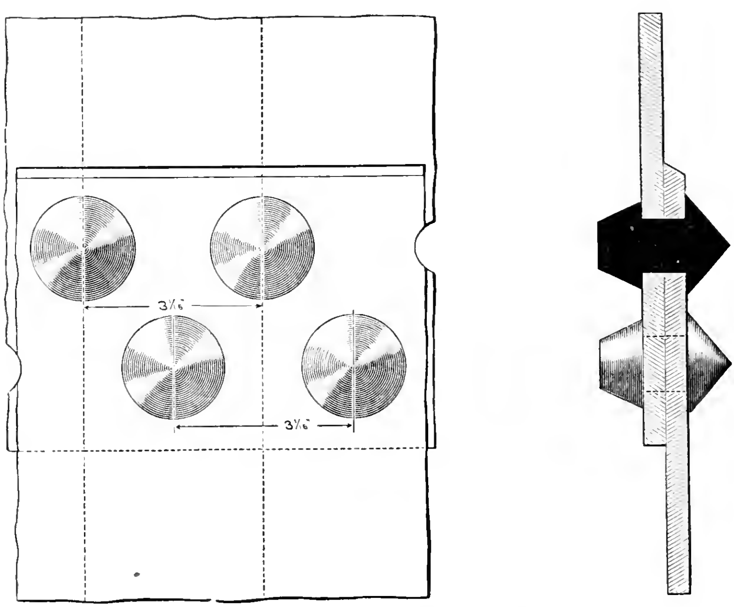

Fig. 4. — Double-Riveted Joint.

well done that by the pressure of the hydraulic or steam rivet driver, it will fill the rivet hole full, and make a good head besides. These rivets should be pitched $3\frac{1}{16}$ inches, that is, the rivet holes should be $3\frac{1}{16}$ inches apart from center of hole to center of next hole. The joint is what is known as the double staggered riveted joint. This is the form for the longitudinal joints, and the rivets are not one over the other, but the lower course is so arranged that the lower row is spaced so that the rivets fall between those of the upper row. Now, the strength of the joint is by calculation (verified by test) 70 per cent. of the strength of the solid plate. This is, therefore, the weak point in the boiler. If the boiler was constructed of plates brazed or welded together, its strength would be 100 per cent.; but, inasmuch as many rivet holes have been cut out, its strength has been reduced to 70 per cent. of the solid plate. Returning, then, to our problem, the bursting and safe-working pressure of a boiler 60 inches in diameter: we have $60,000 \times \frac{3}{8}$ inches (thickness of plate) $\times$ 70 per cent. (strength of joint) divided by the radius (or ½ diameter of boiler) 30 inches = 525 pounds, bursting pressure. Now, if we divide this by 5 (factor of safety) we have 105 pounds as the safe-

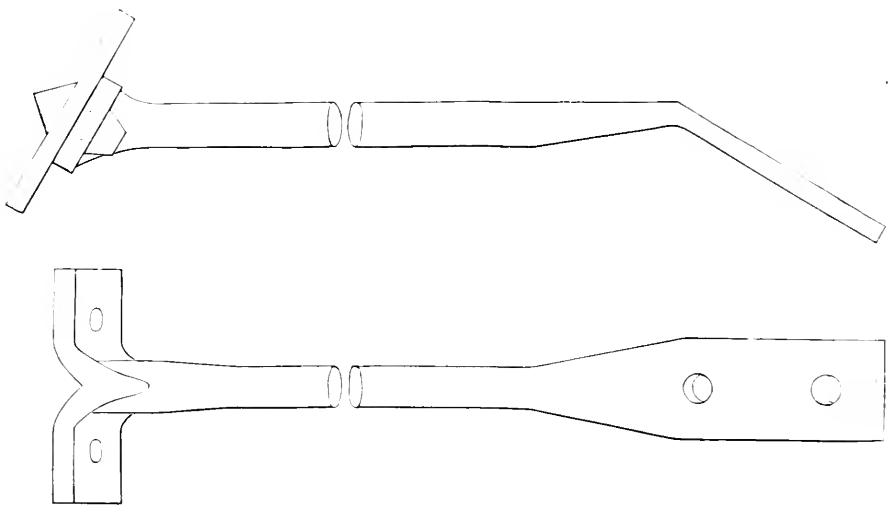

Fig. 5.—Crow-foot Braces

working pressure of the above boiler. This is only an illustration of the method of calculating the safe-working pressure of boilers, of diameters from 48 inches to 72 inches, and of different thicknesses of plates, and for pressures from 100 to 160 pounds.

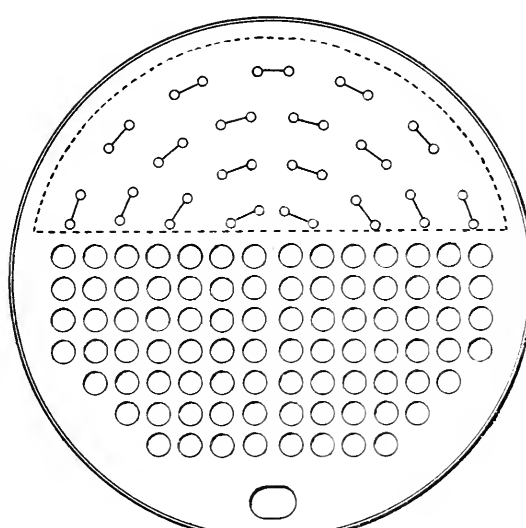

Fig. 6.—Distribution of the Braces.

Now, we will assume that the boiler is properly constructed and set up ready for use. The water which is used in boilers in some localities is a source of constant trouble. In some sections the deposits of lime and magnesia are a great annoyance and expense. There are various boiler purgers on the market which claim to overcome this difficulty. Some of them are good for certain waters, but are utterly inefficient for others. There is no universal panacea. We have a well-equipped chemical laboratory where water is carefully analyzed, and the deleterious ingredients held in suspension or solution are ascertained. We are, from these analyses, enabled to advise what is the best treatment to be adopted to overcome the difficulty. The care and management of the boiler are of the utmost importance in a large plant. A careless, inefficient engineer

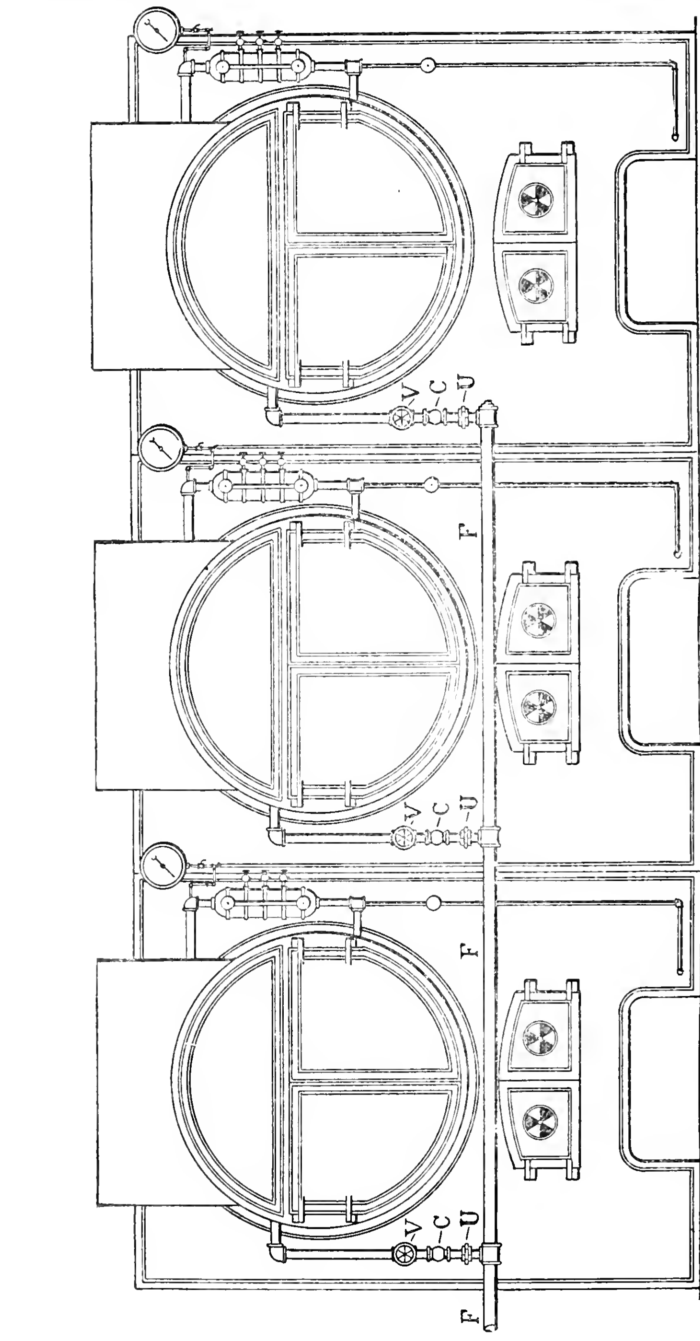

Fig. 7.—Elevation of a Battery of Boilers, Showing the Proper Way of Arranging Feed Pipes.
(*FF*, feed-pipe; *UU*, unions; *CC*, check valves; *VV*, stop-valves.)

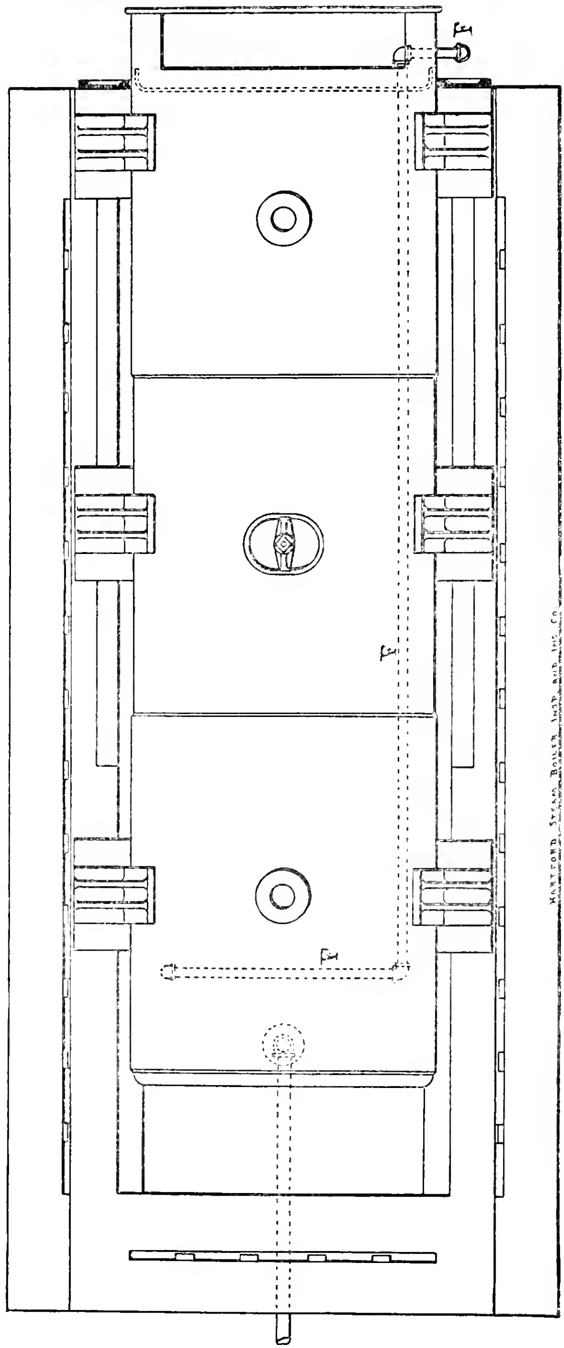

FIG. 8.—PLAN VIEW OF ONE OF THE BOILERS SHOWN IN FIG. 7. THE DOTTED LINES, *FF*, SHOW THE COURSE OF THE FEED PIPE AFTER IT ENTERS THE BOILER.

can waste in fuel more than his wages in a year. In these days of narrow margins of profit a competent engineer saves where an incompetent one would be wasteful. Every attachment to a boiler should be kept in good order. The safety-valve should be frequently tested, that is, raise it often to see that it does not become fast in its seat, and hence inoperative when, from some unforeseen cause, an excess of pressure on the boiler requires immediate relief. The steam gauge also needs watching constantly, and the water column or glass water gauge should have constant supervision. The pipe connections to boiler may become stopped, and the height of water in the glass gauge may be utterly unreliable as indicating the proper height of water in the boiler. First have all the attachments properly connected, and then have an intelligent supervision, and trouble and expense will be largely avoided. Much might be said in regard to fuels, feed water heaters, and other matters where the units of heat in fuel are carefully calculated, also loss by radiation, but this brief paper will not admit of exhaustive discussion on these and cognate points. They come in the regular course of advice to our clients, whose particular cases are often widely different, and require special and different treatment.

It will be proper here to say a word before closing about boiler explosions — those dreaded accidents that we are all working to avoid. Their frequency forces upon us the importance of proper construction and management as outlined above. Careful investigation into the causes of these terrible accidents divests them of the mysterious atmosphere, which, in the minds of the majority of people, surrounds them. Investigation shows that in almost every case the cause is traceable to poor material, faulty construction, poor workmanship, and incompetent management, the latter including over-pressure and over-work, that is, making the boiler do more work than it can do safely. The metal becomes fatigued, its elastic limit is exceeded, and it "lets go." There may be in some cases hidden defects in the metal plates, but such cases are comparatively rare. It is a lamentable fact that there are boiler-makers who will use a cheap and low grade of material, and whose workmanship is very inferior. They "scamp" and "shim," and to cover the defects put on a thick coat of coal tar, and the boiler is ready for market. This type of boiler-maker is not as common as it was some years ago, but there are some left, and life and property are jeopardized by the greed of these men. When we consider the energy that is confined in a steam boiler under pressure, we shall appreciate the importance of good material, good workmanship, and good care and management.

In a horizontal tubular boiler 60 inches in diameter, and 16 feet long, ready for use, there would be 1,135.91 gallons, or 9,465.8 pounds of water. When we start the fires under the boiler, the heat is communicated to the water, which rises in temperature until at 212 degrees Fahr. it begins to emit steam from its surface. The steam, however, is formed at the heating surface of the boiler and forces its way up through the water to its surface. As the fires are continued, this process goes on with great energy, and violent ebullition is the result. If there is no outlet for the steam thus generated, and the safety-valve is weighted to, say, 80 pounds, the steam will accumulate in the steam room above the surface of the water, until it reaches a pressure of 80 pounds to the square inch, when it will begin to issue from the safety-valve. The temperature of the steam and water at this pressure is 324 degrees Fahr., or 112 degrees above the temperature of steam at atmospheric pressure. The velocity of discharge of steam at this pressure is about 1,450 feet per second, or at the rate of 16 miles a minute, or 960 miles an hour. The pounds of steam discharged per minute per square inch of opening at this pressure would be about 82 pounds, which, multiplied by 4.56, the volume of one pound of steam at 80 pounds pressure, will give us 373.92 cubic feet. I give these figures in order to give some adequate idea of the velocity of steam under pressure of 80 pounds. At 100 pounds pressure its actual velocity of efflux would be not less than 1,600 feet per second. But from investigation we have good grounds for believing that steam alone at this pressure would not be sufficient to cause a disastrous explosion even if rupture were to occur. Steam cylinders of engines sometimes fail. The steam is nearly at boiler pressure, and the cylinder is usually of cast-iron, but the pieces are not thrown violently away. The pressure is immediately released, and its force is gone. We must look, then, for some other cause than steam alone for destructive boiler explosions.

To refer again to the boiler with a steam pressure of 80 pounds, what are the conditions? We have a boiler 60 inches in diameter, under 80 pounds of steam. The quantity of water is 168.17 cubic feet, or 1,135.91 gallons, or 9,465.8 pounds. This water is heated up to a temperature due to the pressure of steam, or 324 degrees Fahr. All this contained heat in excess of 212 degrees is ready to flash into steam if it had the opportunity, but the superincumbent pressure of steam on the surface of the water holds it in subjection, as a reservoir of power from which to draw as the steam above is used. If we now suppose a rupture to occur above or near the water line, the steam already formed would rush out at a velocity at first of at least 1,450 feet per second. The steam space of the boiler would be nearly emptied before the heat contained in the water could so far overcome the inertia of the water as to disengage additional steam. The steam which would rise from the water, carrying a great quantity of water with it, would strike with great velocity upon the upper part of the boiler, and, in my judgment, would be sufficient to rend the boiler in pieces, and project the broken parts to a great distance. I have always found that the most destructive boiler explosions were those where there was evidence of the usual supply of water. In discussing one of the experiments at Sandy Hook, in 1871, Prof. R. H. Thurston presented the following calculations of the energy stored up in the boiler, and of the work done by the liberated forces. The steam boiler referred to weighed 40,000 pounds, and contained about 30,000 pounds of water, and 150 pounds of steam in the steam space, all of which had a temperature of 301 degrees Fah., when, at the moment before the explosion, the steam pressure was 53½ pounds above that of the atmosphere. Prof. Thurston says: "When the explosion took place, the whole mass at once liberated its heat until it had cooled down to the temperature of vapor under the pressure of the atmosphere." I will not follow Prof. Thurston's calculations through, but he concludes that the maximum possible effect of these liberated forces was sufficient, had it acted in one direction, to have thrown the boiler more than five miles high. As it was, with the liberated forces acting in all directions, portions of the boiler were projected from 200 to 400 feet high.

I might continue this discussion at great length, for it is a most interesting subject, but time and space in this brief paper will not allow it. Sufficient, however, has been said to show the importance of buying good, honest, well-made boilers, of honest boiler-makers. Don't buy a boiler simply because it is cheap. A cheap-built boiler is dear at any price.

Another point is, have your boilers carefully inspected by competent men at stated periods. By such inspection incipient defects are discovered, which, if neglected, will sooner or later result in serious accident. It may not be improper for me to state in this connection that the company with which I am connected made guaranteed inspections of 62,000 boilers in the year 1896, and only eight exploded of the whole number. But we employ more than 200 skilled inspectors, who devote their entire time to this important branch of the company's business. It costs the company between $300,000 and $400,000 a year to maintain this inspection department, but, by it, the number of explosions is reduced to a very small percentage of the boilers inspected and insured. As I was requested by your secretary not to be too technical in this paper, I trust I have not erred in going too far the other way by being too elementary.

The Locomotive.

HARTFORD, MARCH 15, 1897.

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

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

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

WILLIAM E. PURDUE, who was injured on December 30th by a boiler explosion near Mt. Vernon, Ill. (see No. 333 in our list for December, in the February LOCOMOTIVE), died from the effects of his injuries on January 1st.

One account that we have received of boiler explosion No. 11, in the list given in the present issue, says that, "It is believed that the water-guages on the boiler had been tampered with, as surviving witnesses state that they had indicated a safe level of water, although it was noticed that the steam pressure ran up unusually high." Here we have the same old story. A boiler blows up, and nobody knows why. Later on it appears that there was plenty of water present, and then there springs up a harrowing tale of an inhuman miscreant who has broken into the boiler-house and "tampered" with something. The local sharps do not appear to suspect any connection between the explosion and the admitted fact that "the steam pressure ran up unusually high." They seem to think that so long as the water level is above the fire line, it is all right to pile on steam till the load on the boiler is millions of pounds to the square inch. And then when it blows up there is a mystery, and a romantic yarn in the newspaper about some black-hearted outcast of society creeping in through a crack and "tampering."

The Sea Mills of Cephalonia.

The wonderful sea-mills on the island of Cephalonia, near Greece, have attracted the attention of tourists for many years, and new interest in them will be aroused by a recent paper by F. W. Crosby and W. O. Crosby, originally published in the *Technology Quarterly*, and now partly reprinted in *Cassier's Magazine.*

Quoting from Baedeker's description of the town of Argostoli and its surroundings, the Messrs. Crosby say: "The first of these sea-mills is the one of Dr. Migliaressi, established in 1859, and one-fourth of a mile further on, at the north end of the peninsula, is the old mill, erected by Mr. Stevens in 1835, where we obtain a better view of the phenomenon whence the mills derive their name. The mills are driven by a current of sea-water, which flows into the land for about fifty yards through an artificial channel, finally disappearing amid clefts and fissures in the limestone rock. Authorities are not yet unanimous as to the explanation of this unique phenomenon."

This state of affairs — a current of water, running continuously, for many years, from the sea into the land and losing itself in fissures in the rock — can probably be paralleled nowhere else in the world. The constancy and size of the current is sufficiently indicated by the fact that mills have been erected there to utilize the water-power by means of large, under-shot wheels. Owing to the many improvements in the manufacture of flour, as well as to the building of large flouring mills at Patras and elsewhere, the sea-mills are no longer used, but are fast crumbling to decay. Yet the water still flows unceasingly from the sea into the land, and there is no sign of lessening in the flow.

In investigating the probable cause of the phenomenon, the Messrs. Crosby have estimated the quantity of water that flows through the channels in the course of a year. It was noticed, when the second mill was built, in 1859, that the power of the old mill was perceptibly diminished by it; that is, either mill had a more copious discharge, and therefore more power, when the other was not running. It is fair to conclude from this that the entire outflow from the two mills eventually finds its way into a common underground channel of rather limited capacity. The quantity of water that pours down through this channel in the course of a year is estimated at over 2,000,000,000 cubic feet. This would be sufficient to fill a cavern about five miles long, 1,000 feet wide, and 75 feet deep; or if the water runs into a fissure, say 10 feet wide, it must be about 10 miles long and 4,000 feet deep in order to hold one year's influx at this point. It will be seen that in order to explain the long-continued and still unabating flow of water, on the hypothesis that it is running into a hole that is still unfilled, but which one day *will* be filled, we should have to assume the existence of a cavern of vast and altogether improbable dimensions.

Réclus, in his book on *The Ocean*, takes the ground that the water is disposed of somehow by *evaporation*. "The calcareous rocks of Cephalonia," he says, "dried on the surface by the sea breeze and the heat of the sun, are pierced and cracked throughout by innumerable crevices, which are like so many flues, aiding the circulation of the air and the evaporation of the hidden moisture. We can compare the entire mass of the hills of Argostoli, with all their caverns, to an immense *alcarraza*,* the contents of which are gradually evaporated through the porous clay. In consequence of this constant loss of liquid, the level of the water is always lower in the caverns than in the sea, and to restore the equilibrium the brooklets, which are fed by the waves, descend incessantly by all the fissures towards the subterranean reservoirs. It is probable that the constant evaporation of the salt water has resulted in the accumulation in the cavities of the island of enormous saline masses. Professor Ansted has calculated that the discharge of the two great marine streams of Argostoli would be sufficient to form each year a block of more than 1,800 cubic yards of salt."

The evaporation theory seems far less probable than the theory proposed by the Messrs. Crosby, which may be called the "circulation theory." According to this theory, the sea-mill waters pour into a fissure which runs down into the earth's crust for, say, 2,000 feet, and eventually comes up somewhere at the bottom of the Mediterranean sea. It is known that the temperature of the earth increases as we go down, and the theory supposes that the subterranean heat to which the lower parts of the great sea-mill fissure are exposed is sufficient to raise the temperature of the water that it contains to an extent sufficient to cause an active circulation through the fissure, from one end to the other. The system so imagined is therefore much like a giant hot water heating

* [An alcarraza is a vessel made of porous, unglazed earthenware, and used in hot climates for holding water. The water oozes out through its pores and evaporates on the outside, thus keeping the vessel and its contents cool.—Ed.]

apparatus, in which the hot subterranean layers of the earth's crust play the part of the boiler. The *direction* of the circulation would evidently depend upon the shape of the fissure; and there is no reason why it could not occur precisely as observed at Cephalonia, with the cold water pouring into the fissure at the sea-mill end, and hot water coming out at the other end, somewhere on the bed of the sea.

The Messrs. Crosby have shown by means of reasonable assumptions concerning the depth of the fissure and the temperature of its various parts, that a "head" of ten feet could easily be explained by this theory; and such a head "is quite as much as the sea-mills call for."

Inspectors' Report.

JANUARY, 1897.

During this month our inspectors made 8,687 inspection trips, visited 17,486 boilers, inspected 5,651 both internally and externally, and subjected 379 to hydrostatic pressure. The whole number of defects reported reached 10,844, of which 1,222 were considered dangerous; 34 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	755	51
Cases of incrustation and scale,	2,024	85
Cases of internal grooving,	99	20
Cases of internal corrosion,	708	38
Cases of external corrosion,	568	46
Broken and loose braces and stays,	168	58
Settings defective,	274	34
Furnaces out of shape,	433	31
Fractured plates,	343	33
Burned plates,	275	51
Blistered plates,	217	7
Cases of defective riveting,	690	25
Defective heads,	72	20
Serious leakage around tube ends,	2,365	436
Serious leakage at seams,	467	46
Defective water-gauges,	426	84
Defective blow-offs,	115	34
Cases of deficiency of water,	21	15
Safety-valves overloaded,	75	28
Safety-valves defective in construction,	83	32
Pressure-gauges defective,	552	45
Boilers without pressure-gauges,	0	0
Unclassified defects,	114	3
Total,	15,844	1,222

WE referred, some time ago, in an article quoted from the *Scientific American*, to certain forms of oil and gas-engines in which the charge is ignited neither by a flame nor by the electric spark. Certain of our correspondents have assumed that this was an error; but we take this occasion to state that we still believe it to be strictly correct.

Boiler Explosions.

JANUARY, 1897.

(1.) — On January 1st a boiler exploded in Bowman's mill, at Tazewell, near Middlesboro', Ky. Jacob Brewer and Mrs. Joseph Neal were killed, and Oscar Neal was fatally injured. B. F. Bowman, owner of the mill, was also severely injured, and the mill was destroyed.

(2.) — A boiler in the flouring mill belonging to Greenham & Hargitt, of Manchester, near Lawrenceburg, Ind., exploded on January 2d, causing great damage to the building, and severely injuring John Whitaker, the engineer.

(3.) — One of the boilers in the Diamond Fire Brick Company's plant, at Akron, Ohio, exploded on January 4th, wrecking the power house. Nobody was injured, but the property loss was considerable.

(4.) — On January 4th a boiler exploded in a mill belonging to Mr. M. J. Healey, at Hazel Hurst, a small town some ten miles north of Bradford, Pa. Charles S. Cole was almost instantly killed, and Martin Delmage was fatally injured. Three other men also received serious injuries, and the mill was demolished.

(5.) — On January 6th a boiler belonging to the Fisher Oil Company, on the Davis-Howell farm, near Sistersville, W. Va., exploded with great violence. Samuel Bigler and William Austin were killed, and James Nolan and Charles Hinkle were seriously injured. Nolan may not recover.

(6.) — Andrew B. Strain was killed by a boiler explosion, on January 9th, near West Plains, Mo. Several other persons were also injured.

(7.) — A slight accident to the boiler of the tug *Rosaline*, of Chicago, Ill., on January 9th, due to low water, resulted in the serious injury of Eugene Howard and James O'Malley. Mr. Howard may not recover. The damage sustained by the tug was slight.

(8.) — On January 9th a boiler exploded in the Peerless Rubber Works at New Durham, North Bergen, N. J. John Meadama, a fireman, was fatally scalded. The roof and south wall of the boiler-house were carried away, and the east and north walls were also wrecked.

(9.) — By the explosion of the boiler of a steam threshing engine belonging to Edward Maxson, on the farm of Frank Sargent, two miles west of Marshall, Minn., on January 12th, Fireman Daniel Murphy was instantly killed, and Stephen Barnes, Peter Walker, and one other man, were seriously injured.

(10.) — A boiler exploded, on January 12th, in George Greiner' grist mill, about five miles east of Harbor Springs, Mich. All the employés were at dinner, and nobody was hurt; but the mill was totally demolished.

(11.) — On January 12th a boiler belonging to James Danes, of Miller's Run, near Portsmouth, Ohio, exploded with great violence. Elijah Hickman and James Snyder were killed, and John Glassburn was fatally burned and crushed. James Hickman and William Wagner were also badly injured by flying debris.

(12.) — On January 14th one of the boilers at Brown's mill, on Tenth street, Pittsburgh, Pa., exploded, but did very little damage. Two laborers who were working in the vicinity at the time were slightly injured by flying bricks.

(13.) — A boiler belonging to the Iron City Sand Company, of Pittsburgh, Pa., exploded during the noon hour on January 14th. The boiler was used for pumping water out of the Monongahela river, and was located 200 feet east of the south pier of the South Twenty-second street bridge. Owing to the time at which the explosion occurred there was no loss of life.

(14.) — A boiler exploded, on January 16th, in J. P. Farris' cotton mill and gin, near Elkhart, Tex. C. W. Burleyson was fatally bruised and scalded, and a son of the owner of the plant was severely scalded, but will recover. The building and machinery were totally wrecked.

(15.) — On January 19th a boiler exploded in the cotton gin owned and operated by J. R. Lanius, of Harrisonburg, La. Nathaniel Ewings was killed, and his body was blown across a neighboring bayou. The gin house and machinery were completely wrecked.

(16.) — A boiler in the Clear Creek mill, situated near Pollock, La., and owned by Messrs. Seiss & Serin, exploded on January 19th, killing the engineer (whose name we do not know), and also Fireman James Stringer, whose body was blown to pieces. Willis Whateley was badly scalded, and one of his eyes was put out. The building and machinery were entirely wrecked, and everything within a radius of several hundred yards was destroyed.

(17.) — On January 20th a boiler exploded in the pumping station at Evans & Howard's steam brick yard, at St. Louis, Mo. John Palmour, the fireman, was fearfully injured, so that he died on the 28th.

(18.) — One of the boilers connected with the natatorium at Marlin, Tex., exploded on January 22d, causing a considerable property loss. Angeline Anderson, one of the attendants in the women's department, was considerably bruised, but otherwise there were no personal injuries. A part of the cast-iron boiler was thrown up through the floor into the women's bathroom, completely demolishing the floor in that department. Three of the walls of the basement in which the heating apparatus is located were wrecked, and the foundation of the building on that side was displaced.

(19.) — A boiler exploded on January 23d in the Florida Southern Railway machine shops at Palatka, Fla. Engineer George Patten was instantly killed, and Edward Kummer, a carpenter, was fatally injured. George Eville also received a compound fracture of the leg. The shops were wrecked, and the explosion shook every building in the city to its foundations.

(20.) — A boiler used in connection with Reinhard Gans' barber shop, at Wheeling, W. Va., exploded with a terrific report on January 25th. The boiler was situated in a small shed in the rear of the main building, and the damage done by the explosion was small. Nobody was near at the time.

(21.) — The boilers of the tug-boat *Myrtle*, owned by Robinson Bros. and used on Latinash Bayou, near Melville, La., blew up on January 25th while the *Myrtle* was being coaled at the foot of Turnbull Island. Fireman William Stapleton was killed instantly, and a deck hand named O'Nealy was fatally injured.

(22.) — A boiler explosion occurred on January 25th, near Mexico, Mo. Sterling Brown was instantly killed, and John Brown, his brother, was frightfully scalded, so that he cannot recover.

(23.) — The boiler of a traction engine exploded on January 26th, two miles north of Delta, Ohio, on the farm of A. B. Thompson. Lee Dunbar and Frank Hatfield, who were near by at the time, were knocked down and slightly injured.

(24.) — The boiler of a locomotive attached to a freight train exploded at Abbott, Tex., on January 28th, killing W. L. Seaman, the fireman.

(25.) — A boiler belonging to Dickerson Bros., of Fairmont, W. Va., exploded on January 30th, completely demolishing the mill in which it stood, blowing in the end of Reid's marble shops, and the side and roof of Joseph Seece's residence. The boiler itself also passed through both sides of the residence of Joseph Cordray. Fortunately, the accident occurred during the noon hour, and no one was hurt. Mr. Seece's family had just left the dining-room when a piece of iron weighing about 200 pounds crashed through the roof and demolished the table at which they had been sitting.

(26.) — Two boilers exploded, on January 30th, in W. T. Lott & Co's mill at Duke, near Waycross, Ga. Two workmen were badly injured, and the boiler-house was demolished. A locomotive engine which was standing near by was also damaged.

Miscellaneous Accidents from the Use of Steam.

Word has been received from Singapore, under date of December 8th, of a terrible boiler explosion at Singkep. The Sultan of Lingga had been staying there for some days, having business to transact, and in the morning boarded his yacht *Langjut* to return to Singkep. Just before starting, however, the boiler of the yacht burst, killing seven men instantly, and severely injuring several others. The Sultan himself was badly scalded.

The French collier *Madeleine* arrived in San Francisco, on January 22d, from Callao. One of the boilers exploded soon after the steamer left Callao, killing five men and injuring several others. She put into Acapulco for repairs. The voyage was an unfortunate one, throughout; for after leaving Acapulco Chief Engineer Obe shot and stabbed Chief Officer Diamond in the course of a quarrel, and the *Madeleine* was obliged to return to port, to put Diamond in the hospital, and turn Obe over to the Mexican authorities.

On January 25th a water-back exploded in a stove in the Timlin hotel, at West Superior, Wis. Nina King and Pedro O'Donnell were seriously injured. The windows of the building were blown out, and the kettles, it is said, "have not yet been found." A portion of the stove was blown through the ceiling of the kitchen, into the room above.

Word has been received from Valparaiso, Chile, stating that on February 12th a boiler exploded on the Chilean gunboat *Gaviota*, at Lachauno. Five men were killed, and eight others were injured.

A recent English newspaper records the destruction, by fire, of the laboratory and works of Cox, the electrician, near Manchester, Eng. Mr. Cox was formerly a Hartford man, and has been engaged for a number of years in the study of thermo-electricity, in the hope of producing a practical generator which shall transform heat-energy into electrical energy, without the mediation of a steam engine and dynamo. The difficulties that beset a worker in this field can hardly be understood by the uninitiated, but Mr. Cox has struggled with them earnestly, and had great hopes of shortly overcoming them all. The fire that has now leveled his plant has also destroyed his apparatus, as well as the records of his experiments. He will have the profound sympathy of all who learn of his loss.

The Locomotive.

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The Riveting of Re-enforcing Rings.

An article on the re-enforcement of stock-hole openings in rotary boilers, which we printed in the December number of The Locomotive, has aroused a considerable interest in the subject, and we have received a number of letters asking for further information concerning it. The leading question in most of these letters is: In what way should the re-enforcing ring be riveted to the shell? This feature was not discussed in our December issue, as the main point which we wished to emphasize was that the rings, as ordinarily put in, are often altogether *too small.* There is less fault to be

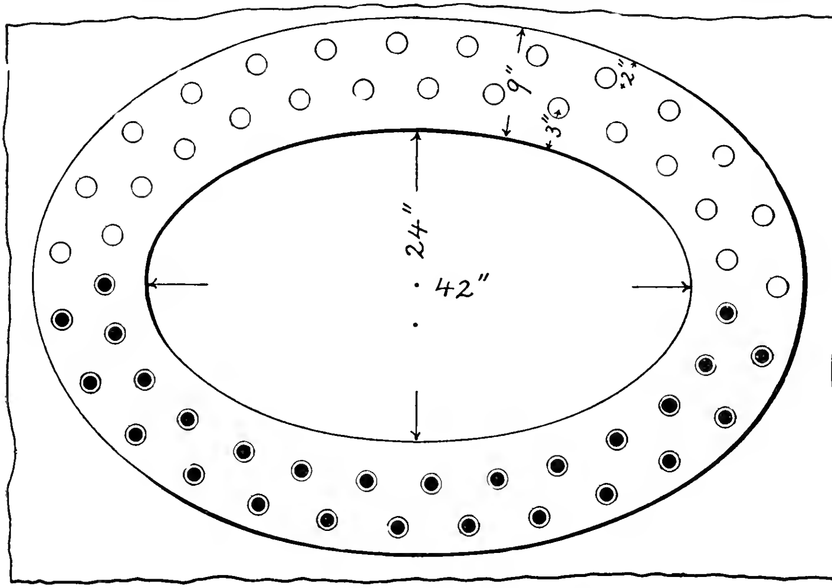

Fig. 1.—A Correctly Riveted Ring.

found with the riveting, as a usual thing, than with the size of the ring; and hence we confined ourselves to a discussion of the ring alone. In the present article, however, we shall consider the proper mode of securing the rings to the shell.

The general principle that should be observed in designing all kinds of structures and machines is to make all of their parts or elements *equally strong.* In the present case the boiler may fail by breaking across the ring, or by shearing free from the ring; and hence our general principle of equal strength shows that the riveting should be so designed that the tensile strength of the ring is just equal to the shearing strength of the rivets that would have to fail in case the ring should shear free from the shell.

In Figs. 2 and 3 we have shown how the shell can free itself from the rings by shearing the rivets. We have shown a *double* ring in these cuts, half of it being inside the boiler and the other half outside; this being, in our judgment, the best way to arrange the re-enforcing material. It will be seen that in order that the shell may free itself from the ring as shown, it will be necessary to shear all the rivets that lie on one side of the center line of the boiler. That is, it will be necessary to shear *one-half of the total number of rivets in the ring.* The advantage of making the ring in halves, one half being inside the boiler and the other half outside, will also be seen; for it is plain

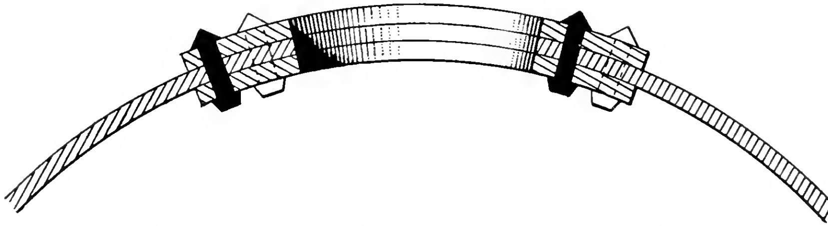

FIG. 2.—SECTIONAL VIEW OF RING, BEFORE FAILURE.

that with the material disposed in this way, each rivet must be sheared *twice;* whereas, in case the ring is made in a single piece, and secured to the shell either inside or outside, the rivets will only have to be *single* sheared.

Referring back to the numerical example given in our December issue, let us find out what arrangement of rivets will fulfil the desired conditions of making the rivet-area equally strong with the ring itself. By applying the rule there given, we found that a stock-opening 24″ wide and 42″ long would be sufficiently re-enforced by a pair of steel rings, each of which is nine inches wide and seven-eighths of an inch thick. In determining the tensile strength of this ring, we must allow for the loss in net section due to the rivet-holes. If a ring such as that shown in Fig. 1 were to break

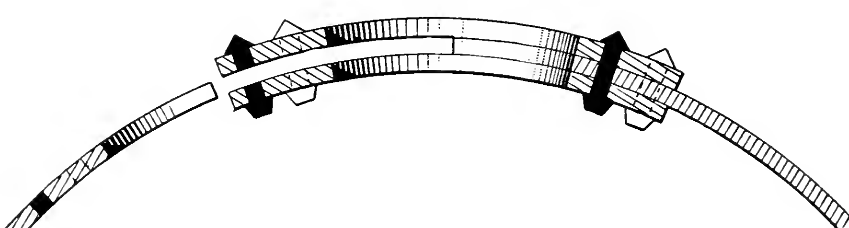

FIG. 3.—SECTIONAL VIEW OF RING, AFTER FAILURE.

across, there is a strong probability that the fracture would pass through two of the rivet-holes; and hence, in figuring the strength of the ring, we must deduct, from the width of the ring, the diameter of two rivet-holes. Let us assume that a 15-16″ rivet is to be used, and that the diameter of the rivet-holes is to be one inch, as these will be convenient sizes in practice. Then the net width of the ring, after allowing for two rivet-holes, will be $9'' - 2'' = 7''$. The thickness of each ring being $\frac{7}{8}'' = 0.875''$, the net sectional area of one ring is $7 \times .875 = 6.125$ square inches. Each ring must be broken in two places in order for the boiler to separate, and hence the total effective area that must be fractured is $2 \times 6.125 = 12.25$ square inches in each ring. Furthermore, there are *two* of these rings; and so the *total* area of ring-section that must be fractured is $2 \times 12.25 = 24.50$ square inches. The rings being made of high-grade steel of 60,000 pounds tensile strength, we find, as the total tensile strength of the rings,

$$24.50 \times 60{,}000 = 1{,}470{,}000 \text{ pounds,}$$

and hence the number of rivets used must be such that the combined shearing strength of all the rivets along one side of the opening is 1,470,000 pounds.

After the rivets are driven, they will be one inch in diameter, and the area of a one-inch circle being 0.7854 sq. in., the shearing area of each rivet will be 0.7854 sq. in. The shearing strength of good rivet iron being 38,000 pounds per square inch, the shearing strength of each of these rivets is

$$.7854 \times 38{,}000 = 29{,}845 \text{ pounds.}$$

Now this is the strength of a rivet that is to be *single sheared.* In the form of ring shown in our December issue, each rivet must be *double* sheared, or sheared in two places at once; and hence each rivet, in this construction, offers a total resistance much greater than the 29,845 pounds indicated by the foregoing calculation. It would be natural to assume that a rivet that must be sheared in two places at once is *twice* as strong as a rivet that is to be sheared only in one place; but this is not quite the case, since experiment shows that the strength of a rivet in double shear is only 1.85 times as great as the strength of one in single shear.* Taking this fact into account, we find that each rivet in the present case offers a total resistance to shear of

$$29{,}845 \times 1.85 = 55{,}213 \text{ pounds.}$$

To find the total number of rivets required to give the necessary shearing strength, we have, therefore, merely to divide 1,470,000 pounds by 55,213 pounds, and we find

$$1{,}470{,}000 \div 55{,}213 = 26.6 \text{ rivets,}$$

or (say) 27 rivets. As has already been explained (and as may be seen by reference to Figs. 2 and 3), this is the number of rivets that must be provided *on each side of the center line of the boiler;* and hence the total number of rivets required is $2 \times 27 = 54$.

In Fig. 1 we have shown how these rivets may be advantageously distributed. The center line of the inner row of rivets is placed 3″ from the inner edge of the opening, in order to leave space enough for the cover-plate. The outer row of rivets is placed 2″ from the outer edge of the ring, as this gives a good disposition of rivets, and offers a strong form of joint. (The 27 rivets whose failure would allow the shell of the boiler to fracture at the ends of the stock-hole, as shown in Fig. 1 in our December issue, are indicated, in Fig. 1 in the present issue, by the black circles.)

It must be carefully borne in mind, in applying the method of calculation here given, that this method is only applicable when the re-enforcing ring is *made in two parts,* one inside of the boiler and the other outside; for it is this mode of construction which causes the rivets to be exposed to *double shear.* If the ring is made in only one piece (as is often the case), the rivets are only exposed to *single shear,* and we can then allow only 29,845 pounds as the strength of a 15-16″ rivet when driven in a 1″ hole. In case the ring is *single,* the number of such rivets that would be required would be

$$1{,}470{,}000 \div 29{,}845 = 49 \text{ rivets}$$

on each side of the opening, or $2 \times 49 = 98$ rivets in all. If these 98 rivets were driven *in two rows,* the pitch, or distance from rivet to rivet, would be too small to give a good form of joint; and if rivets of the size given above were to be used, it would be better,

* See THE LOCOMOTIVE for July, 1891, page 102.

so far as the pitch is concerned, to arrange them in *three* rows, with 33 in each row. A disposition of this sort, however, would be objectionable from another point of view, as will be seen by the following considerations: The ring has been so proportioned that its total sectional area is *at least* equal to the sectional area cut away from the boiler shell, along the length of the stock-hole. Now, if holes are drilled or punched through the ring, for rivets, the net section of the ring is thereby reduced, and the ring itself is correspondingly weakened. Speaking in the language used for riveted joints, we may say that the *efficiency* of the ring is lessened by the rivet-holes; and we may find the efficiency of the ring in any given case precisely as we do in riveted joints, by dividing the net section of the ring (taken along the weakest line) by the sectional area of the solid ring. The efficiency so found should not be less than the efficiency of the joints which unite the shell plates of the boiler to one another. In the case shown in Fig. 1, the fracture would be most likely to pass through *two* rivet-holes; and hence the *length* of the fracture would be $9'' - 2'' = 7''$ (leaving out of account the *obliquity* of the crack where it passes from one rivet-hole to the next, which we may do, since we shall thereby err on the safe side). A fracture of the solid ring would be 9″ long; so that the "efficiency" of the ring, so far as the weakening effect of the rivet-holes is concerned, is $7'' \div 9'' = 0.77$, or 77 per cent., and this would be permissible for a boiler whose shell plates are double riveted, because the 77 per cent. efficiency of the ring would be at least as great as the efficiency of the shell joints. On the other hand, if there were *three* rows of rivets, the fracture would be likely to pass through *three* rivet-holes, and its length would therefore be $9'' - 3'' = 6''$ (omitting the obliquity of the fracture as before). Hence the efficiency of the ring would be reduced to $6'' \div 9'' = 0.66$, or only 66 per cent., which is a smaller efficiency than a good job ought to have.

The results that we have reached, thus far, may be summarized thus: A pair of re-enforcing rings, each 9″ wide and $\frac{7}{8}''$ thick, can be secured to a stock-opening of the proportions shown in Fig. 1 by means of 54 rivets driven in 1″ holes, and arranged in two rows; for the shearing strength of this construction is ample, and the "efficiency" of the ring, where cut away by the rivet-holes, is at least as great as the efficiency of the joint by which the shell plates are united. On the other hand, if the re-enforcing ring is made *in one piece*, instead of in halves, the joint shown in Fig. 1 would not do at all, since the rivets are then only in *single shear*, and the combined shearing strength of the 54 rivets is far too small. If one-inch rivet-holes are to be used, we should have to provide at least 98 rivets to secure the necessary shearing strength, and these would have to be disposed in three rows, of 33 rivets each. But the efficiency of the ring, with three rows of such holes, would be reduced to 66 per cent., which is somewhat too small; and hence we conclude that when the re-enforcing ring is made in one piece, a good joint cannot be had with rivets of the size heretofore assumed. If the rivet-holes were $1\frac{1}{4}''$ in diameter, a better joint may be realized in this case. The sectional area of each rivet, when driven, would then be

$$1.25'' \times 1.25'' \times .7854 = 1.227 \text{ sq. in.},$$

and the shearing strength of one rivet would therefore be

$$1.227 \times 38,000 = 46,626 \text{ lbs.}$$

Hence, proceeding as before, we find that the number of rivets on each side of the stock-hole must be

$$1,470,000 \div 46,626 = 31.5,$$

or (say) 32 rivets; and the whole number of rivets must therefore be 64. If these are arranged in two rows, the resulting pitch will be sufficiently wide; and the efficiency of the ring will also be satisfactory, as will be seen from the following calculation: The diameter of one hole being 1.25″, the combined diameter of the two holes through which the fracture will probably pass is 2 × 1.25″ = 2.50″; and hence the length of the fracture (still omitting its obliquity) is 9″ — 2.50″ = 6.50″. Then, the width of the ring being 9″, we have, as the "efficiency" of the ring, 6.50″ ÷ 9″ = 0.72, or 72 per cent., which is as great as the efficiency of the shell joints (assuming them to be double-riveted).

In presenting this article, we have aimed to *illustrate* the mode of designing a re-enforcing ring, rather than to give a hard-and-fast rule for doing it. Such a rule could be given, but unless it were made rather lengthy (and, therefore, hard to understand and hard to use), it would be apt to be misleading, since it would be likely to be applied to cases that it was not designed to cover. We cannot, of course, in an article of the present length, go into this subject at all exhaustively: but we have presented the general ideas in the hope that they may serve to clear up some of the mystery that seems to surround the re-enforcing ring in the minds of some of our correspondents. In conclusion, let us say that as a rule re-enforcing rings have too small a cross-section to give the requisite strength, and that they are often *too narrow* to allow of proper riveting, consistently with a due regard to preserving a net section of ring sufficient to ensure a "ring-efficiency" which shall be at least as great as the efficiency of the shell joints.

Inspectors' Report.

February, 1897.

During this month our inspectors made 7,779 inspection trips, visited 15,650 boilers, inspected 5,025 both internally and externally, and subjected 431 to hydrostatic pressure. The whole number of defects reported reached 8,404, of which 751 were considered dangerous; 39 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	609	37
Cases of incrustation and scale,	1,564	50
Cases of internal grooving,	58	7
Cases of internal corrosion,	527	16
Cases of external corrosion,	584	35
Broken and loose braces and stays,	156	40
Settings defective,	223	45
Furnaces out of shape,	305	33
Fractured plates,	200	33
Burned plates,	189	20
Blistered plates,	97	6
Cases of defective riveting,	922	20
Defective heads,	53	12
Serious leakage around tube ends,	1,406	161
Serious leakage at seams,	381	34
Defective water-gauges,	305	39
Defective blow-offs,	158	49
Cases of deficiency of water,	10	6
Safety-valves overloaded,	43	17
Safety-valves defective in construction,	77	40

Nature of Defects.	Whole Number.	Dangerous.
Pressure-gauges defective,	440	47
Boilers without pressure-gauges,	4	4
Unclassified defects,	93	0
Total,	8,404	751

Boiler Explosions.

FEBRUARY, 1897.

(27.) — On February 1st a boiler exploded near Carrollton, Ohio, blowing Samuel Morrison through a partition and fatally injuring him. James Cartwright was also seriously injured.

(28.) — On February 2d a terrible boiler explosion occurred in Brister & Co.'s big mill at Bogue Chitto, ten miles south of Brookhaven, Miss. Simpson Scott, John Branning, and Nelson Buchanan were instantly killed, and Thomas McGhee, James McCaffery, Commodore Smith, Peter Goodwin, and Susan Buchanan were terribly scalded. It is thought that McCaffery cannot recover. The mill was wrecked, and fragments of the debris were scattered for half a mile around.

(29.) — By the explosion of a boiler at Strattonville, Clarion County, Pa., on February 3d, Pierce Taylor was instantly killed, and Thomas Lohr was fatally injured. The mill in which the boiler stood was totally destroyed.

(30.) — A boiler exploded, on February 4th, in C. A. Pin's phosphate mill at Fort White, near Jacksonville, Fla. We have not learned particulars.

(31.) — On February 6th a boiler exploded in a feather renovating establishment at Olin, near Vinton, Iowa, badly injuring Frank Woods.

(32.) — A boiler exploded, on February 6th, on the ferryboat *Columbia*, plying between Brooklyn and New York. None of the passengers were harmed, but several of the crew were injured.

(33.) — A boiler exploded, on February 8th, in the Odessa chair factory, near Toronto, Canada. The building was wrecked, and some damage was done to a schoolhouse next door.

(34.) — John Pollock was killed, on February 9th, by the explosion of a boiler near Concordia, Ky. We have not learned the details.

(35.) — A boiler belonging to Charles Bush exploded, on February 9th, near Canal Winchester, Ohio. George Bush was blown fifty or sixty feet, but was not seriously injured. His father was bruised somewhat by flying timbers, and his recovery is doubtful.

(36.) — A boiler in the county jail at Frankfort, Ky., exploded on February 9th, completely demolishing the boiler-room and the office, which was directly above it. James Rodgers, a contractor, was fatally injured. Cabell Hardin, Judge T. B. Bullock, Deputy Jay Robinson, Dr. Alvin Duvall, and Capt. Leon Hill were also injured, though not fatally so. The explosion shook the city for squares away. At first it was thought that the entire building had been wrecked and many people killed; but the second and third stories, comprising the prisoners' apartments, merely received a bad shaking up, and none of the prisoners were hurt.

(37.) — A nest of boilers in the gang mill of Simpson & Co., at Bagdad, twenty miles east of Pensacola, Fla., exploded on February 9th, killing Paul Raymond, and scalding Adam Riley severely and perhaps fatally. The mill itself was badly damaged.

(38.) — John Lewis and one other man were killed, on February 10th, by the explosion of a boiler in Wyrick Bros.' mill, at Magnolia, Ark. John Wyrick and Calhoun Wyrick were fatally scalded, and four other persons were injured more or less seriously, one of them perhaps fatally so. The property damage amounted to about $5,000.

(39.) — A boiler exploded at Weathersfield, near Youngstown, Ohio, on February 11th, at William Lee & Co.'s slope. John Wollick was killed, and J. G. Vetter, Jr., and Leslie Kyle were seriously injured. The boiler was two-thirds full of water at the time, and was carrying 75 pounds of steam. The district mine inspector had examined the mine and machinery only the day before, and as he went away his last words were: "You have a nice plant here, and I wish you success."

(40.) — A boiler in the Nettie Morgan shaft of the Big Six Mining company, near Leadville, Col., exploded on February 12th, blowing the boiler-house to pieces and damaging the machinery. Nobody was hurt. The engineer was in the shaft-house at the time, but he fortunately escaped injury. Eight or ten men, who were in the mine, escaped by means of a ladderway.

(41.) — A small boiler exploded, on February 13th, in Max Grabowsky's bicycle repair shop, at Detroit, Mich. Mr. Grabowsky was painfully, but not seriously hurt.

(42.) — A boiler exploded, on February 15th, at the Galena mine, Central City, Colo. The west end of the building in which the boiler stood was wrecked, but nobody was injured.

(43.) — A boiler exploded, on February 16th, near Oglesthorpe, Ga., and a mass of machinery, weighing 9,000 pounds, was blown 100 yards and half buried in a hillside. Nobody was hurt.

(44.) — On February 17th a boiler exploded in John Massey's saw-mill, some three miles west of Lansing, Tenn. Fireman Hughes was killed. L. S. Howard had both legs broken and was badly injured about the head, so that he is not expected to live. The owner of the mill had a leg broken, and his son was slightly hurt. Mark Howard was fearfully injured about the shoulder, and John Anderson was badly scalded about the face.

(45.) — A small portable boiler, used for supplying steam and hot water for Hamill & Montgomery's slaughter-house at Newark, Ohio, exploded on February 17th. The boiler was located just outside of a brick building, about eight feet from the wall. It blew a hole about 15 feet square in this wall, went up in the air some 50 feet, struck the ground, and, rebounding, it crashed into a neighboring kitchen. The owner of the damaged kitchen was in the yard, about thirty feet from the boiler, when it exploded. He says he felt no shock, but that it seemed as though an immense force was bearing down on him from above, forcing him down on his knees. Where the boiler stood the ground was not even broken. Nobody was hurt.

(46.) — A boiler exploded, on February 18th, in the saw-mill of J. S. Hyre, at Montrose, on the West Virginia Central & Pittsburgh Railway, twelve miles from Elkins, W. Va. J. S. Hyre, the owner, was instantly killed. J. V. Johnson was scalded so badly that he will not recover. Lloyd Hyre, Lake Cross, Joseph Wolf, and two brothers by the name of Polling were badly injured. The mill was totally wrecked.

(47.) — A boiler exploded, on February 19th, in George Bowen's grist-mill, five miles northeast of Attica, Ohio. Ragan Merling was badly burned and bruised, and Mr. Bowen was himself injured, though to a lesser degree. The building in which the boiler stood was blown to pieces.

(48.) — A boiler exploded, on February 20th, in the Glenside Woolen Mills, at Skaneateles, N. Y. William Major, Sidney Slater, Prof. Jay M. Whitham, and Mr. James H. Huxford were badly scalded and otherwise injured. Mr. Huxford may lose his eyesight. Prof. Whitham is the well-known writer on boilers and engines, whose book on "Constructive Steam Engineering" we reviewed some time ago. He had been retained by the Glenside company to test the boiler that exploded.

(49.) — A boiler exploded, on February 20th, in the flouring-mill at Cadiz, near Charleston, W. Va. James King and Daniel Welch were killed, and William Clark, George Clark, and two other men, whose names we have not learned, were injured. The mill was completely wrecked, and pieces of the boiler were blown 300 yards. The residence of J. M. Sanford, a short distance away, was partially wrecked, but none of the inmates were hurt.

(50.) — On February 22d a boiler exploded in White's saw-mill, at Mt. Victory, near Kenton, Ohio. William Gardner, the engineer, was seriously and perhaps fatally in-ured. Several other employes were injured to a lesser extent, and the mill was partially wrecked.

(51.) — On February 24th a boiler exploded in Kimmell Bros.' big planing-mill at Bluffton, Ohio. Engineer Abraham Shook and William Kimmell (one of the owners) were fatally injured, and Edward Cramer was also badly injured, though it is thought that he will recover. The explosion shattered the boiler-house and badly damaged the main building.

(52.) — A boiler belonging to David Anderson, of Alikana, Ohio, exploded on February 26th. No person was injured. The explosion damaged a neighboring church to some extent.

(53.) — A boiler exploded, on February 27th, in J. R. Templer & Co.'s mill at Bethany Church, some five miles from Hartwell, Ga. Steven Norman, the engineer, was instantly killed, and J. M. Partridge was badly injured.

(54.) — The boiler-house, harness-shop, and cloth-room of the Acushnet mills, at New Bedford, Mass., were wrecked by a boiler explosion on February 27th. Manuel M. Matthias and Arthur Aspin were killed, and George Howard, Manuel Enos, Edward Sylveiria, John King, Manuel Medade, and Joseph Lambert were seriously injured. Fire followed the explosion, and much damage was done by it. The property loss from the explosion alone was at least $15,000, and that from the fire was probably as much more.

The steam-chest of a 500 horse-power engine in Ashly & Bailey's silk mills, at Columbia, Pa., exploded on October 28th. John Allison, the engineer, Ralph Hale, fireman, and Frederick G. Erfin, the purchasing agent of the company, were in the mill at the time, and were all severely injured and burned by the steam. The damage amounts to about $5,000.

Miscellaneous Accidents from the Use of Steam.

At an early hour on the morning of February 14th an iron tallow tank exploded with disastrous effect in the large packing-house of B. Franz & Bros., situated just outside of the limits of the city of Springfield, Ill. The walls of the building and two smoke-stacks were blown down, and the machinery in the entire plant was badly damaged. The bottom of the exploded tank was found four hundred feet from the ruins, buried four feet in the ground. No lives were lost, but three men had close calls for their lives. Engineer Albert Krimmell and John Torr, his helper, were buried in the ruins. The fireman, John Diefenbach, ran to the nearest farm-house to get help. While he was gone Kimmell got himself free, and succeeded in extricating his companion. Both men were badly bruised, and Kimmell's face was scalded. The property loss will approximate $10,000.

Word has been received from Tacahuano, Chile, by way of Valparaiso, that a boiler on the Chilean gunboat *Gaviota* exploded about February 10th, killing five persons and injuring eight others.

Here is another one of those "fiendish attempts" to blow up a boiler, which the newspapers love to tell about, but which are seldom or never true: The Detroit, Mich., *News*, in its issue for February 16th, says: "Whitney Wells, who contracted to put in the intake-pipe extension at Oak Grove, near Bay City, Mich., reports a dastardly attempt to blow up the boiler during his absence. The water-gauge had been stopped up, showing a pressure of 20 pounds of steam [!], and the water drawn off the boiler. The fireman built a hot fire, and soon discovered that the boiler was red-hot. He opened the valves and put the fire out. The boiler is almost ruined." We venture to suggest that Mr. Whitney Wells gets one of those new kinds of water-gauges that shows where the water is, and doesn't bother itself about showing 20 pounds of steam when the boiler is cold. We also suggest that he puts a flea in his fireman's ear, and instructs him to find out whether he has got any water in his boiler or not before he goes to building fires under it. We guess that if these things are attended to, we shall not hear much from Oak Grove about any further "dastardly attempts."

On March 21st, as the Lake Shore fast train, which left Chicago at 10:30, was pulling out from the depot at Englewood, Ill., at a speed of twenty miles an hour, the boiler of the locomotive exploded. Alexander Franks and Edward B. Smith were killed, and the locomotive was totally destroyed. This explosion came to the notice of a certain Professor Herbert W. Hart, an English food reformer, who came to America to promulgate a dietary by which he claims that the period of human life will be much prolonged, and we hear that he is now giving his spare moments to an attempt to devise some automatic arrangement to prevent boilers of locomotives from exploding. "I have been under the impression," says the professor, "that such explosions were rendered impossible by the tubular boiler system. Notwithstanding the opinion of the railway officials that the explosion could not have been due to want of water, because the engine had only recently left the round-house, in my opinion a want of the necessary water was the sole cause, as the steam could not have had its power without having a space that should have been reduced by pressure of the water." It is more or less evident, if the professor is quoted correctly, that he doesn't know so much about boilers as he does about food reform. We hope, of course, that he may devise some way to prevent boiler explosions; but our candid opinion is that he would do better to stick to his doughnuts.

The Locomotive.

HARTFORD, APRIL 15, 1897.

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

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

The fund raised by subscription for the relief of those who suffered by the boiler explosion in the office of the Detroit *Evening Journal*, which was illustrated and described in The Locomotive for April, 1896, amounted to almost $27,000. The report of Mr. F. C. Harvey, secretary of the relief committee, showed that the total number of deaths from the explosion was 40.

Agency Changes.

A number of changes have been recently made in the agencies of the Hartford Steam Boiler Inspection and Insurance Company. Mr. Curtis C. Gardiner, Jr., has been appointed Assistant General Agent in the Southwestern Department. Mr. Gardiner is a son of Col. C. C. Gardiner, our present General Agent for that department, and will have his office in St. Louis. Mr. James W. Arrott has been appointed General Agent for the county of Allegheny, Pennsylvania. His office is at Pittsburgh. Mr. Benjamin Ford is Chief Inspector for the same district. Mr. Scott R. Benjamin, who has been for a number of years head book-keeper in our Hartford office, has been made General Agent for the Home Department, with his office at Hartford, Conn. Mr. James L. Foord has also been made Chief Inspector for our Northwestern Department, his office being in Chicago. Mr. Foord has been in the employ of this company for a considerable time, and for the past six years has been connected with the inspection service in our Northeastern Department at Boston.

Obituary.

Mr. Nelson Hollister.

Mr. Nelson Hollister died, on March 2d, at his home on Grove street, Hartford, Conn. He was born at Andover, Conn., on February 12, 1810. He came to Hartford when a young man, and about 1840 he engaged in business on Front street, where he laid the foundation of a large fortune. He sold the business out, in 1867, to Henry Albro, and since that time he had not been actively engaged in any kind of business. Mr. Hollister was a director of the Charter Oak Life Insurance Company, and was at the same time superintendent of the large building owned by that company, in which the Hartford Steam Boiler Inspection and Insurance Company now has its home offices. While a director of the Charter Oak Company, Mr. Hollister became interested with Mr. James C. Walkley in the construction of the Hartford & Connecticut Valley Railroad and became the first treasurer of that road. At the time of his death he was President of the Cedar Hill Cemetery Association, and a director in the State Bank, the Ætna Insurance Company, and the Hartford Steam Boiler Inspection and Insurance Company. Mr. Hollister was a man of venerable appearance, with white hair and beard ; and his familiar figure on the streets will be missed by a wide circle of acquaintances.

The *Report* for 1895 of Chief Engineer Francesco Sinigaglia, of the Naples Associazione fra gli utenti di caldaie a vapore, is at hand, and we take pleasure in certifying that Cav. Sinigaglia knows a good thing when he sees it, as he has taken some half dozen illustrations from The Locomotive, for the delectation of his constituents. We are gratified at the compliment that he pays us, but we should have preferred to see ourselves explicitly mentioned as having had some connection with these illustrations, at a former time. It may be, however, that this is a mere vanity, and that the matter with us is, that we are like Mr. Insect O'Connor, who burned with an unquenchable desire to "get his name in de pape'."

We have received from the publishers a copy of a work on *Steam Boilers* written jointly by Professors Cecil H. Peabody and Edward F. Miller, of the Massachusetts Institute of Technology. Considered as a whole, it is a very good book, and although, as the authors have said, it is "intended primarily for the use of students in technical schools and colleges," we feel sure that they are justified in their hope, also expressed in the preface, "that it may be found useful to engineers in general." One excellent feature about the book is, that it represents our distinctively American practice rather better than some of the other volumes on the same subject that have appeared in recent years. We are credited on page 72 for certain cuts that are used in the text ; but we fancy that we can see traces elsewhere in the book of the influence of The Locomotive ; — on page 270, for example. But accidents *will* happen in the best regulated books, and we are not complaining too loudly about it in the present case. (John Wiley & Sons, 53 East Tenth street, New York. 380 pages, 140 cuts, and 5 plates ; cloth, $4.00.)

Mr. F. R. Hutton, who is Secretary of the American Society of Mechanical Engineers and Professor of Mechanical Engineering in Columbia University, has written an excellent book on *The Mechanical Engineering of Power Plants*, from a point of view that is somewhat different from that adopted by most of the recent writers. He has mostly avoided mathematical discussion, and has endeavored to bring out more prominently "those principles underlying successful practice which cannot be conveniently expressed by mathematical formulæ," and to "present the machinery and appliances of the power-house before the reader's mind from the practical or experimental side, and . . . to familiarize him with the solutions which experience and good judgment have proposed for problems of this sort." We once heard a distinguished professor of steam engineering say that in his opinion the technical schools ought to find out, first of all, how the men who are engaged in the business of steam engineering do things ; and that the schools ought to base their instruction on this information, and make their theories fit it. This appears to us to be sound doctrine, and it forms the keynote to Professor Hutton's book. The book begins with a number of chapters on the steam engine, passing then to a more detailed discussion of valves, valve motions, and the parts of engines, and finally taking up the subject of boilers. Some books have acute appendicitis, but this cannot be said of the present volume. There is an appendix, it is true, but it occupies only a small part of the book, and contains much information in the way of notes and references, which should prove very useful in connection with the text. The condensed "Historical Summary" is a good feature. (John Wiley & Sons, 53 East Tenth street, New York. 725 pages and 512 illustrations. Cloth, $5.00.)

Gigantic Reptiles.

At the next session of Congress the directors of the National Museum at Washington will ask for another appropriation running away up in the thousands. The funds, if obtained, will be used for the erection of a suitable building in which can be displayed to advantage the fossil remains of some of the largest and strangest forms of animal life that ever existed.

For the past ten years Professor O. C. Marsh of Yale College, with able assistants, has been at work for the United States government gathering together this great collection, a collection that is now the wonder of all palæontologists. A great impetus has been given to the study of organic remains as a consequence of his labors, and a new classification of the fauna of the primeval world has become necessary. Could the illustrious Cuvier but take a peep into the boxes and crates Professor Marsh has stored away at Washington and New Haven he would see monsters most wonderfully and fearfully made, animals whose existence the great pioneer and master of comparative anatomy never dreamed of. These fossils are particularly interesting to the people of Connecticut. Away back in the early geological history of the state, when there were no men or women on the earth having authority over the fishes of the sea and the fowls of the air, the owners of these antique bones roamed over the hills and through the valleys of this land of the triassic era, disporting themselves in the waters of the lagoon, where are now the Portland quarries, or cropping the succulent vegetation on its sloping banks. These animals, who left their well-known footprints upon the shores of the waters which they frequented, failed to leave much other evidence of their presence. A few fossil bones have been found. The absence, however, of organic fossil remains is easily accounted for.

The two great destroyers of animal remains from which life has departed are air and water. Exclude these two, and it is wonderful how long even the most perishable things may be preserved. But air and water are almost everywhere, water even filtering through the hardest rock, and since it contains dissolved air, it causes by chemical action the decay of animal and vegetable substances. Take the case of a leaf falling into a lake or some quiet pool in a river. It sinks to the bottom, and is buried up in gravel, mud, or sand. It will stand a very poor chance of preservation on a sandy or gravelly bottom, because these materials, being porous, allow the water to pass through them easily. But if it settles down on fine mud, it may be covered up and become a fossil, as the mud is by pressure hardened into rock. So we can thus easily understand how it is that rocks composed of hardened sand or gravel contain but few fossils, while such rocks as clay, shale, slate, and limestone often abound in fossils, because they are formed of what was once soft mud, that sealed up and protected these remains. The water could not get through the shale, slate, and limestone as easily as it could through the sandstone. About the time the Portland stones were laid down, limestone beds were being formed in what is now called Death's Valley, in the West. The great Dinosaurs living in the Connecticut valley died, and their bones were resolved back into their original elements, because the sandstone formation was not suitable for their preservation. But in the limestone formations going on at the same time in the West, the remains of these mighty reptiles were laid away in Nature's storehouse for safe keeping, for this rock is of so close a texture that the air and water is excluded. After a while these water-formed rocks were raised far above the level of the sea. Then began an era of destruction. The frosts of winter, the heat of summer, the falling rain, and the running rivers wore away the rocks, disintegrated them, and ground the pieces up again into pebbles, sand, and silt. This process of destruction exposed to view on the hillsides the bones of some long-buried saurian, and the eager geologist, with pick and spade, soon had complete skeletons of many an antediluvian monster. The Dinosaurs unearthed would make the same tracks in walking as those so often found by workmen in the Portland quarries.

To the geologist, his science presents certain self-evident truths. He has no doubt whatever that the earth is a vast cemetery, for he knows that the old has ever been passing away to make room for the new. In plant and animal life, from the beginning, there has been a steady improvement in structure and ability to fight the battles for existence. The winners in life's race are but a few of the countless multitudes that have played their parts, making their entrances and exits quietly, and leaving little behind to tell the story of their struggles. Nearly fifteen hundred species of Trilobites have been found fossilized in the Paleozoic rocks, and in later formations none. Five hundred species of the Nautilus tribe have been in existence; now there are three. Over one thousand species of Ganoids have been found fossil; the tribe is now nearly extinct. The remains of twenty-five hundred species of plants and over forty thousand species of animals have been found in the rocks, not one of which is now in existence.

Is it not true, then, that the earth is a vast cemetery of vanished races and tribes? Well, Professor Marsh has been opening up some of the graves of this old cemetery. His most enthusiastic hopes have been more than realized. He has unearthed the remains of so many extinct animals, monsters of the reptilian type, that the age of dragons no longer appears a myth. His geological mining has been in the rocks of the triassic group of the Mesozoic age. The brownstone at Portland is of the same formation. When these sedimentary rocks were built up the reptilian age had attained its maximum development. Reptiles had full sway on earth at that time. They swam in the sea, flew through the air, and held possession of the earth: in fact, they were the lords of creation. The bones of these gigantic reptiles are well preserved. They have lain undisturbed in their matrix of stone for millions of years away from the decomposing elements and the destructive hand of man. It seems like a fairy tale to give a description of these creatures. There are huge swimming saurians, enaliosaurs, with powerful paddles and cruel jaws; bat-like saurians, or pterodactyls, with a twenty-five-foot spread of wings; four-footed saurians, both grazing and carnivorous, many of them fifty feet long; great biped saurians, or Dinosaurs, sixty feet long, whose footprints are left in the Portland sandstones, and snake-like Mosasaurs, eighty to a hundred feet long, that used to swim in the Mesozoic seas,—fierce creatures, ready at all times to engage in deadly combat with other species or among themselves.

The Dinosaurs are an extinct order, comprising the largest terrestrial and semi-aquatic reptiles that ever lived. They all had four limbs, and they varied enormously in size as well as appearance. Some of them were only two feet long and lightly built, while others were truly colossal, far outrivaling the modern rhinoceros and elephants. They show in their bony structure a very remarkable semblance to birds; in fact, anatomists have always held to the opinion that there was a close relationship between the reptilian and the feathered tribe. Did certain long-legged Dinosaurs eventually give rise by evolution to the running birds, such as the ostrich and others of his class? The discoveries of Professor Marsh seem to have settled this question conclusively in the affirmative.

A few years ago the opponents of evolution used as one of their strongest arguments the break in the animal series between the now living birds and reptiles. Professor Huxley soon showed, however, that this gap has been virtually filled by the discovery of bird-like reptiles and reptilian birds. In his own words he says: "They are the stepping-stones by which the evolutionist of to-day leads the doubting brother across the shallow remnant of the gulf once thought impassable." It seems incredible that the ancestors of our summer songsters, flitting about from limb to limb, clothed in their brilliant plumage, should have been these huge creatures of the Mesozoic age. But it is generally admitted by scientific men, especially by biologists who have made a study of vertebrates, that birds have come down through the Dinosaurs. The resemblance of certain characteristics of the two orders amounts to a demonstration of the case.

In order to realize what manner of creatures Dinosaurs were, one must give up all previous ideas of reptiles; for these forefathers of the race were unlike anything that now inhabits the air, the earth, or the waters surrounding it. They were peculiar to an age, and represent one stage of life development, just as fishes had represented a previous age and mammals a later one. The type did not please Mother Nature, for she destroyed them all; but she stored away in her museum down in the heart of the rocks a few specimens of her monstrous growths that man might read the record of the lost creations. There were vegetable as well as flesh-feeding Dinosaurs. Brontosaurus, sixty feet long, and weighing over twenty tons, belonged to the former class. It was a stupid reptile, with a small brain and wholly without armor of defense. The legs and feet were strong and massive, and each track made as it walked covered one square yard.

The more active carnivorous species preyed upon its helplessness, and undoubtedly it was a prime factor in the food supply of the time. The most gigantic Dinosaur of any so far discovered was Atlantosaurus, which attained a length of eighty feet and stood thirty feet high upon its hind legs. Its huge thigh bone, which can be seen at the Yale museum, is six feet two inches long, a little taller when stood upright than a full-grown man. Their food was the luxuriant foliage of the sub-tropical forests. There was plenty of rank vegetation in those days, for the air was loaded with carbonic acid gas and saturated with moisture. These mighty reptiles must have had a hard struggle for existence with the flesh-eaters that flourished in great numbers at the same time.

One of the most formidable of these carnivorous monsters was the Megalosaurus. Armed with long, sharp-pointed teeth, and with claws on its feet, it must have been a terror to all its contemporaries. It was thirty feet long, and, with its strong hind limbs, capable of free and rapid movement. Undoubtedly it was the most astonishing jumper the world has ever seen. It pounced upon its victim much as the lion or tiger springs upon its prey. The strength of this creature was something prodigious, and with its powerful jaws and sharp-cutting teeth it was a most ferocious adversary. There were plenty of quarrelsome Dinosaurs to cope with Megalosaurus, and it is probable that some of them were very fierce indeed.

Stigosaurus and Tricoratops were most remarkable beasts. Stigosaurus was a gigantic armored Dinosaur and was the most singular looking four-footed animal that ever existed. Imagine a creature resembling a crocodile in shape, about thirty feet in length, with huge bony plates three feet in diameter standing upright on its back, its powerful tail armed with sharp spikes two feet long, and with hoofs on its feet. The fore limbs could be moved freely in various directions like a human arm. They were used in self-defense as well as for walking. This monster had two brains. At the lower end of the back was a great enlargement of the spinal cord, more than ten times larger than the brain in the skull itself. This posterior brain was used for the purpose of directing the movements of the great hind limbs and massive tail. We can easily understand what a terrible weapon this singular tail was, and what execution it was capable of, in contact with an enemy's hide.

Perhaps the strangest of the Dinosaurs was Tricoratops, which flourished during and after the period of the Portland sandstone formation. While other Dinosaurs did most of their walking resting on their hind feet only, Tricoratops used all four. There were two large horns immediately over the eyes and a smaller one above the nose. Beside being well equipped with these horns for defense, this strange creature could kick with a good deal of effectiveness, for it had legs fifteen feet or so in length.

The back part of the skull rises into a bony crest which acted as a shield to ward off blows when one of these fierce creatures was fighting another. In the limestone rock where the bones of Tricoratops were discovered was found a perfect cast of an eye with which it had looked out upon the world three millions of years ago. These uncouth monsters occupied the earth for a great many thousands of years. They were put in the balance and found wanting. In the great cataclysm that upheaved the Alps, the Himalayas and the Rocky Mountains they were wiped out of existence. Smaller animals, more active and with quicker brains, succeeded them. The whole type was developed along a line that resulted disastrously. Tricoratops is a good illustration. Here the head increased in size to bear its armor of bony plates, the neck first, then the fore feet, and then the whole skeleton was especially modified to support it. As these changes took place in the course of the evolution of this wonderful animal, the head at last became so large and heavy that it must have been too much for the body to bear, and so have led to its destruction. "Over-specialization" exterminated the race. What place in the economy of nature these saurian giants occupied is hard to tell. They existed for a purpose, no doubt. What that purpose was is not fully understood at present, but through the labors of such men as Marsh and others the future surely will unravel the object of their existence.— W. C. H. in *Hartford Times*.

A NEW method has been devised for "animalizing" cotton — that is, for giving it the character of animal fiber, so that it can be dyed by the processes that are used for wool. Heretofore this has been accomplished by impregnating the material with albumin or casein ; but in the new process the cotton fiber receives a thin coating of wool. In preparing the bath for this purpose a small quantity of wool is first dissolved by boiling with barium hydrate. The barium is then removed by carbonic acid gas, and a little formaldehyde is added. The cotton cloth is wetted with the solution so prepared, after which it is dried, steamed, and washed. It can then be dyed directly with any acid or basic dye, although the colors obtained are not so fast as on wool.

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Concerning Mercury Columns.

An accurate method of measuring the intensity of fluid or gaseous pressure is indispensable to engineers and physicists, and many forms of apparatus have been devised to meet the requirements of practical use. The Bourdon gauge is most commonly used in connection with steam boilers, because it is compact and durable, and is sufficiently accurate for all ordinary purposes. Gauges in use about steam plants should be periodically tested, however, by comparison with some standard manometer of known accuracy, and as our regular work of boiler inspection requires us to test many thousands of gauges each year, we have given considerable thought to the design and construction of standard apparatus for performing such tests with satisfactory precision.

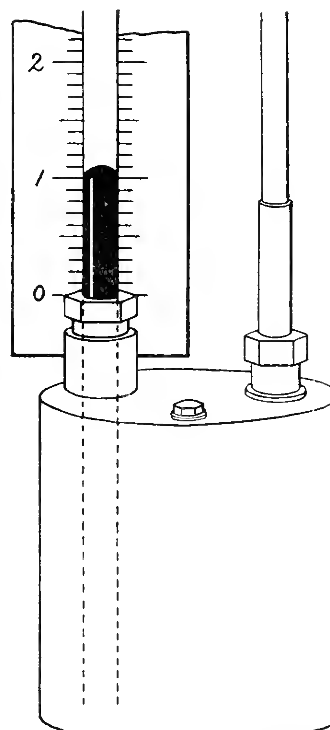

Fig. 1.— A Detail of a Mercury Gauge.

Many experimenters in physics have used manometers in which the pressure is measured by the change in volume that is experienced by a given mass of gas enclosed in a graduated glass tube of known capacity. Nitrogen gas is frequently used for this purpose, because its compressibility has been studied with great care by Amagat. This method of measuring pressures has its advantages, but it has also the marked disadvantage of requiring the observer to note the *temperature* very accurately, because the volume of the test gas varies with the temperature so notably that a small thermometric error may introduce an error in the reading of the instrument, which would be quite inadmissible.

In our judgment the gas manometer is not a satisfactory device for every-day testing purposes. It is much more satisfactory to compare the gauge directly with a mercury column, and this is the method that we use in standardizing the test gauges that are supplied to our inspectors. The apparatus consists in a pump, by which the gauge can be subjected to a water pressure, and a long, vertical glass tube, into which mercury rises to measure the pressure. The mercury is contained in an iron reservoir, as shown in Fig. 1. Two tubes pass out through the top of this reservoir, one of which (shown on the right) transmits the water-pressure from the gauge table to the mercury reservoir, while the other is the glass tube already referred to, into which the mercury rises. The apparatus is so simple that it hardly needs further explanation, except on the one point of fixing the graduation marks on the scale. This appears to be simple enough, but as we have frequent letters asking how it is done, we shall explain the process of graduation in some detail.

Referring to Fig. 2, let us suppose that the diagram on the left represents a little cubical vessel, one inch high, wide and deep, and filled with mercury. The weight of the mercury all comes on the *bottom* of this vessel. Now a cubic inch of mercury weighs about 0.49 of a pound, and hence the pressure on the one square inch that forms the bottom of this little vessel would be 0.49 of a pound. Suppose, now, that we had a similar vessel which is one inch square at the bottom, as before, but which is *three* inches high, as shown in the middle diagram. This vessel would contain *three* cubic inches of mercury, and the pressure on the one square inch of its bottom side would be $3 \times 0.49 = 1.47$ lb. In the same way, if we had a vessel one inch square and (say) 120 inches high, the pressure against the square inch at the bottom would be $120 \times 0.49 = 58.80$ lbs. and so on for any other height.

Now let us consider the right-hand diagram in Fig. 2. Here the vessel is supposed to be only *half* an inch square; but it is plain that the pressure *per square inch* on the bottom of the vessel would be just the same as in the middle diagram, because although there is only one-quarter as much mercury as before, there is also only one-quarter as much area, on the bottom of the vessel, for it to rest upon; and hence the pressure *per unit of area* (that is, the pressure *per square inch*) will be just the same, in either case. It will be evident, by this same process of reasoning, that the *shape of the cross-section* of the vessel (or tube) has nothing to do with the intensity of the pressure. In a word, the pressure exerted by the mercury depends upon nothing but *the height of the column;* and we can calculate it, in any case, just as though the column were an inch square, as we did in connection with the middle diagram of Fig. 2.

In carrying out this idea in the actual work of graduation, certain precautions must be observed. For example, we must make sure that the mercury is clean and pure, and that it is not contaminated with tin or zinc or lead or any other substance which may affect its specific gravity. If these substances are present in appreciable amount, the weight of a cubic inch of the mercury will not be the same as the values given in the standard tables, and hence we must either purify the mercury before using it, or we must weigh a cubic inch of it very accurately, so as to know by how much it departs from the standard density given in the books. It will not be necessary, in this article, to explain the various processes for purifying mercury. We shall simply assume that the mercury that is to be used in the column is known, by analysis, to be free from any foreign substance that would alter its density in any important degree, and shall proceed to explain how the graduation marks are found.

Before entering upon this explanation, it may be well to call attention to the confusing way in which the word "pound" is used. Properly speaking, a "pound" is a definite mass or quantity of matter, and is the same thing in all parts of the world. But in popular usage this simple fact is often concealed from view by talking of the "pound" as though it were the *weight* of that mass of matter — or the *force* with which the mass is attracted by the earth. A pound, properly speaking, is not a force, and has nothing to do with the earth, although as a matter of convenience we do compare the number of pounds of matter that are contained in two bodies by balancing those bodies against each other, because we know, from Sir Isaac Newton's experiments with pendulums, that equal masses of matter are attracted by the earth with equal intensities, when they are compared in this way *at the same place.* If a pound of lead is carried towards the north pole, and is weighed against a standard pound weight in different latitudes, the two will always balance, because although the pull exerted by the earth upon the lead increases as we go north, the pull exerted upon the standard weight also increases by just the same amount. But if we should carry our mass of lead about over the earth's surface, determining its weight here and there *by means of a spring balance*, we should find that the indication of the balance is different in different places, because the varying pull exerted by the earth is not compensated by any corresponding variation in the spring of our weighing apparatus.

It will be seen, from what has been said, that the pressure exerted by a mercury column ten feet high will be one thing in one part of the earth, and another thing in some other part. The difference is not very great, it is true, and yet it ought to be

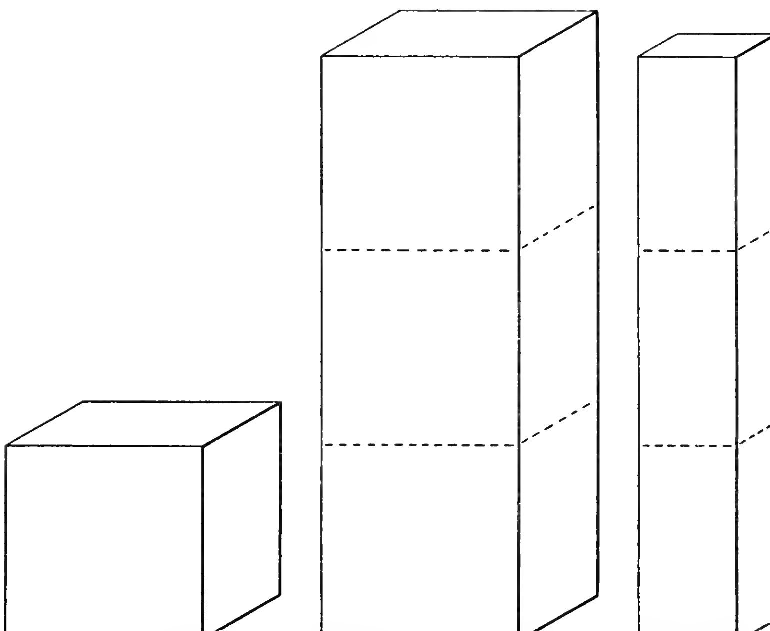

Fig. 2.— Illustrating the Pressure due to a Column of Mercury.

taken into account in designing mercury gauges for accurate testing purposes. The expression "pounds per square inch" is illogical and meaningless, in the last analysis, although it serves well enough for the ordinary rough work of steam engineering practice. We might speak with accuracy of the number of "*poundals* per square inch," but this would take us too far away from the conventions of engineering practice ; and as a sort of concession to the ordinary, though incorrect, use of the word "pound" as a *force*, we may adopt the following provisional definition of the word "pound," as it occurs in the expression "pounds per square inch."

Definition : A "pound," in estimating the pressure produced by a column of mercury, is understood to be the force with which the earth attracts a standard avoirdupois pound weight, at sea level in the latitude of Washington.

With this much admitted, we are ready to proceed to the problem of graduating our column. It has been found, by careful experiment, that a cubic inch of pure mercury, at 32° Fahr., has a mass of 0.49117 of a pound. Hence, according to the foregoing definition, a column of mercury one inch high gives a pressure of 0.49117, when at a temperature of 32° Fahr., at sea level in the latitude of Washington. If this one-inch column of mercury were to be carried towards the equator, or up a hill or a mountain, it would produce a less pressure than this, because the earth would attract it less forcibly in those places. So, too, the pressure produced by a one-inch column would be less than 0.49117 lb., if the mercury were warmer than 32° Fahr.; because mercury expands upon being heated, and hence it weighs less, per cubic inch, at higher temperatures. To find the actual pressure produced by a one-inch column of mercury, as it stands in the column in our Hartford office, we must therefore take account of three things: (1) The temperature of our column, (2) the difference in latitude between Hartford and Washington, and (3) the elevation of our office above mean sea level.

Looking first at the question of elevation above sea level, we find, by means of the usual formulas for calculating the diminution of gravity as we go up from the earth's surface, that an elevation of 4,000 feet above sea level would affect the reading of the mercury column by only about the fortieth part of one per cent. An error of this magnitude would be of no consequence, even in the most refined engineering practice; and as all of the important centers of industry in the United States are at a lower level than this, we may safely neglect the influence of elevation above the sea, in graduating columns for gauge testing, and other work of a like order of refinement. The middle point of the long standard column in our home office at Hartford, Conn., is only 112 feet above mean tide water, and hence we are far within the limit beyond which elevation would produce a sensible effect.

There remain the questions of *temperature* and *latitude*. The average temperature of our column, throughout the year, is not far from 70° Fahr. It is a few degrees warmer in the summer, and a corresponding amount cooler in the winter; but the mean temperature is very nearly 70°. The pressure, in the latitude of Washington, due to a column of mercury one inch high, and at a temperature of 70° Fahr., may be shown, by Regnault's data on the expansion of mercury, to be 0.48932 of a pound. (To correct for other temperatures in the *neighborhood* of 70°, decrease 0.48932 by .000.049 for each degree, Fahrenheit, that the actual temperature exceeds 70°, or increase it by a like amount for each degree that the actual temperature falls short of 70°.)

For the latitude correction, we must refer the reader to books relating to the variation of gravity on different parts of the earth. Owing to the increase in the pull of the earth as we go northward, the pressure produced by a given column of mercury will be somewhat greater in northern latitudes, than in southern ones. The variation of pressure with latitude and temperature are all taken into account in the following tables, which give the data required for graduating a standard column in any part of the United States.

The numbers in the second table are found by taking the reciprocals of those in the first one. For example, we see from the first table that at a temperature of 60° in latitude 45°, a column of mercury one inch high produces a pressure of 0.4900 of a pound per square inch. To obtain a pressure of one pound per square inch, we should have to increase the height of the column in the proportion of 0.4900 to 1. That is, we should require a column whose height is $1 \div 0.4900 = 2.0408$ in., which is the number given in the second table, except that we have kept only three places of decimals, and have called this number 2.041, which is nearer to the actual figure than 2.040 would be.

TABLE OF THE PRESSURES, PER SQUARE INCH, DUE TO A COLUMN OF MERCURY ONE INCH HIGH.

Temperature. (Fahr.)	Latitude of Place.				
	30°	35°	40°	45°	50°
32°	0.4908 lb.	0.4910 lb.	0.4912 lb.	0.4914 lb.	0.4917 lb.
40	.4904	.4906	.4908	.4910	.4913
50	.4899	.4901	.4903	.4905	.4908
60	.4894	.4896	.4898	.4900	.4903
70	.4890	.4892	.4894	.4896	.4898
80	.4885	.4887	.4889	.4891	.4893
90	.4880	.4882	.4884	.4886	.4888

TABLE SHOWING THE HEAD OF MERCURY THAT IS REQUIRED TO PRODUCE A PRESSURE OF ONE POUND PER SQUARE INCH.

Temperature. (Fahr.)	Latitude of Place.				
	30°	35°	40°	45°	50°
32°	2.037 in.	2.037 in.	2.036 in.	2.035 in.	2.034 in.
40	2.039	2.038	2.037	2.036	2.036
50	2.041	2.040	2.039	2.038	2.038
60	2.043	2.042	2.041	2.041	2.040
70	2.045	2.044	2.043	2.043	2.042
80	2.047	2.046	2.046	2.045	2.044
90	2.049	2.048	2.048	2.047	2.046

The latitude of our Hartford office being 41° 46′, and the temperature of the mercury column being always very near to 70°, we see from the table that it is necessary to allow 2.043 inches for each pound of pressure desired. The best way to carry out the actual work of graduation is probably to lay off, first, the positions of the marks for 10 lbs., 20 lbs., 30 lbs., etc., allowing 20.43 inches for each ten pounds. Then the intermediate one-pound divisions can be filled in upon the skeleton so laid down, with great accuracy.

The scale itself is best made of well seasoned and varnished pine wood, since the coefficient of expansion of pine is so small that a scale 45 feet long will vary in length by less than the thousandth part of an inch for each Fahrenheit degree of change in its temperature. The scale, when once made and graduated, is to be so adjusted that the mercury column reads accurately zero, when there is no pressure on the testing apparatus.

The reading of any mercury gauge that is open to the air at one end, merely gives the excess of the observed pressure, above that of the atmosphere. If the absolute pressure is desired, the reading of the barometer must be noted at the same time, and the atmospheric pressure, so determined, must be added to the reading of the column.

When high pressures are to be determined, it is often inconvenient to read the ordinary mercury column, since the top of it is then far above the floor of the testing room. To remedy this difficulty various modifications of the column have been proposed. One of the earliest plans (proposed, we believe, by Fahrenheit) is that suggested in Fig. 3. Instead of a single long column, we have here a considerable number of shorter ones, arranged in *U*-shaped tubes. The various spaces between the successive lengths of mercury are filled with water or glycerine or some other practically incompressible fluid, which serves to transmit the pressure from each body of mercury to the next. The position of the mercury when in equilibrium under atmospheric pressure at each end is

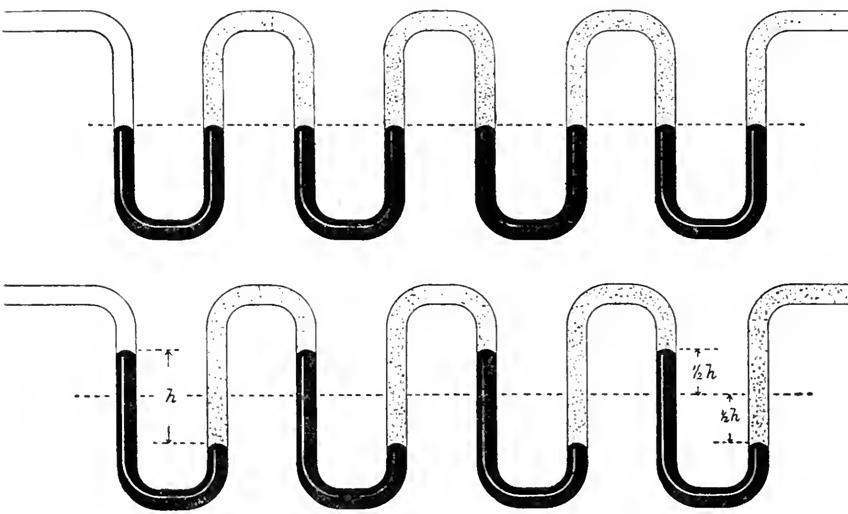

Fig. 3.—Illustrating the "Siphon Gauge."

shown in the upper part of the figure. When pressure is applied, the system assumes the configuration shown in the lower diagram, each *U* of mercury rising in one leg and falling in the other. The head due to each body of mercury is indicated on the left by the letter *h*, and (as will be seen) it is equal to *double* the amount by which the level has risen or fallen in any one leg. The total head of mercury, in the entire apparatus, is found by multiplying *h* by the number of *U*-tubes that are present; and a considerable head of mercury can therefore be realized, without the necessity of extending the column to an inconvenient height. The full head, *h*, of the mercury in the *U*-tubes cannot be taken in computing the pressure produced by the system, since each of the columns, *h*, is partially balanced by an equal column of water or glycerine, and allowance must be made for this fact. We shall not discuss this point any further, however, because the "siphon gauge" (as this form is called) is described and explained in a paper by Mr. D. N. Melvin in the second volume of the *Transactions* of the American Society of Mechanical Engineers, to which paper we must refer those desiring further information.

Other methods have also been proposed, for reading the mercury column conveniently. One of the most important and interesting of these is the one described by Prof. W. W. Bird, of the Worcester Polytechnic Institute, in a paper entitled "An Open Mercury Column for High Pressures," and printed in the eleventh volume of the *Transactions* of the American Society of Mechanical Engineers. Attention is also directed to the method suggested by Prof. D. S. Jacobus, in the discussion which followed Prof. Bird's paper.

Inspectors' Report.

MARCH, 1897.

During this month our inspectors made 8,906 inspection trips, visited 17,025 boilers, inspected 5,467 both internally and externally, and subjected 574 to hydrostatic pressure. The whole number of defects reported reached 10,500, of which 982 were considered dangerous; 54 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	776	38
Cases of incrustation and scale,	1,992	66
Cases of internal grooving,	78	16
Cases of internal corrosion,	617	28
Cases of external corrosion,	699	49
Broken and loose braces and stays,	190	72
Settings defective,	264	22
Furnaces out of shape,	378	13
Fractured plates,	275	77
Burned plates,	244	53
Blistered plates,	189	10
Cases of defective riveting,	1,160	33
Defective heads,	144	18
Serious leakage around tube ends,	1,779	269
Serious leakage at seams,	421	29
Defective water-gauges,	355	49
Defective blow-offs,	137	34
Cases of deficiency of water,	50	17
Safety-valves overloaded,	55	32
Safety-valves defective,	196	21
Pressure-gauges defective,	355	29
Boilers without pressure-gauges,	5	5
Unclassified defects,	141	2
Total,	10,500	982

Boiler Explosions.

MARCH, 1897.

(55.) — A boiler exploded, on February 25th, in a feed mill belonging to Riley Letts of Bannister, near Elsie, Mich. Riley Letts, Henry Hustin, and Henry Crego were severely scalded, and Letts will probably lose his eyesight.

(56.) — A boiler exploded in the Calwood mill, near Fulton, Mo., on February 27th. The boiler went up through the roof, and the boiler-house and machinery were wrecked. The main building was also damaged. A man named Davis, who was the only person on the premises at the time, was buried in the ruins, but sustained only a few bruises and scalds. [This explosion and the preceding one were received too late for insertion in their proper places in our February list. — ED.]

(57.) — A boiler belonging to Andrew Adams, near Hartwell, Ga., exploded on March 2d, killing Bunyan Adams and injuring two other men.

(58.) — A large boiler used for dissolving licorice in the R. J. Reynolds Tobacco Company's factory at Winston, N. C., exploded on March 3d. Four men were severely scalded.

(59.) — The U. S. revenue cutter *Manhattan* blew out a boiler tube, on March 3d, when off Fort Wadsworth, near Baltimore, Md. She was taken in tow by the tug-boat *Robert Robinson.*

(60.) — A boiler exploded, on March 4th, in a saw-mill at Bruce, near Tiverton, Ont. Kenneth McDiarmid, the engineer, was instantly killed.

(61.) — On March 4th a boiler exploded at Twelve Mile, near Logansport, Ind. Frank Meyers, who owns the mill, and John Marquis, an employe, were present at the time, but were fortunate enough to escape with slight scalds.

(62.) — A boiler exploded, on March 4th, in Dunn & Johnson's flour mill at Drakeville, near Ottumwa, Iowa. Samuel Miller was killed, and John Tice was fatally injured.

(63.) — On March 5th a boiler exploded in L. R. Smith's feed mill, just east of the village of Coral, Mich. L. R. Smith and W. Holmes were fatally injured. Henry Opper and Harry Minore also received painful injuries, but will recover. The mill was completely wrecked, and parts of it were hurled nearly a quarter of a mile.

(64.) — A boiler in W. J. Rainey's Mount Braddock coke works exploded on March 6th, completely wrecking the plant. Engineer Robert Hoxenbaugh was instantly killed, and Fireman Robert Meade was fatally injured. We have seen no estimate of the property loss, but it is said to be heavy.

(65.) — On March 8th a boiler exploded on the Hartman oil lease, at Callery Junction, some twenty miles from Pittsburgh, Pa. John Dunlap was killed, and Charles McKeever was seriously injured. The engine-house, derrick, and machinery were all demolished, fragments of them being found 400 yards away. Later advices state that McKeever recovered.

(66.) — On March 8th a boiler exploded on the dredge boat *Jumbo*, which was stationed at Horn Island Pass, near Scranton, Miss. John H. Alexander was scalded so badly that he died next day. Several other workmen were also scalded to a lesser degree.

(67.) — A boiler exploded, on March 13th, in William Poffenbarger's saw-mill at Beach Hill, on the Kanawha, near Point Pleasant, W. Va. Samuel Poffenbarger, the proprietor's son, was killed instantly, and several others were injured. The mill was destroyed.

(68.) — A small boiler in the feed store of Upton & Shadewalde, at Minneapolis, Minn., exploded on March 16th. The store was pretty badly wrecked, but nobody was injured.

(69.) — On March 17th a boiler exploded in Owen Brock's boiler shop at Charlestown, Mass. Nobody was injured. The initial rupture occurred in the furnace plate, near the base. It is said to have been due to the fact that the plate was very much wasted, so that it had been patched several times. The boiler passed out through the roof of the building, but did not go very far.

(70.) — A boiler exploded, on March 18th, near Lansing, Morgan County, Tenn. A man named Hughes was instantly killed, and Lewis Howard, John Massey, Martin Howard, and John Anderson were severely injured.

(71.) — A boiler at the Carbon mines, four miles east of Oakland City, Ind., exploded on March 19th, almost completely wrecking the boiler-room. Engineer Burton had just left the room, and nobody was injured. If the explosion had occurred an hour earlier, the loss of life would have been very great, as the miners had gathered there before going into the mine.

(72.) — On March 22d the locomotive drawing the New York and Boston special on the Lake Shore & Michigan Southern railroad exploded its boiler in the Englewood yards, near Chicago, Ill. Alexander Frank, the engineer, and E. B. Smith, the fireman, were instantly killed. The engine was completely demolished by the explosion, and the baggage car immediately behind it was partly wrecked. The train came to a sudden standstill, and it is probable that if its speed had not been slow, every car would have been derailed. As it was, the passengers were thrown from their seats, and some sustained slight bruises. The débris of the demolished engine was scattered over the ground for several rods, and the bodies of the engineer and fireman, terribly mangled, were picked up a considerable distance from the track. A line of freight cars on a side-track caught fire, and the flames did considerable damage before they were extinguished.

(73.) — On March 22d a boiler exploded in a saw-mill at Lynch's River, near Hartsville, Darlington County, S. C., killing Engineer Adam Carter and his wife, who chanced to be in the boiler-room at the time. It is said, by one who has visited the place since the explosion, that the fragments of the boiler cut off trees as shells used to do in war times.

(74.) — A hot-water boiler exploded, on March 23d, in the basement of a bachelor apartment house on Twenty-eighth Street, New York city. Nobody was hurt. The damage to the building amounted to about $1,000.

(75.) — A boiler exploded, on March 26th, in the Summers & Poe mill, twelve miles southeast of Paoli, Ind. Leonard Fears, the engineer, and Frank Moon, a helper about the yards, were instantly killed. Not a scrap of the boiler or engine was left in place, pieces having been hurled a quarter of a mile.

(76.) — On March 27th a slight boiler explosion occurred at the Peerless mine of the Coal Bluff Mining Company, at Terre Haute, Ind. Nobody was injured.

(77.) — A threshing-machine boiler exploded, on March 27th, on the farm of Peter McGarvin, on Creek Road, at Harwick, near Chatham, Ontario. Engineer James McGarvin was killed, and John Houston was shockingly scalded.

(78.) — On March 29th a boiler belonging to a Mr. Rose exploded at Hillsdale, near Augusta, Ky. Cassius Williamson, Calvin Tucker, and Talton Boone were killed, and three other persons were seriously injured. The mill was totally wrecked.

(79.) — A boiler exploded in the West Side electric street railroad power house, at Elmira, N. Y., on March 29th, shaking the buildings of the city for a mile around. One-half of the boiler was blown through two brick walls and two electric cars, and landed about 150 feet away in a field. Fireman Frank Albro was instantly killed, and Engineer Philip Kaufelt was seriously injured. The property loss is estimated at $25,-000. Although Kaufelt's skull was fractured, it is said that he may recover.

(80.) — Five men were killed, on March 30th, by a boiler explosion at Greenville, Miss.

The Locomotive.

HARTFORD, MAY 15, 1897.

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

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

In the item headed "Agency Changes," in the April issue of The Locomotive, we omitted to state that Mr. Lyman B. Perkins, who has been associated with this company for many years as general agent for the home office, retains his connection with us in the same capacity, except that his future duties will consist, in large part, of the supervision and decision of the various mechanical questions and problems that arise in our several departments throughout the country. Mr. Perkins is a graduate of the U. S. Naval Academy at Annapolis, and is thoroughly competent to take charge of the work now given into his hands.

Obituary.

John H. Cooper.

Mr. John H. Cooper, widely known as an expert mechanical engineer, died at his home, 4724 Springfield Avenue, Philadelphia, Pa., on Sunday, May 9th. Mr. Cooper was 68 years of age, and was born at Columbia, Pa. He learned the trade of house carpentering, and his early inclinations were toward the study of mechanics. For the past twenty-five years he was connected with the Franklin Institute as one of its most active members, and he was a member of the Board of Managers of the organization from 1870 to 1873. At the time of his death he was one of the auditors of the Institute, and was also a member of the Committee on Science and the Arts. He was connected with H. R. Worthington, a manufacturer of steam-pumping machinery, at 624 Arch Street, Philadelphia. Mr. Cooper was at one time superintendent of the engine works of Jacob Naylor, on Front Street and Girard Avenue. About ten years ago his health began to fail, and he visited Southern California, subsequently being engaged at the Southwark Foundry and Machine Works. While at the latter place he was called upon to design centrifugal pumps for the Mare Island Navy Yard. He made extensive investigations concerning water-wheels, and was chairman of the committee appointed to investigate and report upon the Pelton water-wheel, known as the "tangential wheel." Besides being an extensive contributor to the *Journal of the Franklin Institute*, he was the author of several works, his *Belting Facts and Figures* being regarded as a standard on the use of belting in the transmission of power. He was a member of the Society of Friends, and also of the American Society of Mechanical Engineers.

[The foregoing is from the Philadelphia *Public Ledger* of May 11th. Mr. Cooper was well known to the officers of this company, and has had their confidence and high esteem for many years. He has been a contributor to THE LOCOMOTIVE on several occasions, and was preparing an article for it at the time of his death. He was a man who loved the truth, and this trait of his character was manifested as much in his scientific and engineering work as in his daily life and conversation. He was upright and true in the minutest particulars, and the world would be better if more of its inhabitants were like him.]

WILLIAM H. HUNTER.

Mr. William H. Hunter, who died at his home in Boston on March 17th, was born at Ripon, England. Through the death of his parents, he was thrown upon his own resources at an early age, and he entered the British merchant marine service, subsequently quitting it for the American service, where he became a first-class seaman and sailing master before he was of age. When the Civil War broke out, Mr. Hunter enlisted in the Navy, and was assigned to duty on the *Minnesota* of the North Atlantic Squadron. He was appointed master's mate for meritorious service, and was afterwards commissioned as ensign on the *Nansemond*. He took part in all the battles in which these ships were engaged, being on the *Minnesota* during the fight with the *Merrimac*, when that vessel destroyed the *Columbia* and other sister ships. At the close of the war Mr. Hunter was mustered out of service, and was employed for a short time in the Navy Yard at Portsmouth, N. H., leaving there in 1866 to go to the Atlantic Works, East Boston, where he remained for eighteen years, enjoying the confidence and esteem of his employers and associates. Mr. Hunter was appointed inspector of boilers for the Hartford Steam Boiler Inspection and Insurance Company in 1884, and was assigned to the Northeastern Department, under the direction of Mr. C. E. Roberts, where, at the time of his death, he had served faithfully for thirteen years. He was an able mechanic, with unusual capacity for detail work, and exceptional ability in the practical application of his knowledge. His energy and integrity commanded the respect both of the officers of this company and of its patrons, and he had many friends who will mourn his death.

Priority in Scientific Discoveries.

The illustrious Helmholtz, in a lecture on "Thought in Medicine," delivered in August, 1877, dwelt briefly upon the tendency that we often see, to rob a discoverer in science of the just fruits of his labor, by fishing out, from the forgotten past, some passage in the writings of an equally forgotten author, in which the views of the more recent investigator appear to have been anticipated. We should always give credit to whom it is due, without fear or favor; and it sometimes happens that a scientist — like Carnot — is in advance of his proper time, so that his words fall on deaf ears, and are not understood until years afterward. Yet in the vast majority of cases we should do the later discoverer a grave injustice if we should take from him the reward of his patient toil, and transfer it to some ancient dreamer who ventured a multitude of guesses at the truth, most of which were wrong, but of which one or two chanced to come somewhere near to the actual facts. A natural law enlightens the human mind by showing a relation among phenomena, where none was previously suspected. It is first thought of by some ingenious individual who perceives certain resemblances and analogies among these phenomena; and if this individual proceeds to investigate the soundness of the relationship that he suspects, by a rational course of study or experiment, he is entitled to our confidence and respect. But if he rests his case at once, and proceeds to other speculations on different matters, he has proved nothing, and has discovered nothing; for it is *a priori* probable that his analogies are false, and that they do not represent any *real* relation among the things that he compares.

"To find superficial resemblances [among phenomena]," said Helmholtz, "is easy; it is amusing in society, and witty thoughts soon procure for their author the name of a clever man. Among the great number of such ideas, there must be *some* which are ultimately found to be partially or wholly correct. It would be a stroke of skill *always* to guess falsely. In such a happy chance a man can loudly claim his priority for the discovery; otherwise a lucky oblivion conceals the false conclusions. The adherents of such a process are glad to certify the value of a first thought. Conscientious workers, who are shy at bringing their thoughts before the public until they have tested them in all directions, solved all doubts, and firmly established the proof,— these are at a decided disadvantage. To settle the present kind of questions of priority, only by the date of their first publication, and without considering the ripeness of the research, has seriously favored this mischief.

"In the type-case of the printer, all the wisdom of the world is contained, which has been or ever can be discovered. It is only requisite to know how the letters are to be arranged. So, also, in the hundreds of books and pamphlets which are every year published about ether, the structure of atoms, the theory of perception, as well as on the nature of the asthenic fever and carcinoma, all the most refined shades of possible hypotheses are exhausted, and among these there must necessarily be many fragments of the correct theory. But who knows how to find them?

"I insist upon this in order to make clear to you that all this literature, of untried and unconfirmed hypotheses, has no value in the progress of science. On the contrary, the few sound ideas which they may contain are concealed by the rubbish of the rest; and one who wants to publish something really new —*facts* — sees himself open to the danger of countless claims of priority, unless he is prepared to waste time and power in reading beforehand a quantity of absolutely useless books, and to destroy his readers' patience by a multitude of useless quotations."

The soundness of this argument must appeal to every one; and the man who sent forth a baseless conjecture in '49 should not feel aggrieved because some more patient and persistent worker thinks of the same thing, and works over it until he *proves* it, in the year '97. Let him rather regret that he did not pursue his own thought with equal energy, and thus save the world half a century of waiting

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No Use for It. — A correspondent sends us the following unholy story about a Wisconsin farmer's correspondence with a boiler-maker. It was taken, we believe, from the Syracuse *Standard*: "The farmer wrote as follows: 'Dere Sirs, I hav 1,000 akers of trees that I want cut. I'm pore, but I am willing to pay too hundred dolers fer an engin that will do my work,' and he went on to explain just what sort of an engine he wanted. The boiler firm saw that the machinery necessary to accomplish the devastation of his virginal forest would cost $3,000, and they wrote him to that effect. A week passed, and then the following pithy epistle came back from the Wisconsin woods: 'Dere Sirs, what in hqxl wud I want of a biler if I hed $3,000?'"

The Nasmyth Steam Hammer.

The Great Western Railway Company having successfully dispatched its steamship *Great Western* between Bristol and New York, and having elected to construct another steamer, the *Great Britain*, procured tools for making the engines from the Bridgewater [*i. e.* Nasmyth's] Foundry. They were perplexed, however, about the forging of the intermediate paddle shaft, which was of a size never before attempted. They applied to Mr. Nasmyth, and he devised the steam hammer, the most famous of his inventions — an instrument with which, as he says in his autobiography, the workman might, "as it were, think in blows. He might deal them out on to the ponderous glowing mass and mold or knead it into the desired form as if it were a lump of clay; or pat it with gentle taps according to his will, or at the desire of the forgeman." All was going well for setting the hammer in operation, when the plan of the vessel was changed by the introduction of the screw propeller, which rendered the immense shaft unnecessary. No patent was taken out for this invention, but the drawings of it were kept in the shop, open to the inspection of visitors. Among those who looked at them were M. Schneider and M. Bourdon, his foreman, of the great iron works at Creuzot, France. A few years afterward, when Mr. Nasmyth visited Creuzot, he admired the excellence of a certain piece of machinery, and asked M. Bourdon how the crank had been forged. M. Bourdon replied, "It was forged with your steam hammer." Mr. Nasmyth was then taken to the forge department, where he saw this "thumping child of his brain," which for him had existed only in his books, at work. The foreman had recollected the drawings, and embodied them substantially in the machine. Mr. Nasmyth at once secured a patent, introduced some improvements, and made the construction of the steam hammer a branch of his business.

Though he was prompt enough in explaining to them the merits of his invention, it took considerable time to arouse the official minds of the Lords of the Admiralty, "who are very averse to introducing new methods of manufacture to the dockyards." But after he had furnished hammers to the principal manufacturers of England and had sent them abroad, these dignitaries learned in the course of three years that a new power in forging had been introduced. A deputation visited the foundry to see the invention, and were pleased and "astonished at its range, power, and docility." An order came for a hammer for the Devonport Dockyard. Their lordships were present when the hammer was started, and Mr. Nasmyth "passed it through its paces." He made it break an egg-shell in a wine-glass without injuring the glass. It was as neatly effected by the two-and-a-half-ton hammer as if it had been done by an egg spoon. Then "I had a great mass of hot iron swung out of the furnace by a crane and placed upon the anvil block. Down came the hammer on it with ponderous blows. My lords scattered and flew to the extremities of the workshop, for the splashes and sparks of hot metal flew about. I went on with the hurtling blows of the hammer and kneaded the mass of iron as if it had been clay." Orders followed to supply all the royal dockyards with a complete equipment of steam hammers.

The extension of the docks at Devonport called for an immense amount of pile driving. The contractor for the work had witnessed the operation of the steam hammer, and asked Mr. Nasmyth if the principle could not be applied to the pile driver. Such a pile driver was constructed. It was tested. Two piles of equal length and diameter were selected, one to be driven with the new machine and the other in the old way. The result was four minutes and a half with the former to twelve hours with the latter; and the steam-driven piles were hardly bruised, while the others suffered in the usual way. — *Appleton's Popular Science Monthly.*

A Wonderful Machine.

The announcement was made a few days ago that a large "diffraction grating" spectroscope had just been finished at the shops of John A. Brashear, in Allegheny, Pa., for a German astronomer. This news calls fresh attention to a unique, almost unknown and remarkable piece of machinery, the ruling engine of Professor Henry A. Rowland, of Johns Hopkins University, wherewith an important part of the instrument just mentioned was made.

The object of a spectroscope is to analyze light from a star, a nebula, the sun or some other luminous object. In this operation the image of a narrow slit is expanded sideways until it is converted into a long prismatic band or spectrum, violet at one end and red at the other. For studying most of the heavenly bodies, glass wedges or prisms are employed to perform the work. These, properly arranged, will render good service, where a high "dispersion," or magnification, is not desirable. But with the sun, whose light is so intense that it will stand great dilution (so to speak), a far more considerable dispersion is entirely feasible. And the astronomical spectroscopist is anxious to produce this effect, in order more completely to separate lines in the spectrum, which are ordinarily too close together to be properly distinguished. The whole point of certain researches depends altogether on the possibility of identifying a suspected line positively, and of measuring its position in the spectrum with precision. Such separation can be much better obtained with a "grating" than with a prism.

There are two kinds of gratings. One consists of glass, on whose surface a series of fine, parallel lines are ruled. The other is a highly polished metal plate, similarly engraved. The former lets the light shine through it; the latter reflects it. In either case, the effect is to produce a spectrum exactly as a prism does. To the metal plate a slight concavity is previously imparted, so that it will focus the image without the use of an extra lens. It is this latter type of grating which was introduced into the new spectroscope. Brashear made the mirror, gave it just enough curvature to make the focal distance some twenty odd feet, and then sent it to Baltimore for treatment in Professor Rowland's laboratory.

It is stated, no doubt with truth, that the lines on this particular grating are so fine and so close together that there 110,000 to the inch! A simple comparison will enable one easily to realize what this means. In the majority of books there are from 200 to 250 leaves to the inch, when the covers are pressed firmly together. In a small minority, the number will range from 300 to 350. These latter figures represent rather thin paper. Now, if we could split one of the very thinnest of these leaves into 300 layers of uniform thickness, the product would be equivalent to 105,000 to the inch, or a little less than the number of lines in this spectroscope grating. It must be remembered, moreover, that there must be a little space between the lines, if one is to be distinct from the other. Therefore, if an inch be divided up into 1,000,000 equal parts, nine of them would be covered by a line and a space. Of course, it is impossible to see such lines with the naked eye. Only a very powerful microscope would reveal them. But they are there, and as smooth, straight, and regular as one can imagine.

The ruling engine is kept in a dark chamber, underground, in a dustproof glass case, and when in service is guarded against temperature changes with almost inconceivable caution. No one is permitted to enter the dungeon at such times, and only a very few on any other occasion. Some of the most distinguished scientists of foreign lands have made special pilgrimages to Baltimore for this purpose, and have esteemed it a rare privilege to be allowed to see the machine. The principle of the apparatus, however, is very simple. It is the exquisite workmanship on it, and the extraordinary safeguards employed while using it, which make it a wonder. A diamond point, whose selection occupied months of time, because of the need that it should possess a certain prescribed shape, has been mounted in a tiny carriage that is driven to and fro over the mirror. The carriage runs on a set of "ways," or rails, and is propelled at an exceedingly uniform speed by means of a hydraulic motor. After each trip, the carriage is moved a little to one side, so that the diamond will cut its next line in a new place. This adjustment is made automatically, at the right instant, by a screw, which is the crowning glory of the whole mechanism. It is the perfection of accuracy. The screw remains motionless while a line is being engraved, is then turned a small fraction of a revolution by gearing, and again keeps still while the diamond is at work. It will be readily understood that by multiplying the gear to the right degree, and having one tooth of the fastest wheel shoved along for each line, the number of lines to the inch can be raised to any degree consistent with the possibilities of the graving tool. In several of the best gratings now in use, there are only from 10,000 to 40,000 lines to the inch; 110,000 has thus far been attained in only two or three instances. One instrument in which the ruling had this degree of fineness was completed about two years ago, and went to the Royal Observatory in Dublin. Another was ordered for Magill University in Montreal. The one just finished is to go to Hans Hausawaldt, of Magdeburg, who is described in the papers as "a wealthy scientist." — *New York Tribune.*

[There is a story told about this marvelous ruling machine, which may be of interest, in connection with the foregoing extract from the *Tribune.* It was the intention to make the machine as nearly perfect as possible, but the best-laid plans often go wrong, and as the work progressed Professor Rowland was anxious to see how things were coming out. He assembled the parts of the machine, therefore, before they were entirely finished, and after adjusting them approximately, he began to test the screw — which, as the *Tribune* indicates, is the most important feature of the whole apparatus. As the work progressed, it became increasingly apparent that the threads were nearly perfect; and eventually, when the investigation was completed, it was found that the screw was excellent in all parts, and, which was of far greater moment, it transpired that for a space of four inches in its length, it was impossible to detect the least deviation from absolute correctness. This fortunate fact can only be regarded as an accident, since perfection is never attainable by man, except by some happy chance. At all events, Professor Rowland appreciated his good luck, and refused to let the machine be taken apart to receive the finishing touches. He feared that when it was again put together it might not work so well, and he was content to let perfection alone, and do without the higher finish of the parts that his workmen wanted to add So the finest "diffraction gratings" of the world are now ruled by these four perfect inches on the famous Johns Hopkins screw. We do not know where the machine now stands, but some years ago it was located in a cellar, in a space that was formerly used as a coal bin, this place being chosen after much careful thought, on account of the almost absolutely uniform temperature that could be had there. — EDITOR OF THE LOCOMOTIVE.]

The Locomotive.

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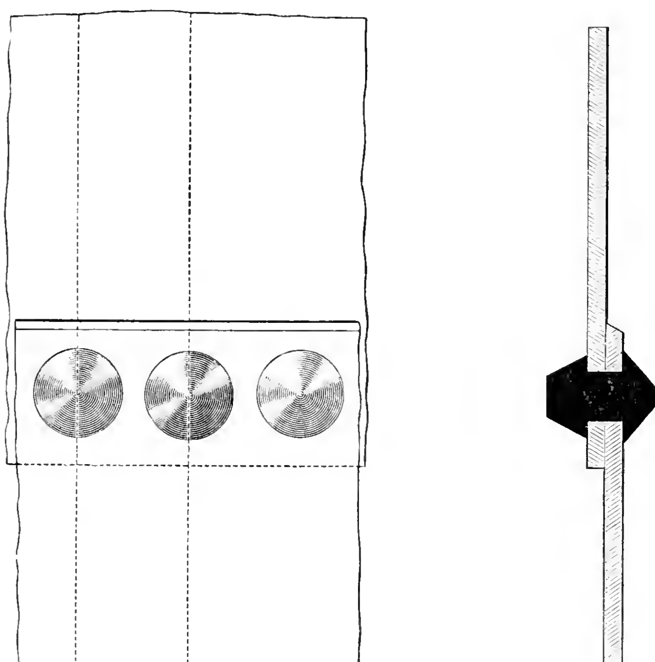
The Reduction of Pressure on Shell Boilers.

There appears to be quite a widely prevalent impression that shell boilers having fire-tubes or flues can be used for only a short time at anything like maximum pressures, and that a reduction in pressure is likely to be made on such boilers by state and insurance inspectors within three or four years, followed, from time to time thereafter, by further reductions of the same sort. Now while a superficial observation might indicate



No. 1. — Single Riveted Joint.

that there is some truth in this belief, a more intimate and correct knowledge of the true facts would show that it has little or no real foundation. The fear of reduced pressures is based upon the fact that pressures that are desired by the boiler owner are frequently refused by the inspector, owing to some structural weakness in the boiler itself. Boilers are often sold with the assurance that they are perfectly safe for 125 pounds or 150 pounds, as the case may be; and when a man buys a boiler in good faith on the strength of this representation, it is natural that he should feel that something is wrong, when the inspector afterwards tells him that his boiler is not constructed for more than 100 pounds. Well, there certainly *is* something wrong, and yet the trouble is not with the inspector, nor with the insurance company. It lies rather in the calculations (or the want of calculations) on which the boiler-maker's statement is based.

An example of pressure reduction will serve to make this clear. In the first place, all boilers should have a factor of safety of not less than 4½ or 5, except that in certain special cases where the material has been rigidly tested and the construction has been carried out under the eye of a disinterested expert, a factor as low as 4 may sometimes be allowed. Now suppose that a manufacturer has just installed a new steam plant, and that he needs a boiler pressure of 125 pounds or more; and let us also suppose that at this pressure the factor of safety is below the limit above stated. The material is perhaps of good quality, but not quite up to the proper thickness; and the work is well done, but the design of the boiler is (let us say) a little weak. These conditions, which are by no means uncommon, might justify one in running the boiler on a factor of safety of 4, for a limited time, provided it is faithfully watched. The inspector makes careful periodic examinations of the boiler, and one day he notices that it is showing signs of weakness or distress. The boiler is then put at once on its proper factor of safety of 5, and this, of course, means a reduction of pressure. The trouble was not that the boiler was a *shell* boiler, but that it was not properly designed, in the first place, to enable it to run at the pressure desired. The trouble was not with the *type* of the boiler, but with the poor design or construction of this individual specimen. The inspector should not be blamed for cutting down the pressure; he should rather be thanked for watching it so carefully that the owner has been able to run it for a time on a factor of safety for which it was never designed.

The tendency of boiler-makers to rate their products too highly is partially explained by the history of steam practice in recent years. A committee of eminent engineers canvassed the United States, in 1886 and 1889, to arrive at the average pressure carried upon power boilers used for stationary purposes. Their investigation showed that 70 pounds was the average pressure then carried in this country. The boilers, at that date, rarely were more than 60 inches in diameter, and they were built with lap joints, double riveted. The average factor of safety, at the time, was undoubtedly 5 or more. To-day these conditions are all changed. The average boiler is much larger in diameter, and we incline to the opinion that the average pressure carried on stationary boilers used for power purposes is considerably more than 100 pounds. As higher pressures and greater diameters came into use, a corresponding change in boiler construction was also called for, in order that the new conditions of practice might be properly met and provided for. To a certain extent, this change was made. Some boiler-makers, recognizing the changed requirements, equipped themselves with the necessary tools, and turned out work in which, with the increased pressures and diameters, the proper factor of safety was still maintained; and on boilers of this kind, adapted to the newer conditions, there has been no evidence of fatigue, and the pressures have not been reduced. This improvement in boiler-making, however, was by no means universal, and many builders continued to use, on boilers for 100 pounds and more, substantially the same designs, materials, and methods of construction, that they had long been in the habit of using for those intended to carry only 75 or 80 pounds. Boilers of this kind, when put in service at the pressure at which they are rated by their makers, are often cut down, when examined by the inspector, to the pressure at which they are really safe. This is the whole truth of the matter, and it constitutes the only foundation for the rumors to which we referred at the beginning of this article, which state that shell boilers are liable to a speedy and gradually increasing reduction of allowable working pressure.

With the first tendency toward high pressures, President J. M. Allen, of this company, called attention to these points, and, by means of lectures and articles in The Locomotive and other mechanical papers, he endeavored to elucidate the principles of boiler construction, and to prepare boiler-makers for the change in methods of manufacture that must inevitably come. Many hundreds of horizontal tubular boilers have been built in accordance with his designs, and in no case have any of these boilers failed, nor have any of them required a reduction of pressure until they had seen a long lifetime of active and satisfactory service. One of the most important things about a boiler is *good material;* but even with the best of material it is still possible to produce

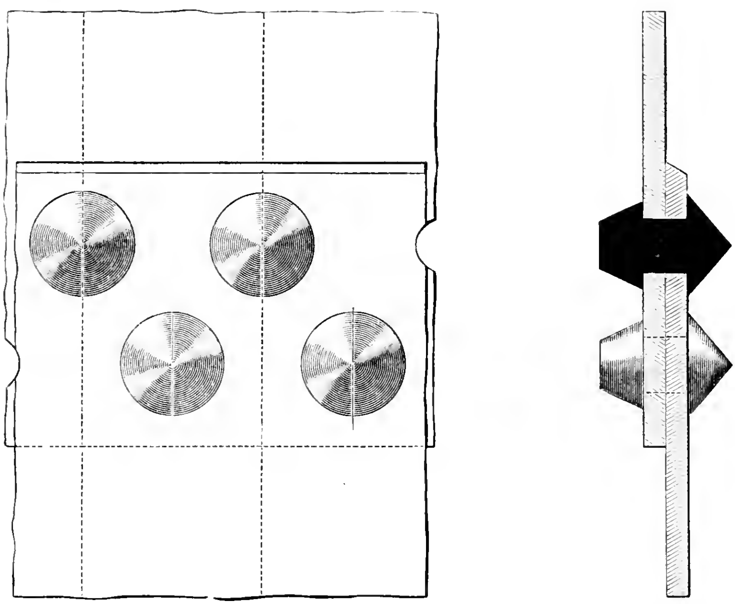


Fig. 2. — Double Riveted Joint.

an inferior boiler, as our experience and observation have abundantly shown. The commonest source of weakness, without doubt, consists in the use of poorly designed riveted joints; and for this reason Mr. Allen has dwelt upon this part of the boiler more, perhaps, than upon any other. An ideal riveted joint should be like the deacon's "celebrated one-hoss shay" — that is, it should be equally strong in every part, so that we cannot tell, in advance, whether it will fail by fracture of the plate, or by a shear of the rivets, or by some combination of the two. This condition can only be secured by using a specially designed joint for each thickness and strength of plate. The method of calculation by which a proposed joint is investigated, to see how nearly it approaches to this state, is given in full in The Locomotive for July, 1891, so that we need not repeat it in the present article.

We fear that Sir William Fairbairn is responsible for much of the cloudiness that obscures this question of riveted joints in the minds of boiler-makers. He said, in summing up the investigations begun by himself in 1838, "We may fairly assume the following relative strengths as the value of plates with their riveted joints: Taking the strength of the solid plate at 100, the strength of the double riveted joint would be 70, and the strength of the single riveted joint would be 56." Now what he *meant* was, that it is *possible* to realize these figures with *well-proportioned* joints: and yet the sentence here quoted has become sort of a fetish in engineering practice, and we find that many men who ought to know better are still allowing 56 per cent. and 70 per cent., respectively, as the actual strengths of single and double-riveted joints, *without regard to how the joint is proportioned.* Such a proceeding would doubtless amaze the venerable Fairbairn beyond expression. The attitude of too many of the modern boiler-makers is, "A double-riveted joint is a double-riveted joint, and Fairbairn says it's worth 70 per cent." Fairbairn's reply would have been, "Gentlemen, you can *make* it worth 70 per cent. if you design it properly: but if you don't design it properly, you must not expect to realize anything like that value, and in any case you must not allow for it any more than it actually figures."

The fallacy of allowing 56 per cent. and 70 per cent., respectively, without regard to the actual proportions of the joint, is well shown by the following cases, which are taken almost at random from measurements recently made by our inspectors upon boilers proposed for insurance. We could multiply these cases indefinitely, if it were profitable to do so.

PROPORTIONS OF ACTUAL JOINTS. — STEEL PLATES OF 60,000 LBS. T. S.

Thickness of plate.	Pitch of rivets.	Diameter of holes.	Kind of joint.	Actual efficiency.	Efficiency by Fairbairn's dictum.
$\frac{5}{16}''$	$2''$	$\frac{3}{4}''$	single riveted	44.7%	56%
$\frac{5}{16}$	$2\frac{1}{2}$	$\frac{13}{16}$	..	42.	56
$\frac{5}{16}$	$2\frac{3}{4}$	$\frac{11}{16}$	double riveted	54.7	70
$\frac{3}{8}$	$3\frac{1}{5}$	$\frac{3}{4}$	..	47.7	70
$\frac{7}{16}$	$3\frac{1}{5}$	$\frac{3}{4}$	..	40.9	70
$\frac{1}{2}$	$3\frac{1}{4}$	$\frac{3}{4}$	..	34.4	70

The danger of applying the blind rule of 56 and 70 to all cases, without regard to the actual facts, is well shown by comparing the last two columns of the table. Every one of the four *double* riveted joints here tabulated is weaker than a good *single* riveted joint ought to be: and in the last case the joint is less than *half* as strong as it ought to be, so that if we figured the working pressure of the boiler by using a factor of safety of 5 and assuming this double-riveted joint to have an efficiency of 70 per cent., we should actually be running on a factor of safety of 2.46 instead of 5, which would be highly dangerous. The boiler from which the fourth line of the table was taken will further illustrate the danger of this kind of thing, and show why we sometimes have to cut down pressures. The builder rated this joint at 70 per cent., and stated that a factor of safety of 4 was large enough for all practical purposes. From these data it followed that a working pressure of 110 pounds could be allowed: but when the boiler was proposed for insurance we pointed out that the real efficiency of the joint is only 47.7 per cent. instead of 70. This would make its bursting pressure about 300 pounds, and hence, in order to run at 110 pounds, we should have to admit a factor of safety of only

300 ÷ 110 = 2.73, which was entirely out of the question. In fact, we could see nothing about the boiler that would justify a factor of safety less than 5, and hence, taking account of this and of the actual efficiency of the joint, we could not allow a greater pressure than 300 ÷ 5 = 60 lbs. This was only about half the pressure desired, and it is easy to imagine the owner's disappointment; but the point to be observed is, that we did not cut down the pressure because the boiler was of the horizontal tubular type, but because it was badly constructed, so that ever since it was first put into use, it had been on the ragged edge of explosion.

In concluding, let us give one more illustration of the importance of having things right at the outset. Let us suppose that Messrs. *A* and *B* are to purchase boilers. Each wishes to carry about 110 pounds pressure. Mr. *A* buys a boiler for $50 less than Mr. *B* pays for his. The cost of installation is the same in both cases, as the boilers are identical in size, each being 72 inches in diameter. Mr. *A*'s is constructed of $\frac{3}{8}''$ plate, with punched holes and a double-riveted lap-joint, having an efficiency of (say) 65 per cent. as compared with the solid plate. The material is a good quality of fire-box steel, and at 60,000 pounds tensile strength the boiler has a bursting pressure of 406 pounds, which, with a factor of safety of 5, would make the working pressure 81 pounds.

Mr. *B*, on the other hand, purchases a boiler made of the same quality of material, but $\frac{7}{16}''$ thick, with a triple-riveted double strap butt joint, with the holes drilled in place; the efficiency of the joint being 87 per cent. The bursting pressure of Mr. *B*'s boiler is easily shown, from these data, to be 634 pounds per square inch, which, with a factor of safety of 5, would make the working pressure of the boiler 127 pounds.

It will be seen that Mr. *B*'s boiler, built at a slightly increased cost, has a factor of safety of more than 5 at a working pressure of 115 pounds, while Mr. *A* cannot carry even 100 pounds without running on a factor of safety of 4, which might be allowed, under some circumstances, when the boiler is new. As soon as *A*'s boiler shows the least sign of fatigue from running at so low a factor, we should have to place it at once on a basis which would give it the factor 5, which it ought to have; and that means, that we should have to cut down his working pressure to 81 pounds, while we should have no occasion to cut down *B*'s pressure, because his boiler was built right in the first place, and we could even allow him to increase his pressure to 125 pounds, if he should find it desirable to do so.

In what has been said in this article we have everywhere assumed that the boiler is in good condition, so far as corrosion and other forms of deterioration are concerned. Every type of boiler is liable to become weakened from the wasting away of its material from chemical causes, and the inspector, as he watches over a boiler from year to year, notes all changes of this sort, and makes such allowance for them as he thinks is necessary; but this has nothing to do with the general question that we have proposed for consideration in this article. That question was, whether a horizontal tubular boiler, which is reasonably well cared for, is likely to have its working pressure reduced, in a short time, from the maximum which is allowed upon it at first. This was the problem, and the answer is, that if such a boiler is correctly designed and constructed, so as to have a proper factor of safety, it is no more liable to a reduction of pressure than any other type of boiler is.

Inspectors' Report.

APRIL, 1897.

During this month our inspectors made 8,774 inspection trips, visited 17,924 boilers, inspected 6,915 both internally and externally, and subjected 663 to hydrostatic pressure. The whole number of defects reported reached 11,373, of which 920 were considered dangerous; 64 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,020	44
Cases of incrustation and scale,	2,370	60
Cases of internal grooving,	95	6
Cases of internal corrosion,	682	35
Cases of external corrosion,	779	53
Broken and loose braces and stays,	268	95
Settings defective,	396	23
Furnaces out of shape,	434	26
Fractured plates,	303	44
Burned plates,	266	46
Blistered plates,	227	6
Cases of defective riveting,	881	50
Defective heads,	145	29
Serious leakage around tube ends,	1,595	167
Serious leakage at seams,	385	29
Defective water-gauges,	345	53
Defective blow-offs,	184	50
Cases of deficiency of water,	11	4
Safety-valves overloaded,	89	24
Safety-valves defective,	113	25
Pressure-gauges defective,	673	48
Boilers without pressure-gauges,	3	3
Unclassified defects,	109	0
Total,	11,373	920

Boiler Explosions.

APRIL, 1897.

(81.) — A heating boiler exploded, on April 4th, in the basement of Mr. James Anderson's residence, at Salt Lake City, Utah. The kitchen range was blown from its place, and the furniture in the house was badly damaged. Mr. Anderson was on his way down to the boiler when it exploded, but fortunately he was not yet near enough to it to receive any serious injury.

(82.) — A flue in the boiler of the Campbell, Henault & Co. mill, at Westerly, R. I., collapsed on April 6th. Nobody was immediately injured, but Henry Crosby, a machinist, was slightly scalded while attempting to make some repairs, shortly afterwards.

(83.) — On April 7th, a boiler exploded in S. T. Jones' tile mill, near Kenton, Ohio. The building and machinery were wrecked. James Wilson and A. T. Gooder were injured, the former being struck on the head by a broken shaft, and the latter cut on the head by some other part of the flying wreckage.

(84.) — An awful boiler explosion took place on April 7th, in William McEvoy's grist mill, at Washington, Ga. A young man named Evans was blown to a considerable distance, and was seriously and perhaps fatally injured.

(85.) — On April 15th, a boiler exploded in Mr. Desire Boudreaux' shingle mill, some two miles east of Gibson, La. Engineer Frank R. Smith had his skull fractured, and Victor Turerc had his leg broken, and was otherwise injured. Smith cannot recover. The mill was a new one, and had never been used until the day of the explosion.

(86.) — A locomotive boiler exploded, on April 15th, on a north-bound Houston & Texas Central train, near Garrett, Texas. It is said that nobody was hurt by the explosion. Another locomotive was procured at Garrett, and the train pulled into Dallas only about forty minutes late.

(87.) — The boiler of locomotive No. 27, of the Richmond, Fredericksburg & Potomac Railroad, exploded at Ashland, Va., on April 16th, with a terrific noise. The track was torn up and the glass was broken in a number of windows in the town. The engine was badly wrecked, but nobody was killed. It was standing opposite Randolph-Macon College at the time, and was attached to a work train. The fireman, who was in the cab, was blown into the tender, but was not seriously hurt.

(88.) — On April 16th, the boiler of locomotive No. 229, on the "Big Four" railroad, exploded at Osborn, some ten miles northeast of Dayton, Ohio. Fireman John Fagan was blown fully two hundred feet into the air, landing on a pile of cinders near the tracks, two car lengths from the starting place. Head Brakeman Henry Daly, who was behind the tender ready to make a coupling, was knocked down by the tender, which struck him in the head and fractured his skull. Engineer John Hutchins was thrown sidewise to a distance of thirty feet, landing outside the tracks, stunned and bruised. Mr. Daly died at midnight, and Mr. Fagan passed away an hour later. The locomotive was a complete wreck, being torn and scattered in all directions.

(89.) — A boiler exploded, on April 21st, in Marion's saw-mill, at Bluefields, W. Va. Patrick Ford, M. Satey, J. Harrison, and T. Spence were instantly killed, and badly mutilated.

(90.) — A boiler in the factory of the Webster Bicycle Company, at Paterson, N. J., exploded on April 24th. Engineer Henry Bridder was seriously injured. Elsie Shrepfer, four years old, and her grandmother were struck by flying debris, but their injuries are not serious.

(91.) — Andrew McDaniels, a rodman at the Leasdale mine of Jesse Sanford, two miles from Carnegie, Pa., was fatally injured, on April 26th, by the explosion of a boiler used to haul cars from the mine. Mark Fisher, the engineer, was blown fifty feet or so through the air, but was not dangerously injured. Four other men also received slight injuries. McDaniels was close to the boiler-house when the explosion occurred, and pieces of the wooden building were driven into his face and neck. His head was badly hurt, and he received internal injuries. Fisher's escape from instant death was marvelous, as he stood very near the boiler. His worst injuries consisted in scalds from the steam. The windows in the Protestant Episcopal Church, the schoolhouse, and all other buildings within 500 feet were shattered.

(92.) — The Middletown Waterworks plant, at Middletown, Ind., was blown to atoms, on April 28th, by the explosion of one of its boilers. The plant was in charge of Assistant Engineer Brown, who was standing in front of the boilers. He was entirely buried by the falling bricks and timbers. Help soon arrived, and he was dug out, and found to be covered with bruises, but not seriously hurt. Electrician Davis, who was in the pump-room, was blown with great force against a wall, but escaped without serious injury. Two workmen who were in the rear of the boiler-room received a number of bruises from falling timbers. The plant was erected in 1896, at a cost of $12,000.

(93.) — The boiler of locomotive No. 6, of the Pittsburgh & Lake Erie railroad, exploded, on April 28th, near Montour Junction, Pa., scalding six trainmen. Frederick Arnold, the engineer, may die, and George Henderson, fireman, and S. L. Turner, superintendent of motive power, were scalded seriously. The locomotive was a new one, and was pulling a train of fifty-two loaded cars up a steep grade, as a test, when the explosion occurred.

(94.) — On April 28th, a boiler exploded in Vinton Alderman's saw-mill, on Deevers Fork, near Standing Stone, Wirt County, W. Va. Perry Deevers and George Conley were killed, and Z. W. Hickman, Thomas Hickman, William Balton, Vinton Alderman, and John McCauley were seriously injured, so that Balton and the two Hickmans will probably die. The mill was badly wrecked, and it is said that the loss will be heavy.

(95.) — Cary & Richardson's turpentine still, near Tallahassee, Fla., was destroyed by a boiler explosion on April 29th. Alphonse Duval, the engineer, was severely burned and was thrown several yards, but he will recover.

(96.) — On April ——, a big boiler belonging to the Hudson River Stone Supply Co., near New Hamburgh, N. Y., blew up, severely injuring William Dietz and Jerome Phillips.

The American Society of Mechanical Engineers.

The American Society of Mechanical Engineers met in Unity Hall, Hartford, on the evening of May 25th. Mr. C. E. Billings, chairman of the local committee, introduced the meeting with a few remarks, after which Mayor Miles B. Preston delivered an address of welcome to the society. President W. R. Warner replied in a very neat speech, and was followed and ably seconded by Secretary F. R. Hutton. The formal opening exercises over, the society and its guests devoted the remainder of the evening to social intercourse, and to the informal discussion of mechanical problems and refreshments.

On the morning of May 26th the regular business of the meeting was resumed at Unity Hall, and the following professional papers were read and discussed: "Diagram for the Relative Strength of Gear Teeth," by Forrest R. Jones; "Experiments in Boiler Bracing," by F. J. Cole; "Adiabatics," by DeVolson Wood; "A New Form of Transmission Dynamometer," by Frederick A. Bedell; "Flue Gas Analysis in Boiler Tests," by R. S. Hale; and "Hygrometric Properties of Coals," by R. C. Carpenter.

The afternoon was devoted to visiting Hartford's manufacturing establishments. The members were divided into two parties, for convenience, the first visiting the Pope Manufacturing Company and the Billings & Spencer Company, while the second visited the Motor Carriage Works, the Hartford Rubber Works, the Pope Tube Works, and the Pratt & Whitney Company. A reception was meanwhile held at the Allyn House for the many ladies who attended the meeting. The hotel parlors were prettily decorated, and refreshments were served. In the evening a second reception was given to the members of the society by the Corporation of Trinity College, in Alumni Hall.

On the morning of May 27th the reading of professional papers was resumed, and the following were presented: "Electricity versus Shafting in the Machine Shop," by C. H. Benjamin; "Electric Power Equipment for General Factory Purposes," by D. C. Jackson; "Volumnar Contraction of Cast Iron," by Francis Schumann; "On Rating Electrical Power Plants upon the Heat Unit Standard," by W. S. Aldrich; "The Laws of Cylinder Condensation," by A. L. Rice; "Tests of Sulzer Engines," by H. A. Hill; "Method of Accounting, to Determine Shop Cost and Selling Price," by H. M. Lane.

A notable feature of the morning was the change of opinion with regard to power transmission by electricity. When this subject was discussed by the society a few years ago, the prevailing sentiment was in favor of belting for transmission; but it may fairly be said, we think, that the sentiment of the society has turned the other way, and that most of the members now favor electricity.

In the afternoon the shop-visiting program was continued, the same places being visited as on the day previous, except that the two divisions of the society changed places, so that each went over the ground that had already been covered by the other division. The ladies meanwhile took a trolley ride to South Manchester, where they were received and escorted through the silk mills by a committee representing the Messrs. Cheney Brothers. In the evening Mr. Leonard Waldo entertained the society with a popular and well illustrated paper on the "History and Development of the Bicycle."

On May 28th the first thing on the programme was an exhibition of the big self-propelling fire-engine, "Jumbo," which was put through its paces on Trumbull street, at 9.30, for the edification of the society. The members then repaired again to Unity Hall, where the following papers were announced: "Tests of Centrifugal Pumping Engines, etc.," by R. C. Carpenter; "Current Practice in Engine Proportions," by John H. Barr; "A Continuous Steam Engine Indicator," by Thomas Gray; and "The Best Load for Compound Steam Engines," by A. K. Mansfield. In the afternoon a portion of the society visited the big plant of the Colt's Patent Fire Arms Company. Through the courtesy of the Hon. John H. Hall, Col. N. H. Heft, and others, an excursion was taken by the rest of the members, beginning with a trip down the Connecticut river to the great brown-stone quarries of the Brainard, Shailer & Hall Quarry Company, at Portland, Conn. From the quarry special cars took the excursionists to Middletown, and thence to Berlin, where the Berlin Iron Bridge Company's plant was visited. From Berlin the party was taken to New Britain, and thence back to Hartford over the new "third rail" electric line.

In the evening the final papers of the session were read, and resolutions were adopted, expressing the appreciation of the society for the kindly reception it had received from the people of Hartford and vicinity. The meeting then adjourned.

The Locomotive.

HARTFORD, JUNE 15, 1897.

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

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MR. ALVAN G. CLARK, the famous telescope maker, died at his home at Cambridge, Mass., on June 9th, as the result of a stroke of apoplexy. His latest great work was the mammoth lens for the Yerkes telescope of Chicago. The way in which the Clark family built up their famous lens-making business is well set forth in an interesting letter from Alvan Clark, Sr., published in THE LOCOMOTIVE for April, 1889.

Postscript Concerning Mercury Columns.

In our issue for May, 1897, we described the mercury gauge, and explained the way in which it should be graduated, so as to give its readings in pounds per square inch. On page 69 of this article we find the following words:

"The latitude of our Hartford office being 41° 46', and the temperature of the mercury column being always very near to 70°, we see from the table that it is necessary to allow 2.043 inches for each pound of pressure desired. The best way to carry out the actual work of graduation is probably to lay off, first, the positions of the marks for 10 lbs., 20 lbs., 30 lbs., etc., allowing 20.43 inches for each ten pounds. Then the intermediate one-pound divisions can be filled in upon the skeleton so laid down, with great accuracy."

This is all quite true, so far as it goes, but it was our intention to qualify it by a little further explanation, in which the effect of the cistern shown in Fig. 1 should be taken into account. A paragraph was in fact prepared for this purpose, but in some way it was omitted in the final transmission of the copy to the printer, and it is therefore given below:

"As the mercury rises in the graduated glass tube, it must fall in the cistern into which the tube dips: and in order to have our readings strictly accurate, we must take account of the change of level in the cistern. The length allowed on the scale for each pound of pressure (*i. e.*, 2.043 inches), must therefore be slightly reduced: but the amount of the reduction thus rendered necessary will depend upon the proportions of the apparatus. In one of our office columns the glass tube is $\frac{3}{16}''$ in diameter internally, and $\frac{5}{16}''$ externally, and the cistern is 4" in diameter, inside. From these data we can easily calculate the allowance that must be made for the change in level in the cistern. Suppose, for example, that the mercury rises 100" in the column. Then the volume of mercury that has entered the column is found by multiplying 100" by the sectional area of the inside of the tube. The area of a $\frac{3}{16}''$ circle being 0.02761 sq. in., the volume of mercury that has entered the tube must be $0.02761 \times 100'' = 2.761$ cu. in. We have next to find the change in the cistern-level that will be produced by abstracting 2.761 cubic inches of mercury. The area of a four-inch circle is $4\times4\times.7854=12.5664$ sq. in.; but we cannot base our calculations on this full diameter, since the glass scale-tube projects downward into the cistern, and takes up a certain part of its volume. As we have already said, the external diameter of this glass tube is $\frac{9}{16}''$, so that its sectional area (outside) is 0.2485 sq. in. The actual area of mercury surface in the cistern is therefore $12.5664-0.2485=12.3179$ sq. in. To find out how much this level falls when 2.761 cu. in. of mercury are withdrawn, we have merely to divide 2.761 by 12.3179. Hence we see that when the mercury rises 100″ in the glass tube, it falls, in the cistern, by $2.761\div12.3179=0.224''$. The total difference in level between the mercury in the gauge glass and that in the cistern is therefore 100.224″, instead of being just an even 100″. But if we want to figure the matter down to a very fine point, we must take account of the fact that when mercury leaves the cistern, an equal amount of water enters to take its place; so that we must not count the full amount that the cistern level has fallen as a clear gain of 0.224″ of mercury. Water weighs approximately one-thirteenth as much as an equal bulk of mercury; and hence in our calculations we must only allow *twelve-thirteenths* of 0.224″, as the *effective* change in level in the cistern. Twelve-thirteenths of 0.224″ is 0.207″; and this, added to the 100″ that the column has risen in the glass tube, gives a total *effective* head of 100.207″ of mercury, for each 100″ of actual rise in the glass gauge. In other words, the actual pressure due to the column will be greater than the apparent pressure (as deduced from the simple rise of mercury in the index tube) in the proportion of 100 to 100.207. Hence if the column is to read with strict accuracy, we must shorten all its graduation marks in this same proportion. Instead of laying off 2.043 inches *on the scale* for each pound, we must only lay off as much as is indicated by the proportion

$$100.207 : 100 :: 2.043 : x;$$

whence $x=2.039''$. That is, in laying down our graduation marks upon the scale, we should allow 2.039″ for each pound of pressure, or 20.39″ for each ten pounds. The error committed by omitting this correction is doubtless very small, and yet it has been thought best to discuss it in the present place, so that the entire process of graduating a mercury column with any desired accuracy may be thoroughly understood. The correction for change in cistern level, in the present example, amounts to only about one-tenth of a pound for each 50 pounds of actual pressure."

Rules and Regulations of "The Sterile Hotel."

Antiseptic precautions are very good in their way, but if we should try to carry out all the anti-microbe advice that we get in the daily papers (and even in the scientific ones), we should cry out with Burns:

> "Oh, life! thou art a galling load,
> Along a rough, a weary road,
> To wretches such as I."

This remark is called forth by a glance into our editorial scrap-book, where we find a collection of rules, written out for the use of an imaginary "Hotel Sterile," by Dr. Ellis of Danbury, Conn. These rules originally appeared in the *New England Medical Monthly*, and we extract some of them for the benefit of such hotel proprietors as may chance to be readers of The Locomotive:

The medical press of this country (says the doctor) has for some time insisted that hotels should offer their patrons aseptic hospitality, especially since so many travel in search of health and make "septic" every hotel visited, by leaving behind them colonies of festering bacteria. We beg to inform our patrons, therefore, that hereafter we shall offer them strictly aseptic accommodations; and we respectfully call their attention to the rules under which this hotel will be run in the future:

1. The hotel bacteriologist will examine everything, everywhere, every morning, and submit a daily report.

2. All food is sterilized before it is admitted to the hotel, by our kitchen bacteriologist. This operation is carried out in our sub-kitchen, which is one mile from the hotel.

3. All bedding is removed daily and sterilized by our sterilized porter. Guests on rising in the morning are requested to touch the button marked "non-sterilized porter." He will immediately remove the debris.

4. No pictures, hangings, carpets, or furniture of any kind are used at this hotel.

5. After the bedding is removed by the porter, guests are obliged to enter the antiseptic bath, during which time their clothing will be examined by our own lightning bacteriologist, and then sterilized.

6. Guests will observe that as germs hustle for the corners, all corners have been rounded, and are daily painted with germ-proof shellac.

7. Positively no carpets or curtains are allowed; but guests may order a sterilized rug, which can be used no longer than *six hours*. An alarm clock connected with the rug will ring at the end of that time for the non-sterilized porter or rug boy.

8. Guests arriving at this hotel must first enter the germ room, where they are rendered aseptic by our new antiseptic methods. While they remain here they must wear the sterilized garments that are furnished by the hotel. It is the aim of the management to give as good a fit as possible.

9. No baggage can be opened in this hotel at any time. It must be kept closed and stored in our trunk room, which is kept sterile by being maintained constantly at a temperature of 420° Fahr. At this temperature whiskey bottles are explosive, and hence all baggage will be searched for them by means of our giant X-ray apparatus.

10. Before leaving, all our patrons are washed and sprayed with a ten per cent. solution of bichloride of mercury, and then packed in sterilized gauze, which must not be removed until the guest is as least a mile from the hotel. If the wind blows in our direction, a distance of two miles is absolutely required.

11. Sterilized towels, one to each guest, are furnished in portable cans. When soiled they must be immediately folded in a small bundle and placed in the non-sterilized can which is furnished.

12. In the dining-room sterilized dishes of compressed paper are used. These are burned immediately after using. No dish is allowed on the table more than five minutes after a meal is served.

13. Our employes are all enclosed in sterilized steel suits which supply compressed air for two hours. Should an employe suddenly grow black in the face and leave, you may know that the air is exhausted, so do not feel offended. If possible, the same attendant will return. If impossible on account of his death, another will be sent immediately.

14. Our closets, flushed with sterilized bichloride, are open day and night. They are reached by our aseptic underground private walk, and are but ten minutes from the hotel. As no lights are allowed, guests are cautioned to keep to the right.

15. The entire building is sprayed and douched at ten A. M. daily, and then kept at a temperature of 200° for two hours. Guests are therefore advised to don our waterproof aseptic gown at 9.45 sharp.

16. Guests must not die in this hotel, as this practice, if countenanced, would speedily make our antiseptic service impossible.

17. It is not necessary to sterilize money before entering. We accept this necessary evil at its face value (unless plugged), deposit it in our improved pasteurized pockets, and sterilize it afterwards at our own expense.

18. Any guest finding a microbe about this hotel, will please report him promptly at the office.

Elmwood's Poet Writes Us a Letter.

Following is a copy of a letter recently received at the home office of this company :

"Brother Allen, it was Monday, if my memory serves me true —
I had made a run to Hartford, and I made a call on you.
You were occupied, and yet I'll own you gave me cordial greeting,
And I sat me down and entered on the business of the meeting.
The reason, you'll remember, that I gave for my invasion,
Was a need that I rehearsed at once for your consideration.
You thought that you could help me — you would bear my case in mind —
And the very thing I wanted you could very likely find.
Through the scrap heaps of my neighbors I have often longed to poke,
Yet I've waited the fulfilling of the friendly word you spoke.
Now I write to ask if I can be forgotten (as I seem),
For I long to get that second-handed boiler under steam,
And I fear that other matters may have made you spring a leak —
That the joints about your head end may have started (so to speak);
Your safety-valve, it may be jammed ; the pressure on your shell
It may have blown my small request into the depths of —— well,
I only meant to write a word, your memory to touch —
I'm sure I've written quite enough, and possibly too much."

Our friend had not been forgotten, but his wants were fulfilled as promptly as possible, and to his entire satisfaction.

Facts from an Old Map.

It is well known that our Appalachian Mountains were once very much higher than the Rocky Mountains of to-day, and that the reason why they are now comparatively low mountains is simply that they are very old and have been worn down by denudation. The same destructive influences are still degrading them, very slowly as we measure ordinary time, to lower levels. We know that changes are constantly going on in the physical condition of the earth's crust, but these changes are so slowly accomplished that they can scarcely be observed, in many cases, in an ordinary lifetime. In the coming ages, students of physiography will have a great advantage over those of today; for the art of accurately delineating the surface of the earth by means of contoured maps is a comparatively recent invention. Hundreds of years from now the physiographers will be able to learn from the maps we are making now exactly what the surface features of large areas were in our time, and it will be easy to make instructive comparisons with the same features as they find them.

Prof. Edward Bruckner has recently described in *Petermann's Mitteilungen* the very interesting results of a comparative study of a remarkable map of the seventeenth century and one of the Swiss survey maps of to-day. In 1667, Mr. J. C. Gyger completed his map of a part of the Alpine region extending from the Rhine on the north to the Reuss on the south, and including the whole of the canton of Zurich, in Switzerland. The map was on an unusually large scale for that time. The scale was 1 : 32,000, or one inch on the map for about a half mile in nature. He worked compass in hand, paced his distances, and was very careful and laborious in his survey. He gave a great deal of time for thirty-seven years to his map. He was the first to use lights and shadows to indicate and contrast mountain slopes. Two copies of his map, both signed by him, are extant, and they still excite the admiration of cartographers for the wonderful accuracy with which they depict topography. Until this century the Gyger map was regarded as the best cartographic delineation of the Zurich canton. Small parts of it have been published with corresponding sections of the present surveys, to show the high standard of accuracy Mr. Gyger attained.

Mr. H. Walser has carried out, in the Geographical Institute of the University of Berne, the comparison between the Gyger map and that of the present day. Mr. Gyger carefully showed every lake, large and small, in the canton, and sharply distinguished the lakes from the swamps. His map showed 149 lakes in the canton. Of these no less than seventy-three are not found on the present maps. These lakes, as Mr. Walser points out, one by one have become extinct. They were all small, most of them having an area of less than twenty-five acres. The area of sixteen other lakes is now much reduced, and twenty others are somewhat smaller than in the seventeenth century. Forty lakes have undergone no important change.

Mr. Walser has ascertained by observation the causes of the shrinkage or disappearance of fifty-four of these lakes. The farmers, in their efforts to secure more meadow land, have played an important role. They have drained quite a number of the lakes and turned their beds into hay farms or pasture lands. Of course, in geological time, all lakes are drained by the natural cutting down of their outlets, but, on account of the unimportant slope of the outlet channels of these particular lakes, the deepening of the channels was very slow, and this form of lake effacement seems to have cut no figure.

The effects of two other natural causes, however, are very evident. One was the silting up of the lakes by the deposit of sediment, and the other, and more important, the gradual encroachment of plant life in the lakes, which finally completely filled them, the decay of vegetation forming soil, and thus the lakes were gradually extinguished. Some of the lakes are still undergoing this process, the carpet of plants extending all around the shores, while a little water surface is still visible in the center. The deposition of sediment and the growth of plants which finally obliterated these little lakes were of course supplemented, as Mr. Walser says, by the human activities that, in the past century, largely cut off the water supply that made and fed them.

Mr. Gyger very carefully showed the forests on his map, and the comparison that has now been made between the area of forests in the canton two centuries ago and at the present day is very interesting in view of the statement, often heard, that Europe is gradually undergoing deforestation. Proof is afforded that, at least in this district, the forests have just about held their own. Two hundred and forty years ago, according to the Gyger map, there were 132,500 acres of forests in the Zurich canton. There are now 120,000 acres of woodlands, or, in other words, the forest area has been depleted only about 10 per cent. since Mr. Gyger made his map. The steeper slopes are still wooded as they were, except here and there where woods have given place to vineyards. The forests have increased on the flood plains of the rivers, and also on the hill slopes near the Rhine; they have held their own in the northwest part, and in the region of the lower Toss, while the wooded area has been reduced a fourth in the Jona district.

Mr. Gyger also delineated on his map the areas given to wine culture, from which it appears that the increase in the amount of land devoted to this industry at the present time is about 25 per cent. As a rule wine culture is not attempted now on shaded slopes and at a high altitude to so great an extent as it was two centuries ago.

A very noteworthy recession of the lake area, very little change in the extent of the forests, and an important increase in wine in the canton of Zurich are the most important changes which have been brought to light by this interesting comparison of maps.— *New York Sun.*

The Canal of Joseph.— How many of the engineering works of the nineteenth century will there be in existence in the year 6000? Very few, we fear, and still less those that will continue in that far off age to serve a useful purpose. Yet there is, at least, one great undertaking conceived and executed by an engineer which during the space of four thousand years has never ceased its office, on which the life of a fertile province absolutely depends to-day. We refer to the Bahr Joussuf — the canal of Joseph — built, according to tradition, by the son of Jacob, and which constitutes not the least of the many blessings he conferred on Egypt during the years of his prosperous rule. This canal took its rise from the Nile at Asiut, and ran almost parallel with it for nearly two hundred and fifty miles, creeping along under the western cliffs of the Nile valley, with many a bend and winding, until at length it gained an eminence, as compared with the river bed, which enabled it to turn westward through a narrow pass and enter a district which was otherwise shut off from the fertilizing floods on which all vegetation in Egypt depends. The northern end stood seventeen feet above low Nile, while at the southern end it was at an equal elevation with the river. Through this cut ran a perennial stream, which watered a province named the Fayoum, endowing it with fertility and supporting a large population. In the time of the annual flood a great part of the canal was under water, and then the river's current would rush in a more direct course into the pass, carrying with it the rich silt which takes the place of manure and keeps the soil in a constant state of productiveness. All this, with the exception of the tradition that Joseph built it, can be verified to-day, and it is not mere supposition or rumor. Until eight years ago it was firmly believed that the design has always been limited to an irrigation scheme, larger, no doubt, than that now in operation, as shown by the traces of abandoned canals, and by the slow aggregation of waste water which had accumulated in the Birket el Querum, but still essentially the same in character. Many accounts have been written by Greek and Roman historians, such as Herodotus, Strabo, Mutianus, and Pliny, and repeated in monkish legends. or portrayed in the maps of the middle ages, which agreed with the folk lore of the district. These tales explained that the canal dug by the ancient Israelite served to carry the surplus waters of the Nile into an extensive lake lying south of the Fayoum, and so large that it not only modified the climate, tempering the arid winds of the desert and converting them into the balmy airs which nourished the vines and the olives into a fullness and fragrance unknown in any part of the country, but also added to the food supply of the land such immense quantities of fish that the royal prerogative of the right of piscary at the great weir was valued at £250,000 annually. This lake was said to be 450 miles round, and to be navigated by a fleet of vessels, and the whole circumference was the scene of industry and prosperity.— *Engineering.*

The Locomotive.

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Diagonal Riveted Joints.

Most of the riveted joints that are met with in boiler practice run either lengthwise of the boiler, or else circumferentially around it. These two forms are commonly known as "longitudinal" and "girth" joints, respectively. There is a growing tendency, however, to make use of what is known as the "diagonal joint"; and as there are some unusual points about the method of calculating the strength of a joint of this kind, we have thought it well to discuss the subject in The Locomotive.

The diagonal joint may be the same as any other joint, so far as its proportions and general design are concerned: that is, it may be single, double, or triple riveted, or it may be "butt-strapped," or have any other of the forms that occur in ordinary practice. It takes its name, not from the way in which the rivets are proportioned and arranged, but from the fact that its general direction makes an acute angle with the length of the

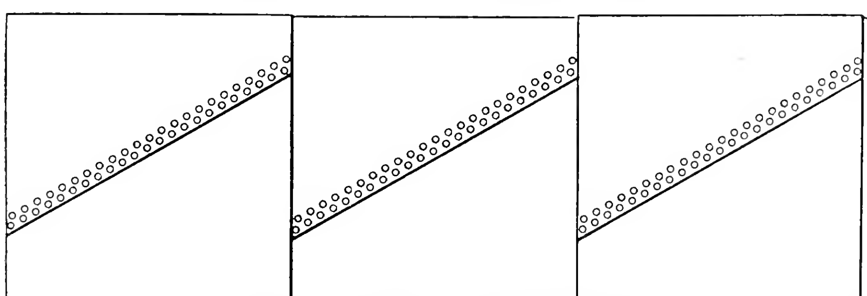

Fig. 1.—Diagonal Riveted Joints.

boiler. It runs *diagonally*, as shown in Fig. 1; and if it were continued far enough, it would run around and around the boiler like a spiral or helix. (In fact, such joints are sometimes called "helical joints.") The problem before us is to determine what effect the obliquity of the joint has upon its strength.

Let us first see precisely what is meant by the "efficiency" of a joint. Fig. 2 represents a boiler with a double-riveted longitudinal joint, *AB*. If this boiler should burst, it would fail along the line *AB* (provided the plates are all sound and good), since this is the weakest part of the whole structure. But we can easily calculate the force that would be required to fracture the plate lengthwise, as shown at *CD*, provided we know the thickness of the plate and the tensile strength of the material. If we should find, when this calculation has been made, that the resistance along *AB* is only (say) 70 per cent. of that along an equal length of the line *CD*, we should express this fact by saying that the joint *AB* has an *efficiency* of 70 per cent.

Turning now to the girth joint, we can find its efficiency in the same way, by comparing the force that would be required to rupture the boiler along *AB* (in Fig. 3) with the force that would be required to break it apart through the solid plate, along the parallel line *EF*. If the girth joint in Fig. 3 were double-riveted, and just like that shown in Fig. 2, of course we should find that it has the same efficiency in either case, because the mere *position* of a joint cannot affect the efficiency of the joint when that efficiency is measured in the way indicated in Figs. 2 and 3. In other words, the force required, in Fig. 3, to tear the boiler apart along *AB* would be 70 per cent. of that required to tear it apart along the parallel line *EF*.

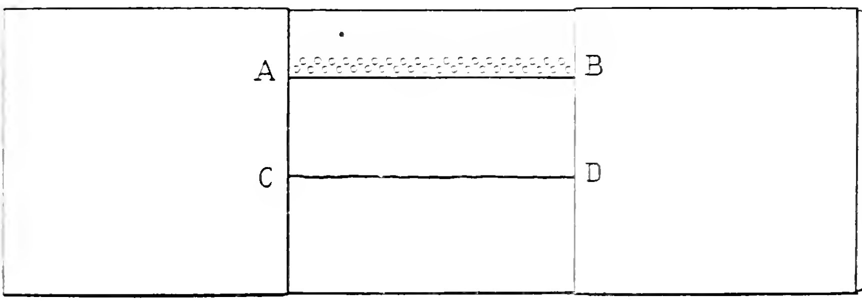

FIG. 2.—DOUBLE-RIVETED LONGITUDINAL JOINT.

There is one very important fact which we have not taken into account, thus far, in making these comparisons. It is that, when a boiler is under pressure, the strain on the boiler is different in different directions, being greatest along a circumferential direction, and least along the direction of the boiler's length. In fact, the strain on a boiler, girthwise, is precisely *twice* as great as the strain in a lengthwise direction. (This fact was discussed in THE LOCOMOTIVE for November, 1891.) In other words, if we should mark off a section of convenient length (say one foot) on the line *CD* in Fig.

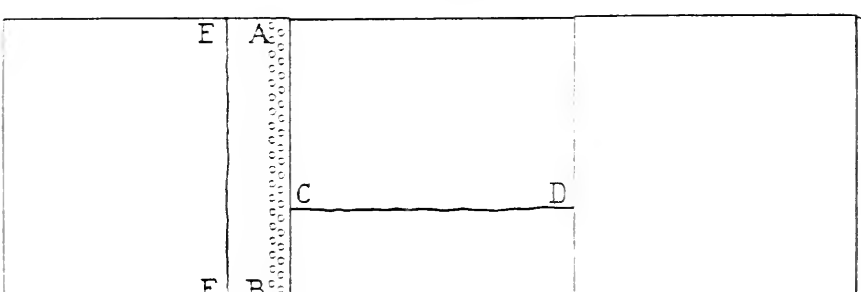

FIG. 3.—DOUBLE-RIVETED GIRTH JOINT.

3, and an equal length along the line *EF*, the strain on the marked part of *EF* would be only half as great as the strain on the marked part of *CD*. It is easily seen, from this, that although the joint *AB* has an efficiency of only 70 per cent. when compared with the solid plate along *EF*, *it has an efficiency of 140 per cent. when compared with the solid plate along CD*. For since the strain on *EF* is always precisely half of that on *CD*, we may say that the effective strength of *EF* is twice that of *CD*; and since *AB* is 70 per cent. as strong as *EF*, it follows that *AB* has an *effective* strength which is $.70 \times 2 = 1.40$ times as great as an equal length of solid plate, measured along *CD*.

We may sum up our results, thus far, in the following words: If the strength of the solid plate along *CD* be taken as a constant unit of reference, then the joint *AB* in Fig. 2 has an efficiency of .70 when compared with an equal length of *CD*, and the joint *AB* in Fig. 3 has an efficiency of 1.40 when compared with an equal length of *CD*.

Still confining our attention to the identical joint that was shown in Figs. 2 and 3, let us now suppose that instead of running either lengthwise or girthwise, it runs *diagonally*, as shown at *AB*, *MN*, or *XY* in Fig. 4. The effective strength of such a joint will evidently lie somewhere between the two values that we have already found. That

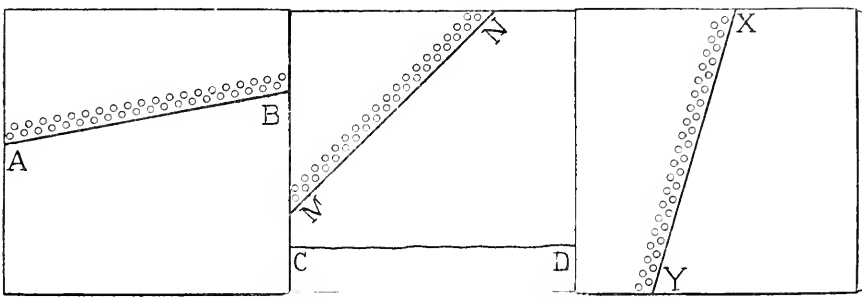

FIG. 4.—DIAGONAL JOINTS.

is, it will be somewhere between .70 and 1.40, when compared with a constant unit of solid plate of equal length, measured along the line *CD*. The joint *AB* (in Fig. 4) will not greatly exceed .70, because it is nearly parallel to the length of the boiler; and the joint *XY* will not fall far short of 1.40, because it is nearly parallel to the girth joints; but we cannot yet say much about *MN*, because it is not anywhere nearly parallel to anything. Its strength *might* perhaps be half-way between .70 and 1.40; but, so far as we can yet say, it might differ quite materially from the exact average of these two figures.

To find a formula that will always give the value of the diagonal joint, we must have recourse to trigonometry. The investigation will be given presently, but for practical uses we may sum up its result in the following convenient

RULE: To find the *effective* efficiency of a diagonal joint, first find the efficiency in the usual way, as though the joint were of the ordinary longitudinal type. (The method of doing this was explained in THE LOCOMOTIVE for July, 1891.) Then measure the

FACTORS FOR COMPUTING DIAGONAL JOINTS.

a.	Factor.	*a*.	Factor.
30°	1.51	50°	1.20
35	1.42	55	1.15
40	1.34	60	1.11
45	1.27	65	1.08

angle *a*, in Fig. 5, that the diagonal joint makes with the girth joint, and find the factor opposite this angle in the table. Finally, multiply the efficiency as found above by the tabular factor, and the result is the *effective efficiency* of the proposed diagonal joint.

The effective efficiency so found is to be employed in casting up the bursting pressure of the boiler in the usual way.

EXAMPLE: A 60-inch boiler has diagonal joints which make an angle of 50° with the girth joints. The material of the shell is $\frac{3}{8}''$ thick, with a tensile strength of 55,000 pounds per square inch. The joint is double-riveted, the rivet-holes being $\frac{15}{16}''$ in diameter, and the pitch $3\frac{1}{16}''$. It is required to find the safe working pressure, using a factor of safety of 5.

SOLUTION: To find the bursting pressure of a jointless shell of these proportions, we must multiply the tensile strength of the material by the thickness of the shell, and divide the product by the radius of the boiler. The radius is here 30″. We have, therefore,

$$55{,}000 \times \tfrac{3}{8} = 20{,}625, \text{ and } 20{,}625 \div 30 = 687 \text{ lbs. per sq. in.,}$$

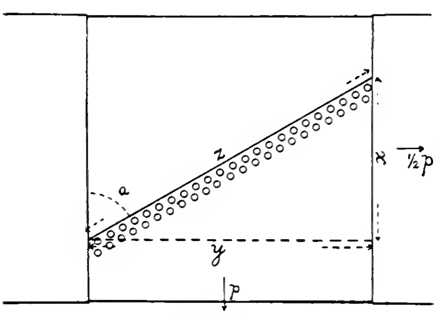

FIG. 5.

which is the bursting pressure of a jointless shell of the proposed dimensions. To find the actual bursting pressure of the boiler, we must multiply 687 by the "effective efficiency" of the diagonal joints, which is to be found by the foregoing rule. The efficiency of an ordinary longitudinal joint having the dimensions here given was computed in THE LOCOMOTIVE for July, 1891, where it was found to be .693. Now opposite 50° in the table we find the factor 1.20; so that the "effective efficiency" of the diagonal joint is

$$.693 \times 120 = .832.$$

Multiplying the bursting pressure, as already found for the solid shell, by this "effective efficiency," we find

$$687 \times .832 = 572 \text{ lbs. per sq. in.,}$$

which is the bursting pressure of the actual boiler, as constructed with the diagonal joints. To find the safe-working pressure, we divide 572 by the factor of safety. Thus:

$$572 \div 5 = 114 \text{ lbs. per sq. in.,}$$

which is the safe-working pressure desired.

The principle of the diagonal joint has an interesting application in repair work. It sometimes happens, for example, that in putting on a patch it is just as easy to give the patch a shape somewhat like that indicated at *B* in Fig. 6, as it is to make it rectangular, as shown at *A*. In such cases the boiler-maker is likely to choose the square-cornered form, because it makes a neater-looking job. The form shown at *B* is much to be preferred, however; for, on account of the inclination of its edges to the girth joint, it gains in strength for the same reason that a diagonal joint is more effective than a similarly designed longitudinal joint. Suppose, for example, that the riveting used at *A* and *B* in Fig. 6 is so proportioned that the joint has an efficiency of 56 per cent. when computed in the usual way. Then the patch shown at *A* cannot have a strength greater than 56 per cent. of that of the solid plate, because two of its edges are parallel to the length of the boiler. At *B*, however, the edge of the patch is nowhere anywhere nearly parallel to the length of the boiler. Assuming that its average inclination to the girth joint is not more than 45°, we can find, in a general way, how much more effective *B* may be expected to be than *A*. For in the table we see that the factor for 45° is 1.27; and hence the riveting on the patch *B* would have an effective efficiency of $1.27 \times .56 = .71$, or 71 per cent.; so that *B*, although only single-riveted, would be as strong as *A* could be, even if *A* were put in with first-class *double*-riveted joints. This point should not be

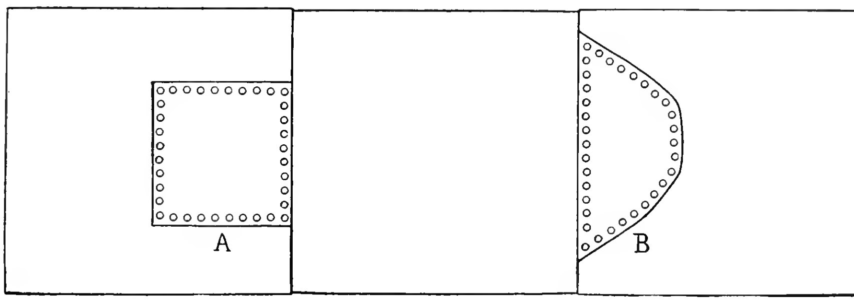

Fig. 6.—Illustrating the Relative Strengths of Patches.

forgotten, when the nature of the defect to be remedied leaves the boiler-maker free to to select whatever shape of patch he prefers.

We shall now give the promised analytical investigation of the diagonal joint. As a rule, we prefer to omit mathematical formulæ from The Locomotive; but in cases like the present, where the mathematics of a problem cannot be found readily in other places, we have sometimes broken over our general rule.

Referring to Fig. 5, let p be the pull exerted circumferentially upon a section of the shell one inch long. Then $\frac{1}{2}p$ will be the pull exerted upon an equal length of the girth joints. The total strain on the joint z is compounded of the total horizontal pull on the length x, and the total vertical pull on the length y. The stresses acting on z may, therefore, be summed up as follows:

(1) A horizontal pull equal to $\frac{1}{2}px$, and
(2) A vertical pull equal to py.

These stresses act along the whole length of z; so to find the stress *per unit length* of the diagonal joint, we have to divide them both by z. Hence the horizontal and vertical stresses, on each unit length of z, are $\frac{px}{2z}$ and $\frac{py}{z}$ respectively. Now we see from the geometry of the figure that $x \div z = \cos a$, and $y \div z = \sin a$; and if these substitutions are made, we find that each unit length of the diagonal joint is subjected to the following forces:

(1) A horizontal stress of $\frac{1}{2}p \cos a$, and
(2) A vertical stress of $p \sin a$.

This state of things is indicated in the diagram given in Fig. 7.

Having found how the actual stresses are disposed, several problems present themselves. In the first place, it would be well to know the *direction* in which the resultant stress (X) acts. For obtaining this the diagram furnishes the equation

$$\tan b=(\tfrac{1}{2}\,p\cos a)\div(p\sin a)=\tfrac{1}{2}\operatorname{cotan} a.$$

If b be found from this equation, then $(a+b)$ is the angle that the resultant force, X, makes with the diagonal joint. For example, if $a=60°$, cotan $a=0.57735$; ∴ tan $b=0.28867$, and $b=16°\ 06'$. Hence $(a+b)=60°+16°06'=76°\ 06'$, which is the angle that the resultant force acting on the diagonal joint makes with the direction of the joint.

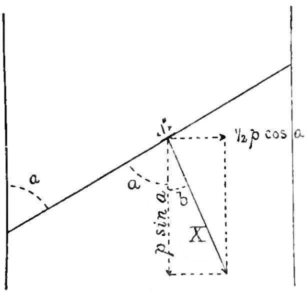

FIG. 7.

Another problem that presents itself is to find the force that acts perpendicularly to the direction of the joint — the "normal force," as it may be called. To solve this problem, we merely have to take the sum of the normal components of the two main forces. The normal component of the horizontal force is found by multiplying that force by cos a; and the normal component of the vertical force is found by multiplying it by sin a. Performing these multiplications and adding the results, we find that the total force that is acting upon each unit length of the joint, and at right angles to it, is

$$\tfrac{1}{2}\,p\cos^2 a+p\sin^2 a=\tfrac{1}{2}\,p\,(\cos^2 a+2\sin^2 a).$$

By a simple trigonometrical transformation this becomes reduced to

$$\tfrac{1}{2}\,p\,(1+\sin^2 a),$$

which is the desired expression for that part of the stress which acts perpendicularly to the joint.

In a similar way we may find the component acting parallel to the joint, by multiplying by sin a where we multiplied by cos a before, and by cos a where we used sin a. It will not be necessary to give the details of the operation. The result is, that the force acting on the joint parallel to its own direction is

$$\tfrac{1}{4}\,p\sin 2\,a,$$

upon each unit length of the joint.

Finally, we may find the *total* stress, X, which comes upon each unit length of the joint. This is compounded of the perpendicular and parallel stresses, which have already been derived, and it acts more or less obliquely, — in fact, we have already found that its direction makes an angle of 76° 06′ with the joint, in the special case in which the joint makes an angle of 60° with the girth seams. The easiest way to find the total stress, X, is by adding the squares of the two forces indicated by dotted lines in Fig. 7, and then extracting the square root of the sum. This gives us

$$X=\sqrt{\tfrac{1}{4}\,p^2\cos^2 a+p^2\sin^2 a}=\tfrac{1}{2}\,p\sqrt{\cos^2 a+4\sin^2 a}.$$

This may be simplified by noting that $\cos^2 a=1-\sin^2 a$. Substituting this in the foregoing equation we have

$$X=\tfrac{1}{2}\,p\sqrt{1+3\sin^2 a},$$

which is the desired expression for the *total* stress acting upon each unit length of the joint.

These various forces have been calculated by the formulas given above, and are presented in the accompanying table for reference. The unit of force in each case is the force acting upon an imaginary *longitudinal* joint of the boiler. For example, in a diagonal joint which makes an angle of 35° with the girth joints, the total force acting on a unit length of the actual diagonal joint would be .705 of the force that would be exerted upon a similarly designed *longitudinal* joint in the same boiler; the force acting *perpendicularly* to this diagonal joint would be .664 times the force that would be exerted upon a similarly designed longitudinal joint; and the force tending to make the two plates slip in the direction of the length of the joint would be .235 of the total pull that would be exerted girthwise (or perpendicularly) upon a similar longitudinal joint.

Angle between diagonal joint and girth joint (a).	Total Force.		Component Forces.	
	Total force.	Inclination of, to direction of joint (*C*, in Fig. 8).	Perpendicular to joint.	Parallel to joint.
30°	0.662	70° 54′	0.625	0.216
35	.705	70 32	.664	.235
40	.748	70 47	.707	.246
45	.790	71 34	.750	.250
50	.830	72 46	.793	.246
55	.868	74 18	.836	.235
60	.902	76 06	.875	.216
65	.930	78 07	.911	.192

The only remaining problem before us is to find out how the effective strength of a diagonal joint compares with the effective strength of a similar longitudinal joint. Now there is some slight question about how this ought to be done. We can compare the strains on the two joints directly, but the difficulty is to decide whether it would be fairer to count the *total* force upon the diagonal joint, or only that part of it which acts perpendicularly to the edge of the sheets. The strains are distributed differently from the distribution which holds in ordinary joints, because the force given in the last column is peculiar to the diagonal joint, and does not occur at all in the common forms of joint that are met with in every-day practice. This new force certainly ought to receive *some* consideration, because it brings a shearing stress on the rivets, although it does not sensibly affect the tensile strain on the net section of the plate. We shall, therefore, base the estimated effective strength of the joint upon the *total* stress, as given in the second column of the table; and we shall take the relative effective strengths of a diagonal and a longitudinal joint, as inversely proportional to the total stress to which each is exposed in the boiler. Now the second column of the table gives the stress on the diagonal joint as compared with that on a similar longitudinal

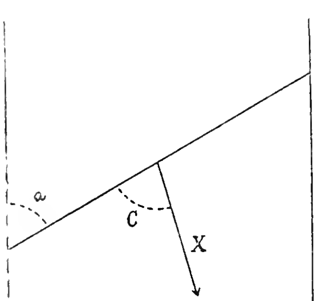

Fig. 8.

joint; and hence the effective strength of a longitudinal joint could be found at once by multiplying the strength of the corresponding diagonal joint by the proper number in the table. But this is not precisely what we want to do. We want to work the problem the "other end to"; and hence we find the effective strength of the diagonal joint by *dividing* the strength of the longitudinal one by the proper number in column 2. Thus in the particular case of a diagonal joint whose angle is 45°, the effective strength of such a joint is found by dividing the strength of the corresponding longitudinal joint by .790; or (which is the same thing) by multiplying it by 1÷.790=1.27. It will be found that 1.27 is the multiplier given for this case in the previous table; and the other multipliers in that table are all found from the corresponding numbers in the second column of the present table, in precisely the same way.

There is still much to be learned about diagonal joints. We need tests of them, made on a large scale, so that we may know exactly how the plates will behave under the oblique stresses to which they are subjected. The only published experimental data that we recall at the present writing are those relating to a test made in England, about twenty-five years ago, by Mr. Kirkaldy. He made up two single-riveted joints of iron plate, .38″ thick, and having a tensile strength (with the grain) of 39,380 pounds per square inch. One of these was an ordinary square joint with six $\frac{13}{16}$″ rivets, pitched 2″ from center to center. The other was a similar joint, except that it contained 8 rivets, and was inclined at an angle of 45° to the direction in which the stress was applied. In the tests, the square joint gave an efficiency of 48 per cent., while the diagonal joint gave an effective efficiency of 64 per cent. In other words, the tests showed that the diagonal joint was stronger than the square one in the proportion of 64 to 48; that is, it was 1.33 times as strong. Our table, on page 99, indicates 1.27 as the theoretical ratio in this case. This is as good an agreement as could be expected; but more extensive data would be very acceptable.

A Big Volcanic Eruption in Japan.

In his interesting book, *The Real Japan*, Mr. Henry Norman describes a volcanic eruption which occurred on July 14, 1888, about 200 miles north of Tokyo. Mr. Norman, who was at Tokyo at the time, immediately set out for the scene of the catastrophe, and in his book he tells what he saw. The eruption is of interest not only on account of its magnitude, but also because it was so plainly due to the fearful expansive force of *steam*.

"We were the first foreigners," he says, "to make a rough but fairly complete examination of the scene of the eruption. At the point of the manifestation of volcanic activity the mountain range consists of three peaks, and the eruption had taken place in the smallest of these, known to the natives as 'Sho-Bandai-san,' and had blown that peak from the face of the earth. The explosion was caused by steam — there was neither fire nor lava of any kind. It was in fact neither more nor less than a colossal boiler explosion. The whole top and one side of Sho-Bandai-san had been blown into the air in a lateral direction, and the earth of the mountain was converted by the escaping steam at the moment of the explosion into boiling mud, part of which was projected into the air to fall a long distance and then take the form of an overflowing river, and part of which rushed down with inconceivable speed and resistless force and poured over the face of the country to a depth varying from twenty to a hundred and fifty feet. Thirty square miles of country was thus devastated and practically buried by this eruption — a fact which places it, as I have said, among the most stupendous on record.

"A few minutes past eight o'clock in the morning there was suddenly the most awful noise. Then in a minute, 'before a man could run a *cho*' (120 yards), darkness darker than midnight, and blinding hot ashes and sand fell out of the skies. And with the noise came an earthquake so terrible that many of the people were thrown to the ground and crawled on all-fours like animals, while the earth undulated like the surface of the sea. Explosion after explosion came in rapid succession, the last one being the greatest, and indeed so great and appalling that after that, my informants at the village of Nagasaka all said, they could not pretend to remember or think what happened. It is certain, however, that all who could move quickly left their houses instantly and ran for their lives across the village, to ford a shallow stream fifty yards wide and seek refuge on the slope of the hill opposite. Not a single soul of these escaped. And here, to my mind, is the most appalling fact of all. The mountain of Bandai san is 10 miles from Nagasaka, as the crow flies. Half of the mountain side which was blown up was shot into the air, striking the ground again nearly four miles away, and then following along in a stream which overwhelmed these people. But the furthest of them was not two hundred yards from the remotest part of the village. Supposing, now, that because of the darkness and confusion and terror, it took the swiftest of them, running for his life, five minutes to cover 200 yards — an ample allowance — it follows that the mud stream must have passed four miles through the air and six miles along the ground in less than five minutes. That is, millions of tons of tenacious boiling mud were hurled over the doomed country at the rate of two miles a minute, or double the speed of the fastest express train! The thought paralyzes one's imagination.

"One man beheld the whole scene calmly. This was a peasant, who was cutting grass upon a mountain opposite, when he heard the noise and saw the ground before him begin to bob up and down. But he had met a fox that morning and now knew that he had been bewitched by it — a common superstition of the Japanese peasant — and that he must above all things keep cool. So he seated himself upon a stone, took out his pipe, and watched the whole eruption with perfect equanimity, knowing it to be merely a subjective phenomenon! When it was all over, this wily *kitsune-tsuki* — the fox-bewitched — resumed his grass-cutting, well pleased to have outwitted the evil one."

An esteemed correspondent writes to say that the cut on the front page of our February issue, illustrating a collapsed corrugated furnace, is upside down. We beg to assure him that we were quite aware of that fact. The cut was made from a photograph taken after the furnace had been removed and placed in the yard. We preferred to represent it just as it lay, and we believed that the diagram on page 18 would make its original position clear. Our correspondent adds, "The heading of the article reads 'Collapse of a Pair of Corrugated Furnaces,' and I know that several persons, simply glancing at the article, have stated that they noticed an article in The Locomotive which was very bad for the reputation of the corrugated furnace. I assured them that if the article had been carefully read, it would be seen that it was commendatory rather than otherwise. As the article has been reproduced in several of the trade papers, would it not be well to make some note about this in a future issue of The Locomotive?" In reply we desire to say that we had no idea of criticizing the corrugated furnace. We felt that the case illustrated furnished a striking proof of the value of the corrugations. A plain, parallel furnace could hardly have held together under such trying circumstances. And yet we hardly know what good it will do to make this explanation, for a person who would merely "glance" at the original article would hardly be likely to read the present editorial note.

The Locomotive.

HARTFORD, JULY 15, 1897.

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

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

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

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

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

WE have received, by the courtesy of the author, a copy of the third edition of William Kent's *Mechanical Engineer's Pocket Book.* We said a good word for this book in May, 1895, upon the appearance of the first edition, and it gives us pleasure to renew our commendation at the present time. There are few changes in the new edition, but the typographical errors that were discovered in the earlier ones have been corrected, and the index has been extended. (John Wiley & Sons, 53 East Tenth street, New York. 1,088 pages; $5.00.)

MR. THOMAS F. DALY has been appointed General Agent of the Hartford Steam Boiler Inspection and Insurance Company in the Denver Department in the place of Messrs. Williams & Tuttle, who have retired. Mr. Daly is well known throughout his district, and does a large insurance business. Our patrons may be assured that their interests will be well served under his able management. We are also pleased to announce that Mr. T. E. Shears, who has been Chief Inspector in this department for the past ten years, will continue his connection with us in the same capacity.

Miscellaneous Accidents from the Use of Steam.

According to the New York *Journal*, a "tank-full of teeth" exploded recently in the dental laboratory of Dr. H. W. Guilshan, New York city. The windows were shattered and the street was filled with a spirited shower of broken glass, false teeth, and dental instruments. William McClure was knocked down and somewhat bruised. He was alone in the laboratory, vulcanizing several sets of teeth in a copper boiler heated by gas jets. The boiler was provided with a device known to the trade as a "safety valve"; but in this case it failed to work, and a violent explosion was the result. An alarm of fire was sent in, but when the engine arrived order had been restored.

Manley A. Fair, an engineer, was instantly killed, on March 3, by the explosion of a steam mangle in the Keystone Laundry at Los Angeles, Cal. He was standing on a ladder at the time. The ladder was blown from under him, and he fell to the ground and broke his neck. J. H. Hickson, proprietor of the place, was injured about the head, but not fatally.

Street railway traffic at Cincinnati, Ohio, was suspended for an hour or so, recently, by an accident at the depot street generating station, near the foot of Price Hill. The main steam pipe burst, and the dynamos, as a consequence, came to a standstill. Fortunately, nobody was injured. Steam was raised on another battery of boilers, and the car service was resumed in about one hour.

Augustus Caster and Richard Lane were instantly killed, on April 5th, by the explosion of a steam chest in the Lawrence Cement company's mill at Eddyville, near Kingston, N. Y. A new engine was being tested at the time, and Lane was the representative of the builders of the engine. Charles Rose, the local engineer who was to have charge of it, escaped through a door barely in time to save his life.

The miscreant has turned up again. We hear from him, every once in a while, in various states of the Union. This time he got in his fine work in the little town of Churchville, near Brooklyn, N. Y. There was a boiler explosion in a pumping station at that place on May 5th, which seriously injured night watchman Adam W. Weitzel. Now it appears that a couple of jobs had been given to Weitzel and another man, and to make room for them it had been necessary to remove Frank Smith and A. M. Doxtater. The explosion followed soon afterwards, and we have no doubt but that it was due to perfectly natural causes; but the Brooklyn *Eagle* darkly hints that "there is a rumor in Churchville that the explosion was caused by the plugging of a valve in the boiler. This may have been done through spite on the part of the replaced men. The matter will be thoroughly investigated. It is possible that arrests may follow." Churchville ought to dramatize its little explosion. This kind of stuff might "go" if properly set on a stage. It would stir up the gallery gods, anyhow. But in a great newspaper it brings on a sense of fatigue.

We have received the following report concerning a boiler which recently exploded. It is doubtless exaggerated in some degree, and yet it is quite possible that it is substantially correct. A man whose employer *has no money at risk* upon a boiler is often tempted to slight the boiler in making his inspection. "The boiler in question," says the report, "was inspected last July by one of the state deputies, but it is said that his work was a mere farce. The boiler was at that time a third full of mud, and, as the owner was not there to put up the necessary five dollars, no pressure was applied. After giving the boiler a hammer test, the deputy informed the man in charge that if certain repairs were made papers would be issued. Whether or not this was ever done, the coroner has been unable to ascertain. The dangerous character of the boiler may be understood when it is stated that two or three engineers refused to run it after looking it over and seeing its condition."

Boiler Explosions.

May, 1897.

(97.) — On May 1st the saw and grist mills of J. F. Rowton, some twelve miles from Groveton, Tex., were literally blown to atoms by the explosion of a boiler. Every piece of machinery about the place was blown to pieces, the buildings were entirely destroyed, and the fragments were scattered over an area of a quarter of a mile radius. The engineer, Samuel Key, was instantly killed, and his body was mutilated beyond recognition. A man named Goyens was fearfully injured by flying debris, so that he cannot recover. A little son of J. F. Rowton was also fatally injured. Another man, whose name we have not learned, was painfully injured.

(98.) — On May 3d a boiler exploded in George Dennis' saw-mill at Center, in Green township, near Portland, Ind., wrecking the building and machinery. Oliver Butcher was blown to a considerable distance, and terribly injured. Mr. Dennis and his son also received lesser injuries, from which they will recover.

(99.) — When Chicago & Alton freight train No. 101, east bound, stopped at First street and Grand avenue, Kansas City, Mo., on May 4th, the locomotive boiler exploded, instantly killing Engineer H. H. Roberts, and injuring Fireman Charles Pardoner so severely that he died shortly afterwards. A dozen men standing on the platform of the station also had narrow escapes from death. The boiler failed by the blowing down of the crown sheet. At the coroner's inquest on May 6th a number of experts testified that they had examined the wrecked boiler, and had found that most of the stay-bolts were badly corroded. The verdict was that the deaths were caused by "defective parts of the boiler."

(100.) — A boiler exploded on May 5th in the pumping station at Churchville, near Buffalo, N. Y. The boiler was blown through the roof of the station, and landed 400 feet away, on the New York Central tracks. The pans on the passenger tracks and the the tanks for freight trains are supplied by this station. The station was completely wrecked by the explosion. Engineer Adam Witzel had gone out of the boiler-house to turn the water into the track pans, and had reached the doorway on his return when the explosion took place. He received a number of severe scalds and burns on the arms and legs, and was thrown quite a distance from the building. Two men, who had been in charge of the place for several years, had recently been removed, and it is darkly hinted in some quarters that the discharged men had something to do with the accident. This sort of talk is all too common, and no attention should be paid to it. An intentional boiler explosion is one of the rarest things that happen on this earth. We doubt, in fact, if such a thing ever did happen.

(101.) — One of the boilers in the Ottawa Hardwood Company's plant at East Tawas, Mich., exploded on May 5th, damaging the building to a considerable extent, and stopping work for several weeks. No one was injured.

(102.) — While R. W. Webb, the city boiler inspector, was examining a boiler on East Walnut street, Louisville, Ky., on May 5th, the boiler exploded, and Mr. Webb was deluged with hot water. His injuries, although painful, are not thought to be dangerous.

(103.) — A boiler used in the stone-sawing works of Schneider & Guthrel at Gallipolis, Ohio, exploded on May 6th, injuring Engineer Ira Corow, a brother-in-law of one of the contractors. His injuries are not necessarily fatal.

(104.) — On May 7th a terrific boiler explosion occurred on the farm of B. F. Hazen at Forest, near Kenton, Ohio. The boiler of a traction engine burst, and blew the engine almost entirely into fragments. It was standing in an open field at the time, and although Mr. Hazen and some workmen were near by when the accident occurred, they all escaped injury.

(105.) — A boiler exploded near Sulligent, Ala., on May 11th, in a mill owned by a Mr. Cox. Nobody was injured, and the damage was not large. A pair of oxen, standing near by, were killed.

(106.) — Nels Swanson and Nels Nelson, who are employed in the stoneware works at Red Wing, Minn., were painfully scalded about the face and arms, on May 8th, by the bursting of the mud drum of the boiler. Steam and hot water were thrown into the clay-grinding room, where they were working.

(107.) — A boiler exploded on May 10th in the Marion brewery, at Marion, Ohio. George Taylor, a steam fitter, and George Need, a machinist, were nearly killed. We have not learned the amount of the property loss.

(108.) — By the explosion of a boiler at Bock, five miles above Mille Lacs (Milaca), Minn., on May 11th, J. G. Canfield was instantly killed, and several other men were badly injured. The accident occurred at the Ellendale mill, the only manufacturing concern at Bock. The front end of the boiler was blown out and hurled several hundred feet. Canfield, whom it struck and killed, was standing 150 or 200 feet away. The engineer, who was on top of the boiler at the time, escaped with slight injuries. Four other employes received burns and bruises.

(109.) — A boiler exploded on May 11th in the Sewall–Day Cordage Company's plant on Western avenue, at Brighton, near Boston, Mass. Michael Mullen, who was on the roof of the boiler-house, was thrown some distance, and had his head and face cut by falling among the debris. John McCloud, the fireman, was burned by the escaping steam. The boiler-house was demolished.

(110.) — On May 13th a boiler exploded in a saw-mill on Reelfoot river, near Tiptonville, Ky. Edward Patterson, Dink Hodges, and two other men, whose names we have not learned, were killed. Three other men were terribly injured, and will die. One of the men was blown to pieces.

(111.) — A boiler exploded, on May 14th, in Ward's mill, at Randolph, Metcalf county, near Glasgow, Ky. J. D. Ward, Thomas Ward, George Brown, and Simon Kirkpatrick were killed outright. Virgil Hundley, William Ward, and George Ward were injured so badly that it was thought that most of them would die. Later advices however, indicate that there is some chance of their recovery. A little girl, whose name we could not learn, was slightly hurt. The mill and the surrounding buildings were completely wrecked.

(112.) — The boiler of a locomotive belonging to the Inter-colonial railroad exploded, on May 14th, in the roundhouse at Richmond, N. S. The engine was blown to fragments, and the brick roundhouse was ruined. Several other locomotives which were in and near the building were badly damaged. The property loss was about $25,000. Nobody was seriously hurt.

(113.) — On May 17th a boiler exploded in the Crown Slate Company's works at Pen Argyle, Pa. George Bartholomew, who was night engineer, was killed, and the boiler-house was blown into a mass of ruins. The explosion was heard at Wind Gap, three miles away. Pieces of wreckage were strewn about to a distance of several hundred feet. One of the flues was found sticking in the ground 300 feet away, and flying bricks knocked holes in the roof of a house over 1,000 feet distant. This explosion affords a good example of the persistently erroneously belief of many persons, that no explosion can possibly occur, except from low water. Bartholomew had been warned, when he went on duty, that there was something wrong about the boiler, and had been told to fire-up one of the other three. He refused to do so, and said, "I'll steam this boiler, or send her up." What he did in the night nobody can know, but the fact that the boiler blew up led to a theory that he fell asleep during the night, and finding the water low when he woke up, he turned on the injector, and the explosion followed. This may possibly be the real cause of the explosion, although we don't believe it; but the point we wish to make is, that this low water idea has taken possession of the public mind so absolutely as to exclude all other possible causes of explosion. For example, we find the Philadelphia *Press*, in its issue for May 18th giving a circumstantial, low-water account of how the explosion occurred, without the least intimation that it is all conjecture. We should think that *some* allowance ought to be made for the admitted fact that the engineer had been previously advised to shut the boiler down, and that he had refused to do so.

(114.) — A big fire occurred in Hoboken, N. J., on May 20th, which destroyed the homes of 128 families, and caused a property loss of something like $650,000. One of the buildings destroyed was a brick factory, occupied jointly by Ward, Leonard & Co., Paul & Gallagher, Benton, Heath & Co., and Nathan Strauss & Co. During the course of the fire the boilers in this factory exploded; but it is difficult to estimate separately the damage due to their bursting.

(115.) — On May 20th a boiler exploded at an oil well on the Bingham tract, near Bradford, Pa., and Martin McNichols, an expert driller, well-known throughout the oil country, was killed. Several other employes were injured, and the oil-well rig was wrecked.

(116.) — A boiler exploded, on May 25th, in the steam lumber mills at Caswell's, about a mile east of Lowellton, Me. F. W. Gushea, Ernest Nichols, Frederick Cheverier and a man named King were killed, and Stephen Nicholls was fatally injured. Several other men were injured to a lesser extent, and the mill was badly wrecked. We have seen no estimate of the property loss, but it is said to be heavy.

(117.) — On May 25th a boiler exploded in James H. Laffoon's mill, about three miles from St. Charles, near Madisonville, Ky. There were several hands present, but only one of them was injured. The mill was completely wrecked, and the machinery was broken into small pieces and scattered for hundreds of feet around.

(118.) — Two men were killed and three were seriously injured, on May 26th, by the explosion of a boiler in Joseph Haney's mill at Glen Hazel, near Ridgeway, Pa. The killed were, Charles Schaffer and William Johnson. The injured are, Joseph Haney, Charles Ward, and Frederick Your. It is thought that Your cannot recover. The mill is on the Ketner & Shawmut railroad, and is used for the preparation of wood for chemical purposes. It was entirely wrecked.

(119.) — The crown sheet of Edmund Hall's dredge No. 1 blew out, on May 26th, at Port Huron, Mich. Captain F. I. Merriman and Fireman Joseph Ortney were severely injured.

(120.) — On May 28th a boiler exploded at the Kickapoo Stone Quarry, near Attica, Ind. Joseph Marlow was blown thirty feet into the air, passing over the guy ropes, and coming down upon his head among the stones in the quarry. Besides being cut and bruised by his fall, he was horribly scalded over the entire body. His son, Jacob Marlow, received several severe cuts and brusises. The father may not recover.

(121.) — One of the seven boilers in T. W. Garbutt & Co's. mill at Wrightsville, Ga., exploded on May 31st. Luke Harris, the night watchman, was killed outright. Thomas Hughes and William Christian were fearfully scalded, and it is thought that they cannot recover. Charles Cummings and four other men whose names we could not learn were also severely scalded. The boiler-house is said to be "in a dilapidated condition."

(122.)—On May 31st a boiler belonging to James Wolfe exploded in a saw-mill on Levi Swigert's farm, in Adams township, between Orange and Bakersville, near Coshocton, Ohio. Engineer Robert Croix, who was standing near the boiler at the time, was instantly killed. Frank Van Dusen, Samuel Newton, and Charles Norman, were injured. The dead engineer leaves a wife and six small children.

(123.)—The boiler of locomotive No. 251, on the Norfolk & Western railroad, exploded, on May 31st, near Vickers, and about three miles east of Christianburg, Va. Fireman Charles Gillespie was killed, and Engineer Joseph Waskey was fatally injured. A flagman was also badly injured in the wreck. The boiler of the locomotive was blown into a field near by.

WE are pleased to acknowledge a copy of *Pray's Calorimeter Tables for Steam*, by Thomas Pray, Jr., who is already well and favorably known to our readers for his *Twenty Years with the Indicator*. The present volume is intended to facilitate calorimetric work of all kinds, and it bears much the same relation to the calorimeter that his *Twenty Years* bore to the indicator. The tables in the present work are based upon the experimental data of Regnault, and are computed by the corrected formulæ given by the Rev. Robert V. Dixon. They are very complete. In the first table the absolute pressure in pounds per square inch, and in inches of mercury, the total and latent heats, and the units of sensible heat in the water (reckoned from 32°) are given for each tenth of a degree on the Fahrenheit scale, from 212° to 446°, inclusive. The second table gives the heat units required to raise a pound of water from 32° to any given integral degree of temperature up to 213°, inclusive. We feel that we must take some exceptions to this table, for if, as the author claims, it is in accord with Regnault's data, it can hardly be serviceable for the finer purposes of calorimetry, because it is notorious that there was something wrong about Regnault's work on the specific heat of water. We do not know just what the trouble was, but his results do not agree at all with those of later observers, and they are also self-contradictory. They are given at the end of the first volume of his *Mémoires*, and it is likely that in the hurry of preparing his work for the press, he overlooked something, or copied in a wrong column of figures. It would have been better, in our judgment, to have thrown Regnault's work away for this table, and substitute the results of Rowland, Griffiths, and others, so far as they will go. But we think there is some deeper trouble with this table, for it will be observed that from 32° to 50° the difference between successive numbers in the second column is uniformly .0002; while at 50° it suddenly jumps to .0008, which it remains up to 68°, when it again jumps to .0016 until we reach 86°. Then it becomes .0025 as far as 104°, and so on. We think that there can hardly be anything in the actual properties of water corresponding to these sudden jumps. Following these tables there are articles on the use of calorimeters of various types. These are illustrated, and contain much useful information. The use of the tables is also explained, and a four-place table of logarithms is also included to facilitate computation.

Mr. Pray has striven to produce a volume that might be serviceable in actual practice, and his book is well worth its price to any one who has to do computing of this sort. (93 pages, cloth, $1.00; may be had of booksellers, or of the author, P. O. Box 2728, Boston, Mass.)

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

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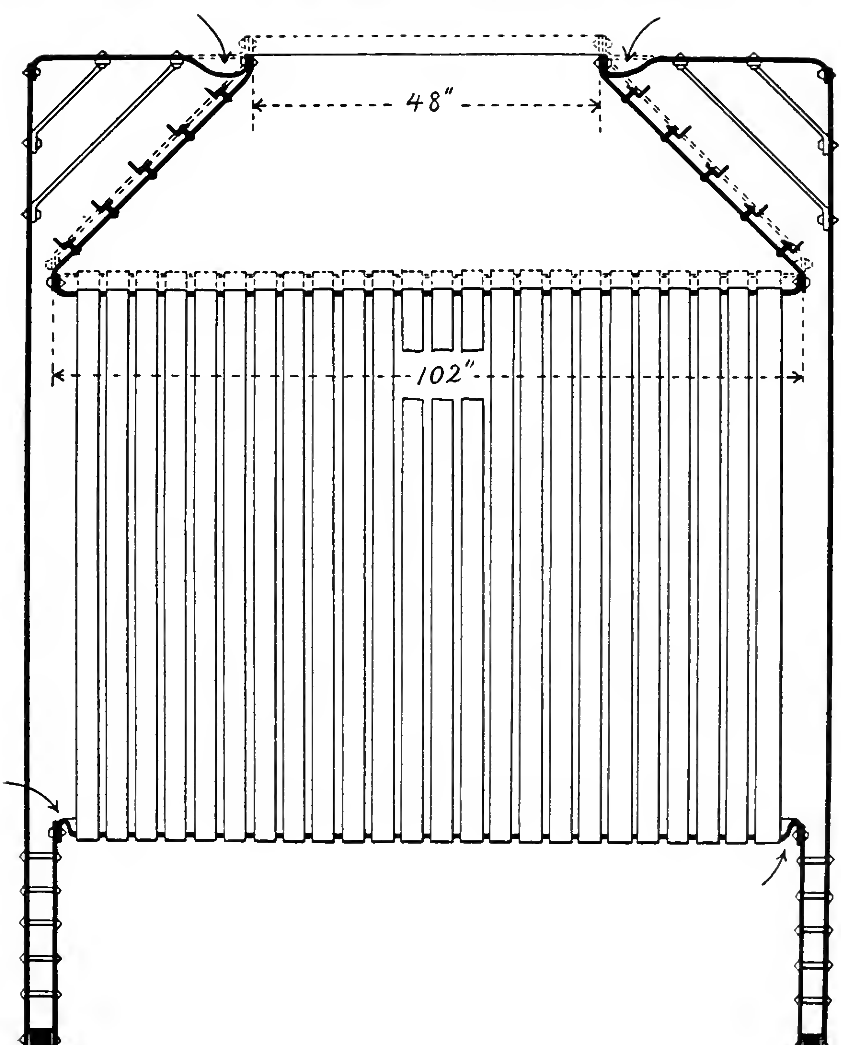
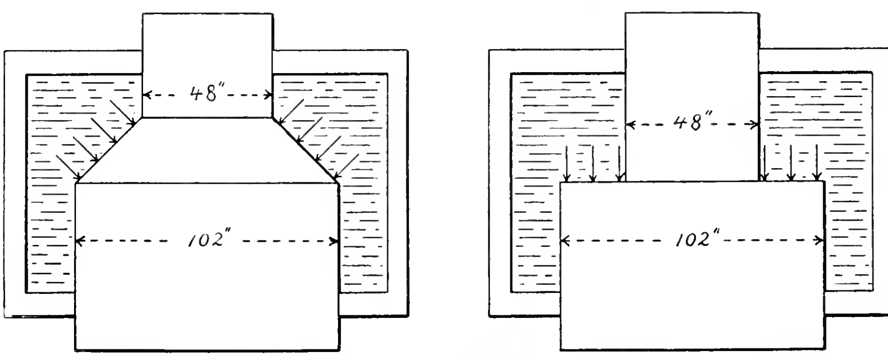


Fig. 1.—Illustrating the Failure of a Cone-Topped Boiler.

Failure of an Upright Boiler.

The designing of a boiler appears to be a very simple thing to one who has never tried it; and, indeed, it *is* a simple thing if efficiency is left out of the question, and the draftsman is allowed to follow some type that is fairly familiar to him. But when the conditions to be met are somewhat out of the ordinary, so that a type unfamiliar to the designer appears to be called for, there is plenty of room to make mistakes about very simple matters. We see illustrations of this fact every day, and in the present article we propose to describe one such illustration, which appears to us to possess a certain degree of interest.

The boiler in question, which is shown in Fig. 1, was built for use in a 115-foot steamboat, and, in order to insure the stability of the craft, it was made short and of large diameter. Externally it was 9 feet in diameter and 11 feet high, with some 200 vertical tubes, each 6 feet long and 2½ inches in diameter. The upper ends of these tubes opened into a conical smoke-box, which was 32 inches high and 102 inches in diameter at the bottom, with an opening 48 inches in diameter at the top. The sides



FIGS. 2 and 3.—ILLUSTRATING THE UNBALANCED PRESSURE ON THE CONE.

of this smoke-box were supported, externally, by five rings of angle-iron, as indicated in Fig. 1, and the upper head of the boiler, which was of half-inch steel, was braced to the shell, substantially as shown.

The boiler was intended to carry a regular working pressure of 100 pounds to the square inch, and it was thought best to test it, by hydrostatic pressure, to 150 pounds.

In the course of the test the boiler soon showed signs of weakness, and when the test-pressure reached the regular working pressure of 100 pounds, it was found that the whole mass of the tubes, together with both tube sheets, had gone down fully one inch, the upper head and lower tube-sheet giving way by bending, as shown by the arrows in Fig. 1. Upon continuing the test, the deformation increased, until, when a pressure of 150 pounds was reached, the sheets had taken a permanent deflection, or "set," of something like two inches and a half.

We do not have to look far to find the reason for this behavior of the boiler while under test. It will be easily seen that the downward pressure of the steam against the lower tube-sheet is just equal to the upward pressure against the upper tube-sheet; so that the two tube-sheets are balanced against each other, and therefore these parts of the boiler need not be considered in our investigation of the cause of failure. The real difficulty is that there is a resultant *downward* pressure of the steam against the outside of the cone top. To understand this point, let us refer to the diagram shown in Fig. 2. In this diagram the outer rectangular vessel corresponds to the shell of the actual boiler, and the cylindrical body within represents the combined tubes, tube-sheets, and cone top. In the boiler, the lower tube-sheet and the upper end of the cone are riveted to the shell ; but in Fig. 2 we have shown the corresponding parts as though they were merely fitted in a frictionless way into water-tight openings in the shell. After considering the problem from this new point of view, we will return to the actual case in which the parts are riveted in place.

The pressure, in Fig. 2, acts perpendicularly to the cone surface, as indicated by the arrows ; so that it tends to collapse the cone, and also to force it downwards. We have no present concern with the collapsing tendency, since this is supposed to be sufficiently resisted by the rings of angle-iron shown in Fig. 1. The *downward* thrust of the pressure, however, is very important. To get at its amount, we may treat our apparatus as though it were constructed as in Fig. 3; for, although only part of the oblique pressure in Fig. 2 is vertical, while that in Fig. 3 is entirely so, yet the obliquity in Fig. 2 is exactly compensated by the fact that the total *surface* exposed in Fig. 2 is correspondingly greater than that in Fig. 3. Now the area exposed to vertical pressure in Fig. 3 consists of a ring which is 102″ in diameter externally, and 48″ internally. The area of a 102-inch circle is 8,171 sq. in., and the area of a 48-inch circle is 1,810 sq. in., and hence the area of the ring in question is

$$8,171 - 1,810 = 6,361 \text{ sq. in.}$$

Now, when the test pressure reaches 100 pounds to the square inch, the total downward pressure against this ring is

$$6,361 \times 100 = 636,100 \text{ pounds,}$$

or over 318 tons.

Returning now to Fig. 1, we have learned that when the pressure in the boiler reaches 100 pounds per square inch, the system of tubes, tube-sheets, and cone top, is exposed to a resultant downward pressure of more than 318 tons, and an examination of Fig. 1 will show that this enormous load has nothing to sustain it except the stiffness of the upper head of the boiler and the edges of the lower tube-sheet. These, in the case under consideration, were made of half-inch steel, and they proved to be altogether too weak to support such a stress. They therefore bent and gave way as indicated, until, when the total load reached 477 tons (*i. e.*, 150 lbs. per sq. in.), they had taken a permanent set of two inches and a half.

It is not our purpose, in the present article, to discuss the proper way of designing cone-topped boilers, but merely to point out how easy it is to overlook an important fact in the design of a boiler. Yet we feel that no article can be entirely satisfactory if it simply points out a defect without any suggestion as to how it is to be remedied ; and, therefore, we shall venture one or two suggestions in the present case.

The main point is to support the cone top in such a way that the load upon it shall be transferred to some proper place. This can be accomplished in various ways. The upper tube-sheet, for example, could be supported by brackets secured to the side sheets of the boiler ; but it would be better and more logical to tie together the two parts of the structure that tend to be forced apart. It is easy to see that the steam pressure tends to force the cone downwards and the upper head upwards ; and, therefore, one good way to secure the desired strength would be to connect the cone with the upper head by means of a sufficient number of braces. Gusset stays appear to be well adapted for this purpose, and if used they should be put in substantially as indicated in Fig. 4, with double angle-iron connections at top and bottom. When gusset stays are used, the stiffening rings shown in Fig. 1 cannot be conveniently put in; so it is better to dispense with them, and to put in the gussets closely enough to prevent the cone from collapsing without the use of the rings. For this purpose the gussets should be put in at such intervals that the space between any two of them shall not exceed eight or ten inches, when measured along the surface of the cone, at the height indicated by the dotted line in Fig. 4. It may be found that when the boiler is of unusually large diameter, the gussets are so far apart, towards the outer edge of the top head, that the sectors into which they divide the head are too large to be secure without more or less additional support. In such cases a brace may be run from the shell to each of these segments to provide the extra staying power that is desired.

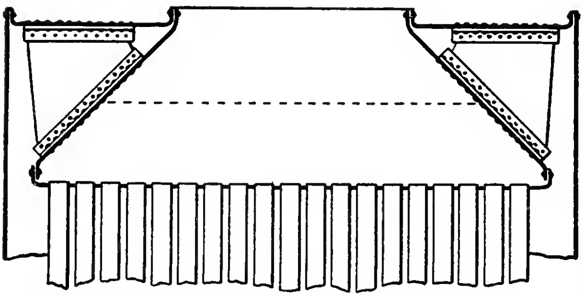


FIG. 4.—PROPER DISPOSITION OF THE GUSSET STRAPS.

Inspectors' Report.

MAY, 1897.

During this month our inspectors made 8,156 inspection trips, visited 16,079 boilers, inspected 7,171 both internally and externally, and subjected 687 to hydrostatic pressure. The whole number of defects reported reached 11,518, of which 1,318 were considered dangerous; 55 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	959	45
Cases of incrustation and scale,	2,402	63
Cases of internal grooving,	71	5
Cases of internal corrosion,	712	34
Cases of external corrosion,	757	57
Broken and loose braces and stays,	196	98
Settings defective,	350	35
Furnaces out of shape,	510	26
Fractured plates,	262	42
Burned plates,	246	36
Blistered plates,	257	3
Cases of defective riveting,	773	59
Defective heads,	169	79
Serious leakage around tube ends,	2,112	526
Serious leakage at seams,	432	17
Defective water-gauges,	262	45
Defective blow-offs,	168	43

Nature of Defects.	Whole Number.	Dangerous.
Cases of deficiency of water,	5	3
Safety-valves overloaded,	61	16
Safety-valves defective in construction,	63	22
Pressure-gauges defective,	630	58
Boilers without pressure-gauges,	3	3
Unclassified defects,	118	3
Total,	11,518	1,318

Boiler Explosions.

June, 1897.

(124.) — On June 2d, a boiler exploded in Austin, Black & Newell's Laramie Peak saw-mill, at Spring Hill, Wyoming. Nobody was injured, but the mill was wrecked and the machinery destroyed. The property loss is estimated at $6,000.

(125.) — A boiler exploded, on June 2d, in the basement of Albert White's coal elevator, at Ripley, Ohio, wrecking the plant. The roof was blown off and the end of the building was demolished. Orange Sutton, the engineer, was slightly injured. James Waters's dwelling, across the street, was badly damaged, and his little child, who was sitting on the front porch, narrowly escaped being killed.

(126.) — A fearful boiler explosion occurred, on June 7th, in the print works of Noriega Brothers, at Puebla, Mexico. Twenty persons were killed. The plant was blown to atoms, and the property loss will be fully $150,000. A part of the boiler was blown high in the air, and, crashing down through the roof of a neighboring house, killed an old man and three children. A fireman, three blocks away, was decapitated by a flying fragment of debris. Troops were called out to guard the ruins while a force of laborers recovered the bodies of the unfortunate operatives.

(127.) — On June 8th a boiler exploded at A. B. Groupe's smelter at Oro Grande, near Los Angeles, Cal. A man named Hood was killed instantly, and Mr. Groupe and two others were seriously injured. The building was entirely destroyed.

(128.) — On June 11th a patch blew off of a boiler in Clark's mill, at Jacksonville, Fla. Nobody was injured.

(129.) — The boiler of a locomotive attached to a train running from St. Johns, N. F., to Harbor Grace, exploded, on June 12th, near Freshwater Valley Station. Engineer Glasgow was killed instantly, and Fireman Byrne was badly injured. The explosion occurred while the train was in motion, breaking the coupling which connected the engine with the cars. Glasgow's body was thrown some distance into the air. Little damage was done to the cars, which did not leave the track, and none of the passengers were injured.

(130.) — On June 18th a boiler exploded in A. J. Rishell's saw-mill on Beaver Creek, in the northeastern part of Fremont county, near Florence, Colo. The mill was wrecked. The owner of the mill and his father, George W. Rishell, were in the building at the time. Both men were killed, and their bodies were thrown a distance of 80 feet. Several of the operatives were in or near the mill, but all escaped injury except the two just noted.

(131.) — A boiler exploded on the steamer *Dauntless*, on June 20th, while she was en route to Cuba on a filibustering expedition, and she was compelled to return by means of her sails. She was captured off India Key by the revenue cutter *McLane*, and brought into port at Key West, Fla.

(132.) — A freight engine boiler on the Mexican International railroad exploded, on June 21st, three miles out of Ciudad Porfirio Diaz, Mexico, demolishing the engine and killing Engineer James Griffin and Fireman Jacob Mann. The big mogul engine was thrown fifty feet and turned completely over. The train was coming slowly across the bridge, the engine having just reached the other side when the explosion occurred. The cause of the explosion is unknown. The body of Griffin was found about 100 feet from the track. The fireman was blown into the coal tender. No one else was hurt, and only one car was wrecked, the rest of the train remaining standing on the bridge.

(133.) — The boiler owned by Frank Young, the oil operator, and used on the Huffman farm lease in Liberty township, near Bluffton, Ohio, exploded with terrific force on June 22d, completely demolishing the outfit, and hurling large pieces of iron over the surrounding fields. No one was seriously injured, but there were several narrow escapes.

(134.) — On June 23d, a boiler exploded in the basement of the Hotel Broezel, at Buffalo, N. Y. Four men, who were in the basement at the time, took refuge in a coal bin, but not in time to escape being scalded. James Martin, a fireman, was badly scalded over the whole body, and the physicians at the hospital have little hope of his recovery. Thomas Smith, the engineer, was badly scalded about the face, neck, ears, feet, and ankles, but, although his condition is serious, it is thought that he may recover. Albert Trader, the assistant engineer, was also scalded about the face, hands, and arms, but not so seriously as the other men.

(135.) — A boiler exploded, on June 23d, in Ferguson & Co.'s planing mill at Rockville, Ind. Solon Ferguson, the senior proprietor, was instantly killed, and Edward Straughn, an employe, was hurt so badly that he died within fifteen minutes. Several others, including the engineer, were injured more or less severely. The building was wrecked, and the dome of the boiler was blown 150 yards.

(136.) — A boiler exploded, on June 24th, in the Good Thunder mine at Tourtelotte park, near Aspen, Colo., demolishing the shaft house. There were five men in the wrecked building at the time, but fortunately the only man hurt was John Nice, who had one of the bones in his left leg broken.

(137.) — On June 25th a boiler exploded in the yards of the Belford lumber company, at Georgetown, Texas. The boiler was outside of the building, and hence the damage done was small. Engineer R. E. Thrift was seriously injured. It was raining hard at the time, and most of the employes were under cover. Otherwise the accident would have been far more serious, as fragments of iron fell all over the neighborhood. The boiler passed over a building and landed in the street, 300 feet away from its original position.

(138.) — A boiler exploded on June 25th in Nathan Hatfield & Son's saw-mill, five miles west of Fostoria, Ohio, demolishing the boiler, boiler house, and mill. Ephraim and Seymour Mills and John Hostler were in the mill at the time. Ephraim Mills was struck in the side by a piece of lumber, which broke a rib and injured him internally also. His brother Seymour was scalded from the neck to the waist in a frightful manner. Hostler was upstairs. The second floor fell to the ground, carrying him with it, and he was buried in the debris. When taken out, it was found that he was not seriously injured.

(139.) — Adam Leck and his son William were instantly killed, on June 25th, by the explosion of a boiler in a small machine shop at Brockport, Elk county, near Brockwayville, Pa. Frank Leck, a brother of William, narrowly escaped a similar fate. The boiler was thrown 350 feet, and the building in which it stood was completely demolished.

(140.) — A boiler exploded, on June 26th, in Kinebrough Bros.' mill, at Marion, Ind., wrecking the boiler house. Joseph Kinebrough was buried in the debris, and Frank Wimmer, who was in a buggy thirty feet from the boiler, was hurled into a ditch. Both men will recover.

(141.) — On June 26th a boiler exploded in Fairhead, Strawn & Co's mill, at Middleburg, near Jacksonville, Fla. Preston Hampton and Albert Wilson were killed, and S. E. Kinnan and John Wilkinson were seriously injured. The mill buildings and machinery were badly damaged, and in places bricks, steam piping, and machinery were piled up in disorder, three feet deep.

(142.) — On the evening of June 26th, just after the Pennsylvania Railroad ferryboat *St. Louis* had entered the slip at the foot of West Twenty-third street, New York city, on her 8:45 o'clock trip, a header blew out of one of her four safety boilers. Charles Farrell, who was standing in front of the boiler, was badly scalded about the head and arms. He was taken to the New York Hospital, and may die. We are informed that this is the eighth accident of this kind that has occurred on the *St. Louis* and her sister boat, the *Pittsburgh*, on the Twenty-third street and Jersey City Ferry.

(143.) — A portable boiler used by Kennedy & Campbell, contractors on the new Water street pavement at Bay City, Mich., exploded on June 28th, but fortunately nobody was near at the time. The steam gauge showed 37 pounds after the boiler had exploded and the steam had all escaped. If the gauge was not injured, this very likely accounts for the explosion. The safety-valve was probably fast, and the gauge good for nothing.

(144.) — A traction engine boiler, belonging to Gobles Bros., exploded, on June 28th, at Dundee, N. Y. The escaping steam scalded Engineer Samuel Cook so badly that his physician declares that he cannot recover.

(145.) — A boiler belonging to King & Edwards of Adairsville, Ga., exploded on June 29th, shattering everything near it. Thomas Weeks, Alexander Warlick, and Samuel Mills were instantly killed, and D. C. Hamby, E. Hamby, Shadrach Towers, and Zacharias King were fatally injured. Clarence Branch also had a leg broken so badly that amputation was necessary. The explosion is said to be "the most serious disaster known in this part of the state."

(146.) — The dairy barn of George Morris, at English, Ind., was destroyed by a boiler explosion on June 30th. Engineer Robert Mason was buried beneath several hundred bushels of grain. He was scalded over the entire body. He may recover, but is very badly injured.

(147.) — On June 30th a flue failed in a boiler at Denton, Denton county, Texas. We have been unable to learn further particulars.

The Locomotive.

HARTFORD, AUGUST 15, 1897.

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

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

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

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

MR. LOUIS F. MIDDLEBROOK, who has been in the employ of the Hartford Steam Boiler Inspection and Insurance Company for thirteen years, was elected Assistant Secretary of the company by the Board of Directors on the 7th of July. Mr. Middlebrook's familiarity with the details of the company's business especially fit him for the responsibilities of the new office to which he has been elected.

WE desire to acknowledge the *Reports*, for 1896, of the Norddeutscher Verein zur Ueberwachung von Dampfkesseln, of Hamburg; the Schlesischer Verein zur Ueberwachung von Dampfkesseln, of Breslau; the Märkischer Verein zur Prüfung und Ueberwachung von Dampfkesseln, of Frankfurt a. O.; the Verein zur Ueberwachung der Dampfkesseln, of Hannover; and the Manchester Steam Users' Association, of Manchester, Eng. It is with regret that we have to record, in this connection, the death, on June 14th, of Mr. Lavington E. Fletcher, the well-known and capable chief engineer of the Manchester Association. Mr. Fletcher was seventy-five years of age, and for thirty-five years he had filled the position that he held at the time of his death.

Intentional Boiler Explosions.

In the July issue of THE LOCOMOTIVE we expressed a doubt whether a boiler explosion had ever been brought about by the deliberate and malicious act of a discharged employé, or other person having a real or fancied grievance against the owner of the boiler. The question is an interesting one, and we should be pleased to receive any information which may show that our surmise is incorrect.

Several cases have come to our notice in which an *attempt* to injure or destroy the boiler appears to be plainly proven. In the first place, we call to mind an experience of our own that had been almost or quite forgotten, since it occurred some eighteen or twenty years ago. The plant in question was in charge of a careful and experienced man, who had been newly installed as engineer in the place of another man who had been recently discharged for some reason or other. The new man appeared to be faithful in his attention to the boiler, and yet he was troubled at frequent intervals by the water in the boiler becoming dangerously low, and on each occasion he found the blow-off pipe more or less widely open. This happened no less than four times within six weeks, and on each occasion, we believe, the boiler was saved by the melting of the fusible plug in the back head. Finally our inspector was called in to diagnose the trouble, and in the course of the investigation the engineer, who, as we have said, appeared to be faithful and competent, insisted strongly that he had always taken particular care to close the blow-off tightly after having used it. The inspector finally had the blow-off valve boxed up and locked, and the key was given to the engineer. After this precaution had been taken, there was never any more trouble from low water. Of course, we cannot say positively how the blow-off happened to be open, but the prompt cure that the lock effected led us, at the time, to suspect the discharged engineer.

Another case which comes to our attention occurred in a paper mill, and the facts in this instance were so plain that the guilty man received two years' imprisonment for malicious mischief. The night fireman, who was a new man, fired up one of the boilers at eleven o'clock, and shortly after midnight he had a pressure of seventy-five pounds. Just before one o'clock he received a call from the discharged fireman whose job he had taken. The discharged man brought another fellow with him as a helper, and after a struggle the visitors overpowered the new fireman, and bound him hand and foot to a workbench in the boiler-room. The former employé then opened the blow-off valve on the boiler, and quickly ran away with his assistant. Owing probably to nervousness and the fear of premature detection, the rascally fellows had bound the fireman in a very bungling fashion, so that he succeeded in freeing himself in a few minutes. He closed the blow-off, shut the damper, deadened the fire, and ran for his superintendent, who immediately notified the police. Within an hour or so the discharged man was under arrest, and he was subsequently sentenced to two years' imprisonment, as we have already said.

We have received word from Raleigh, N. C., stating that in the early part of June a convict attempted to blow up the boilers in the penitentiary there by securing the safety-valves. Another convict chanced to notice what had been done, and gave the alarm in time to prevent any serious consequences.

An esteemed correspondent in Georgia also writes as follows: "In your July issue you say, in referring to an explosion in which it was hinted that the wreck was the work of a discharged employé, that you doubt if such a thing ever actually occurred. Now, I have no data that would prove you to be wrong, and yet I had an experience that came very near to it. We sold a man one of our 36″×10′ boilers for use in a cotton gin. His colored fireman did all right for a time, but on account of his going to sleep so often the owner decided to replace him by another man. So on Saturday he paid off the old fireman, and on Monday he set a new *field* hand at work firing. The boiler was furnished with a pop safety-valve, which was attached to a pipe that ran out through the roof of the boiler house, so that the valve was outside of the building. On Monday the proprietor showed his new man how to fire up. He then went to do some work on his gin, and forgot about the boiler until the fireman called out to him to make haste and start the engine, as the boiler was 'getting mighty hot.' He went down, and the gauge indicated forty pounds; so he told the man he hadn't enough steam yet to start with. 'Yassur, I is, boss,' he replied; 'dat hand done been way *round* dere once.' This called for lively work, of course; and when the boiler had been cooled off, it was found that the safety-valve had been screwed down till the coils of the spring *touched* one another. The gauge was graduated to 200 pounds, the stop pin had fallen out so that the hand could travel clear around the dial, and the boiler must have been carrying 250 to 275 pounds of steam.

The only reason, we think, that this wasn't an 'intentional boiler explosion' was that the boiler had good stock in it, and was well made."

Our correspondent's account is so clear and graphic that one involuntarily fetches a sigh of relief upon reaching the end of it. We guess, after all, that there *have* been intentional explosions; and any further information of this kind will be gladly received by The Locomotive.

Biographical Sketch of Henri Victor Regnault.

The distinguished French physicist and chemist, Henry Victor Regnault, was born at Aix-la-Chapelle, France, on July 21, 1810. Little is known of his early youth, except that it was spent in poverty, and that he had a hard struggle to support his sister and himself. The earliest definite information that we have of him tells of his wandering to Paris and securing a situation as assistant in a big bazaar known as "Le Grand Coude." His ability and devotion to his work in this position made him numerous friends, so that in 1830 he was enabled to enter the famous Ecole Polytechnique of Paris. Upon leaving this institution, two years later, he entered the department of mines, at Lyons. Here he remained until 1840, when he was appointed to a professorship in the Ecole Polytechnique, and also elected to membership in the French Academy. During his connection with the department of mines he had had abundant facilities for the study of chemistry, and he had devoted himself to research in organic chemistry with wonderful energy, producing many papers of fundamental importance, which commanded the attention of the scientific world. In 1841 he became a professor in the Collège de France, and shortly afterwards he became engineer-in-chief of mines. In December, 1850, he was made an officer in the Legion of Honor, and on February 7, 1863, he became commander of the same order. His famous *Cours Elêmentaire de Chimie* first appeared in 1847, and has been many times reprinted. It has also been translated into several other languages.

Shortly after becoming a professor at the Ecole Polytechnique (in 1840), he turned his attention more particularly towards physics, and began the long series of painfully careful measurements which have made his name famous among physicists and engineers the world over. We shall not review these celebrated researches in the present article, because we propose to give them a more extended discussion in future issues. In 1854 he became director of the celebrated porcelain works at Sèvres, where he continued until the time of his death. During the latter years of his life he devoted much time and thought to the improvement of ceramic processes, but he also planned and executed a laborious research on the expansion of gases, which would, doubtless, have been of the greatest value to the world. The Franco-Prussian war put a stop to these researches, for a time, by obliging him to leave Sèvres. His son, Henri, who was a talented painter, fought in this war for France, and was killed on January 19, 1871, at the age of 27. His death was a great blow to the elder Regnault, and it was followed by another misfortune of a widely different sort, and yet, perhaps, of equal severity; for when peace had been declared, and Regnault returned to his laboratory at Sèvres, he found that all the records of his vast researches on gases had been destroyed. The announcement of this loss was his last communication to the scientific world. His scientific labors came to an end in 1872, and, oppressed by grief and by increasing bodily infirmities, he died on January 19, 1878 — precisely seven years after the death of his son, and while the gay artists of Paris were decorating the young man's grave.

In an obituary notice published shortly after his death, *Nature* estimates his charter in these words: "As a scientific investigator, Regnault did not possess the brilliant originality of many of his fellow physicists. It was as the patient, thorough, conscientious observer that he has won his way to the foremost rank. Possessing a wonderful ingenuity in the invention of mechanical appliances for the purposes of observation, and a perfect familiarity with the mathematical department of physics, he has been enabled, by means of his unflagging enthusiasm and unbending resolution, to place the modern physicist and chemist in possession of an invaluable collection of constants, which at the present stage of science are in daily use, not only in the laboratory of research, but for a large variety of industrial purposes."

"Regnault was great as a laborious worker," says the *Encyclopædia Britannica;* "in all his researches he overcame every difficulty by his determined perseverance, his unusual natural ingenuity in devising apparatus, and his rare power of manipulation. Although few discoveries are associated with his name, the mass of physical constants which he determined with the utmost accuracy constitutes a powerful instrument of further advance, and the thorough training which he gave his students has produced many painstaking and exact workers in the field of physics."

Among Our Contemporaries.

Piping for High Pressures.— Tendencies in Steam Engine Development.— Care and Oversight of Power Plants.— The Smoke Question.

In the August issue of *Power* we find what appears to be a very good article on "Piping for High Pressure Steam Power Plants." It gives considerable general information about such piping, and numerous illustrations showing the way in which the standard forms of joints are made, as well as various forms of elbows and tees. There is a table of the proportions of "standard weight," "extra heavy," and "double extra heavy" wrought-iron and steel pipe, a table giving similar information for light-weight cast-iron flanged pipe, and a table giving the various dimensions of "light weight," "medium weight," and "extra heavy" cast-iron flanged elbows. There is also a table giving the weight, per square yard, of various kinds of gaskets. We have not verified these tables, but we presume that they are fairly accurate, and the article, as a whole, should be useful to those who have to do with piping.

In *Cassier's Magazine* for July there is a suggestive article by Mr. James B. Stanwood on "Tendencies in Steam Engine Development." "The most prominent condition affecting all engines," he says, "is a more general employment of higher steam pressure. This increase in pressure has been marked within the last fifteen or twenty years. Multi-cylinder expansion engines have made it possible to use these higher pressures, and to secure their full benefits. Two cylinders are commonly used with pressure of 100 pounds or so, three cylinders with pressures of 135 to 175 pounds, and four cylinders with 200 pounds and over. The cut-off is not earlier than half stroke, being nearly the same for each cylinder." A distinguishing feature in merchant marine practice is the uniformity of the load. The opposite extreme, so far as load is concerned, is met with in electric power plants, where "there may be a great many sudden and rapid sequences of light, moderate, or heavy loads, for long or short periods. There may be intervals of no load, long periods of small load, and occasional periods of exces sively heavy load. To all of these severe fluctuations the engine must adjust itself, and to design an engine which shall meet these demands is a problem which confronts the engineer of to-day. Close regulation is a highly essential feature of such engines, and remarkable improvements have been made in this direction in the past few years, especially in the construction and simplification of the main shaft governor, by the proper combination of inertia and centrifugal force ; but these governors have been applied chiefly to single-valve automatic high-speed engines. Such engines are now run directly connected to the generators, and they possess many valuable features ; but they are extravagant in the use of fuel, and maintenance and repairs are expensive." Referring to the proportions of the engine, Mr. Stanwood says that the mechanical engineer must design the cylinder "so that the most suitable mean effective pressure shall be obtained for the ruling loads. Engines that can develop a maximum power two, three, or perhaps four times as great as the usual working power, will be in demand for plants where violent changes of load are likely to occur." "The question of lubrication is an important one, especially for high-speed engines. The enclosed crank case is perhaps the simplest expedient for small engines. For larger ones, in which there are heavy bearing pressures and high speeds of the rubbing surfaces, continuous forced lubrication seems to be necessary. With the increase of steam pressure and more extensive use of compound engines, the entire field of valve-gears is being carefully studied ; for valves which proved satisfactory with 80 pounds of steam are failures with 125 or 150 pounds. The short stroke grid-iron valve is appearing again, and balanced valves of all sorts are being tried. Flywheel proportions are also commanding attention, and instead of rule-of-thumb methods of design, the strains due to casting and to centrifugal force are being investigated and provided for. In the older and more fixed types of engine, standardization of the parts is reducing the cost of construction."

Mr. T. Carpenter Smith contributes, to the *Engineering Magazine*, a bright and absorbingly interesting article on "The Care and Oversight of the [Electric] Power Plant." "In looking over the list of modern inventions," he says, "one is struck by the continuously increasing speed with which developments in the mechanic arts are commercially adopted. In nothing is this shown better than in the now almost immediate acceptance by the world at large of methods and applications which a few years ago would have met with strong opposition, critical examination, and finally a grudging acquiescence. Comparing the relative time in which the general adoption of the electric telegraph, the telephone, the electric light, and electric power were brought about, we see that the number of months required for the development and adoption of the telephone was smaller than the number of years required for the development and adoption of the telegraph. Almost as soon as the electric light was heard of, there was talk of the immense strides that it was making. And electric power had hardly been suggested before it became an accomplished fact. For years the uncertainty of the electric light was looked upon as natural and to be expected ; the most annoying failures were met with a good-natured shrug. The trite remark that 'electricity is only in its infancy' was a sufficient excuse for these annoyances; but, with the revolution wrought by the electric railroad in city transit, there has come a complete change in the attitude of the public. When the power shuts down the sentiment is no longer that 'blessings brighten as they take their flight.' Public dissatisfaction finds an expression in the query, 'What is the use of granting monopolies to those who don't know how to treat the public decently?' Comparatively few persons realize the care, patience, and technical skill required to properly handle the latest developments of electric power. Nearly every other business has some one dominant condition, but the power station is controlled by several very diverse ones. To understand and successfully direct any one of a large selection of small manufacturing industries is generally thought sufficient for one man, yet the power-station manager must know and satisfy the needs of all. Time will develop a sufficient supply of men fitted for this particular calling. Meanwhile there are many men who, having but moderate experience in one or more of these lines, can only try to do their best. It is for such men that consideration is particularly needed." After discussing the qualifications and relations of the employés, the author passes to the mechanical part of the plant, and here he loses nothing of the keenness of observation that he displays in the earlier part of the article. "It is more in the boiler-room, perhaps, than in any other part of the plant, that money is made or lost, and mostly between the coal pile and the stop valve. One constantly hears of the wonderfully skilled engineer who saves his salary every year, but his opportunities for waste or economy are small beside those of the fireman. An engineer may examine and readjust a valve once a week to produce a trifling economy of steam, but the fireman practically makes an adjustment with every shovelful of coal he pitches. We find engines, dynamos, and other machines all regulating themselves automatically for changes of load, but the cases where automatic regulation is applied to boilers are comparatively few. Engines can practically be shut down at any moment, and stand idle for an indefinite period without loss; but each time a boiler is thrown in or out of service there is waste of coal and labor in starting a fresh fire or hauling an old one." Our author might have added, that there is also a large loss, in such cases, from the cooling down of the brick settings, and of the water in the boiler. "Those who travel on an ocean steamer," he continues, "often wonder at the perfection of engines which run for days and weeks together without a stop. The marine engine, however, generally gets a pretty thorough examination and a partial overhauling at the end of every trip, and in an emergency can always be slowed down or stopped for a few minutes or hours; but the engine in the power house must never slow down. Boilers may leak, valves may break, engines may pound, and journals may heat; but the plant must go on."

A highly interesting discussion of the "smoke nuisance" was lately held at the Franklin Institute in Philadelphia, and is reproduced in recent issues of the *Journal* of that institution. It is too lengthy to be printed in full in THE LOCOMOTIVE, but a few extracts from it may be acceptable. Mr. W. F. Durfee calls attention to the fact that the problem is by no means a new one. "About six hundred years ago," he says, "when the population of London did not exceed 50,000, its citizens petitioned King Edward I, to prohibit the use of 'sea coal,' and he responded by making its consumption a capital offense. His successors, however, were more merciful to the users of coal, and its employment was resumed; but again, in the reign of Elizabeth, there were loud complaints against it, and in 1661 John Evelyn, in his *Fumifugium*, laments that 'owing to the increase of coal smoke, the gardens are no longer fruitful.' There have been numerous investigations and some legislation since that time, but all of it has ended where it began — in smoke! Smoke always has, as an offensive, distinguishing component, more or less of solid carbon in a finely divided condition, associated with numerous gases and vapors of variable composition. Most bituminous coals produce smoke containing large amounts of sulphurous acid, sulphuric acid, ammonia, and carburetted hydrogen, in addition to the ubiquitous carbonic acid and carbonic oxide." We can lessen the production of carbonic oxide and the liberation of free carbon by improving the combustion in the furnace; but the other products are far more difficult to handle, and, in fact, they cannot be avoided except by using specially selected fuel, or by washing the products of combustion so as to remove the objectionable compounds in solution. Mr. Durfee believes that the best solution of the difficulty lies in the use of fuel gas, and he points back for the origin of this idea to the furnace invented by the old alchemist Geber, who lived in the year seven hundred and some odd. He then reviews the various attempts that have been made to put this idea into practice, and says that in 1868 he erected the first steel works in which gas was used exclusively as a fuel. There were ten producers in this plant, the fuel employed was 75 per cent. of very fat bituminous coal, and 25 per cent. of anthracite dust. "There was no smoke from the chimney, and although the works were in the immediate vicinity of residences and cultivated grounds, there was no complaint of smoke or noxious vapors of any kind." Mr. Arthur Kitson emphasized the importance of the invisible components of smoke by stating that "if the sulphurous acid alone which escapes into the air of Sheffield were deposited by rain within the area which gives it off, the ground would be washed every year with 1,000 tons of it per square mile;" and that "the amount of ammonia annually sent off by the chimneys of London would, if properly treated, furnish over 700,000 tons of sulphate of ammonia. The value of this vast quantity of nitrogenous matter disfiguring and vitiating London's atmosphere exceeds that of all the fertilizers which England imports from Chili and Peru." He agrees with Mr. Durfee that the only radical and complete solution of the smoke question consists in "the conversion of coal into gas, and its purification before distribution. Fuel gas, as it is called, meets every objection that can be raised against the burning of coal. It is scientifically correct. It is the only means for ensuring perfect combustion and avoiding the evils I have enumerated." There are many other contributions to this discussion, which combine to make it one of the most important ever held in connection with the smoke evil; and at the end of it, in the issue of the *Journal* for July, there is appended a series of existing municipal ordinances on the subject taken from the cities of Chicago, Cincinnati, Cleveland, Pittsburgh, St. Louis, Detroit, Milwaukee, Philadelphia, and Minneapolis, and the Ohio State Ordinance is also given.

Flying without Wings.

One of the most interesting sights one observes in Southern California waters is a flock of flying fishes in the air; not one or two, but often fifty or one hundred, ten or twenty feet from the water, lifted by the wind and whirling away like quail or a flock of insects, scintillating in the sunlight — a startling picture. The fish appear to be flying, but they are simply one variety of many animals which apparently fly without wings. The writer has had these fliers pass within a foot of his face, and has known several persons who have been struck by them; but while the fishes dash through the air and cover distances of an eighth of a mile out of water, they are not strictly fliers, as they have no power to move the wings, as in legitimate flight. The wings are merely enormously developed fins, the pectorals resembling wings, with powerful branches or veins, the anals being smaller. The fish, then, has not four wings in the strict acceptance of the word, but four wing-like fins which it holds firmly, and which serve as sails or parachutes, bearing it up against the current which it forms as it rushes along. In this way these fishes fly or soar for long distances.

In the Gulf of Mexico there is a fish known as the flying burnard, a really magnificent creature, which bounds into the air when alarmed, spreading its wide pectoral fins and darting away like some gorgeous insect. It has vivid colors of blue, purple, and red, while its large wing-like fins sparkle and gleam in the sun as though they were inlaid with gems. This flier possesses a singular armor, its head being incased in bone, so that a blow from the fish in its headlong flight through the air is liable to result seriously. There are instances known of men being knocked down and stunned by them.

Certain fishes have the faculty of propelling themselves into and through the air in other ways. Such is the large gar of the South Pacific, which, when alarmed, bounds from the water by a twist of its tail and goes whizzing away, a living arrow and a dangerous one. When the ship *Challenger* made her famous trip around the world, the naturalists on board had many opportunities to observe the flier without wings. One struck the cap of an officer, and several instances came to the notice of the naturalists of fishes which had struck natives who were wading in the water, inflicting fatal wounds.

The most perfect fliers without wings are found among the mammals and reptiles. One of the lizards has a peculiar frill connecting its limbs; this frill is braced by a series of false ribs. When the lizard wishes to escape from some enemy, it darts into the air and soars away downward, upheld for a long distance by the side wings, which are boomed out by the false ribs. The little animal now resembles a large dragon fly, its rich metallic colors and tints flashing in the sunlight. On it rushes, making a graceful curve, rising and grasping the trunk of a tree, when it seems to disappear, so close is the protective resemblance. If still followed by some bird emeny, it will repeat the action, continually dipping down and rising, ultimately escaping.

The flying squirrel well illustrates this curious faculty of soaring like a bird. Its fore and hind limbs are connected by a web of flesh that hangs in a wrinkle when the animal is at rest, and would not be noticed; but the moment the little creature darts into the air and moves away, the pure white parachute, wing-like arrangement is seen. It catches the wind or rushing air as the squirrel bears down, and seems to expand and extend outward, taking the little flier safely upward, and enabling it to cross long distances and reach another point of vantage.

The flying lemur is one of the largest and most remarkable examples of this device of nature. Here not only are the limbs connected by a web, but the tail and hind legs are booms for a fleshy, fur-line sail, so that the lemur, with its young clinging to it, leaps boldly into the air and darts away, swooping down with great velocity, rising again to grasp a branch or trunk, to rush to the topmost bough and launch itself again into space. In this way a lemur will, if followed persistently, cover miles in a forest, and as a rule escape its enemies. The grace, ease, and facility with which these flights are made is more than remarkable. The animal has but to extend its limbs, as one intuitively does in diving or swimming, and plunge down into space.

The islands of Sumatra and Borneo have produced some remarkable fliers of this kind. A party of explorers in passing through a forest one day saw what they supposed to be a bird swooping down from a limb. A native was sent in pursuit of it, but the creature rose at the end of its flight and alighted upon a tree, up which it seemed to crawl, then flung itself into the air again. It was finally captured after a long chase, and proved to be a large tree toad. Instead of wings it had large elastic webs between its toes, which caught the air as it dashed away, buoying it up and acting as parachutes. The feet of the animal resembled those of a gull or a duck, so far as the webs were concerned, the four little parachutes offering surface sufficient to bear up the animal in its long flights from tree to tree.

A spider with a flying or soaring apparatus has been discovered. On each side of the abdomen extends a triangular lobe which catches the wind when the spider leaps into the air, aiding its flight to some extent, and well illustrating this remarkable method of flying without wings.—*Mr. C. F. Holder, in The Outlook.*

[It is not uncommon to see certain species of spiders spin long silky threads and cast them out into the breeze until the friction of the air against the thread becomes great enough to sustain the weight of the little creature, who then goes soaring off like an æronaut in his balloon.—Ed.]

The Locomotive.

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Crown-Bars for Locomotive Boilers.

We have received numerous inquiries concerning the proportion and arrangement of crown bars in locomotive boilers, and the present article is intended as a general response to the questions that our correspondents have asked. A rigid mathematical analysis of the strains that occur in crown-bars, and in the braces that tie them to the shell, would be exceedingly difficult, and we shall not attempt it in this place, but will merely point out the nature of the problem, and give some of the principles that have been found to be satisfactory in practice.

The object of the crown-bars, of course, is to support the flat crown-sheet of the furnace, so as to prevent the steam pressure from blowing it down. The necessary support may be had in two ways, both of which are used in practice. Thus we might con-

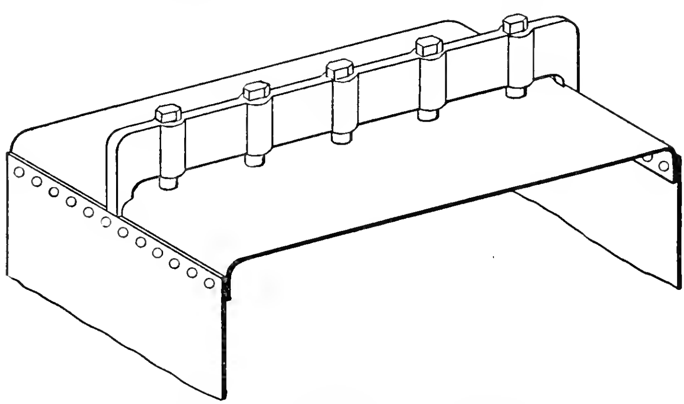


FIG. 1.—DIAGRAM OF A CROWN-BAR.

nect the crown-sheet to the upper part of the shell by putting in a sufficient number of crow-foot braces; but in order to stay a large surface like a furnace crown in this manner, at the pressures that are often carried on boilers of this type, we should have to put in a perfect forest of braces, and this means a great deal of work. It is also difficult to put in so many braces, so as to have them all taut when the boiler is cold, and all under a uniform tension when it is in use. It is therefore quite common to provide part of the support by running bars across the furnace crown as indicated in Fig. 1, and securing the crown-sheet to these bars by means of bolts. We propose to explain how to calculate the pressure that can be safely allowed on a crown that is stayed in this manner.

By comparing Fig. 1 with Fig. 2, it will be seen that the crown-bar acts precisely like a beam that is loaded at the points where the bolts are secured to the crown-sheet.

To find the strength of a crown-bar we therefore have to apply the ordinary rules that are used for beams.

Now the rule for finding the strength of a beam varies according to the way in which the beam is loaded. If the load is concentrated at the middle point, the beam will break quicker than it would if the same load were uniformly distributed over its entire length; and it is easy to understand that in every case we shall have to take account of the way in which the load is laid upon the beam. The pressure upon the crown-

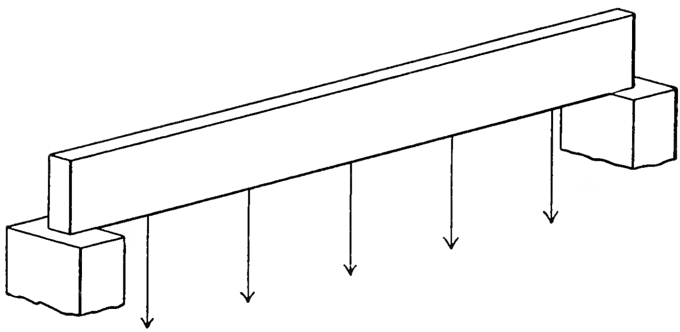


FIG. 2.—DIAGRAM OF A BEAM.

sheet, in locomotive boilers, is transmitted to the crown-bars by means of the bolts indicated in Fig. 1; so that these bars, strictly speaking, are like beams that are loaded at a considerable number of points, all equally distant from one another. But it is not necessary, in practice, to take account of the precise way in which the load comes upon the bar; for since the crown-sheet bolts are equivalent to stay-bolts, they must be spaced pretty closely, in order to give the necessary support to the crown-sheet, and in consequence of this fact we shall not commit any serious error if we treat the beam as though

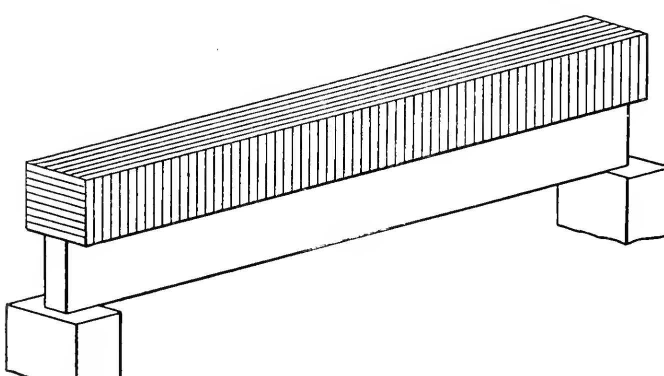


FIG. 3.—DIAGRAM OF A UNIFORMLY-LOADED BEAM.

its load were uniformly distributed from end to end, as suggested by the shaded mass in Fig. 3. We shall therefore calculate the strength of the crown-bar as though it were a beam whose load is uniformly distributed, from end to end.

Having thus disposed of the question of the *load*, we next have to consider the *shape* of the crown-bar; because two beams may be equal in length and contain the same amount of material, and yet they will differ in strength unless they are also identical in the form of their cross-section. If crown-bars had various forms of cross-section, we should have to give a separate rule for each one of these forms; but, fortunately, we are spared this complication by the fact that such bars are almost invariably *rectangular* in cross-section, so that it will be quite sufficient, for ordinary purposes, to give the rule for a uniformly loaded beam, whose cross-section is a rectangle.

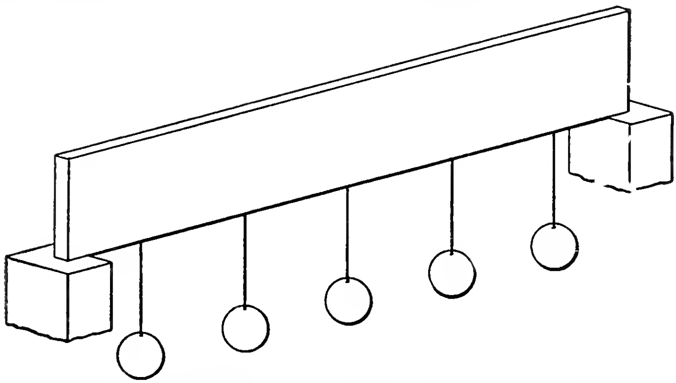


FIG. 4.—RECTANGULAR BEAM IN STRONGEST POSITION.

Figs. 4 and 5 represent a beam of rectangular section in two positions. The object of these two diagrams is to impress the reader with the importance of *height* (or *depth*) in a beam. In these two illustrations the beam is supposed to be of precisely the same size and shape; but, while it is strong enough to stand its load very well when its greatest width is *vertical*, it is very weak when it is turned over upon its side, as in Fig. 5. The most frequent trouble with crown-bars is that they have not the necessary *depth*; and it is hoped that a glance at Figs. 4 and 5 will be sufficient to show the importance of this point.

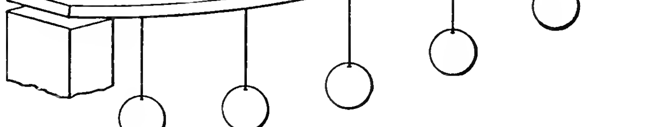


FIG. 5.—RECTANGULAR BEAM IN WEAKEST POSITION.

We have now to consider the rule for finding the strength of a rectangular beam, when uniformly loaded. The formulæ that have been derived for this purpose, from theory and experiment, show that the total load, in pounds, that such a beam can safely support, is found by multiplying the thickness of the beam by the square of the depth (the "depth" being the distance marked h in Fig. 6), and dividing by the length of the beam between the supports (all dimensions being taken in inches). The quotient so found is then to be multiplied by a constant, whose value is different for different materials, and must be found by experiment. For good wrought-iron this constant is about 17,300; and for mild steel it is about 20,800.

As an example of this rule, let us take the following case: A beam is 20 feet long, and its cross-section (which is rectangular) is eighteen inches high (or deep), and two inches thick. It is required to find the total load that the beam can safely support, if the beam is made of steel, and the load is uniformly distributed over the entire length of the beam. Following the rule, we first find that the square of the depth is $18'' \times 18'' = 324$. Then $2 \times 324 = 648$. The length of the beam is 20 feet, or 240 inches; so that we have $648 \div 240 = 2.7$. The constant for steel being 20,800, we find that the beam in question can safely sustain a load of

$$20,800 \times 2.7 = 56,160 \text{ lbs.},$$

provided this load is spread along the beam uniformly, from one end to the other.

To apply this rule to crown-bars, we first find the load that one of the bars can safely sustain, and then we multiply this by the number of the bars. This gives the combined strength of them all. If the total steam pressure on the crown-sheet is less than this, then the crown-bars are safe. When the boiler is of any considerable size, however, and is to carry a pressure of 100 pounds or more, it is usually found that the required supporting power cannot be had from the bars alone, without making them unreasonably large. In such cases the additional support that is needed must be provided by running braces up to the shell, as indicated in Figs. 12 and 13. These shell-braces possess the additional advantage of relieving the side sheets of the furnace of a considerable part of the vertical load that would otherwise come upon them.

Crown-bars may be put in lengthwise of the furnace, or crosswise. In the former case a longer bar is required, and the construction is, therefore, weaker, unless the bar is made correspondingly heavier. On the other hand, the longitudinal arrangement gives better access to the crown-sheet, enabling the inspector to examine its condition far more readily, and facilitating cleaning and the removal of scale.

The method of supporting the bars at the ends depends upon whether they run lengthwise of the boiler or crosswise, the difference being due to the way in which the crown-sheet is riveted in. When they run transversely, or crosswise, it is usual to give them a bearing something like that shown in Fig. 6, where the ends rest partly upon the edges of the side sheets of the furnace, and partly upon the turn of the flanges in the crown-sheet. One method of supporting the longitudinal bars is shown in Fig. 7. The ends of the bars here rest upon wrought-iron blocks or chairs, which are hollowed out on the under side so as to clear the rivet-heads. Whichever way the bars are put in, they must not rest directly upon the crown-sheet, or the sheet would almost certainly be burned. There must be a free space below them of at least an inch or an inch and a half, to allow the free circulation of water. To prevent the crown-sheet from buckling when the stays that secure it to the bars are tightened up, cylindrical or conical collars are provided (as indicated in several of the illustrations), in order to keep the crown-sheet at its proper distance from the bars.

In calculating the strength of the braces that are put in to assist the crown-bars, we proceed very much as in the ordinary case of the bracing of boiler heads. If the braces are taut and sound and well distributed, we may assume them to be all equally strained; and if they are made of good material, we may allow them a safe working strain of not over 6,000 pounds per square inch of section. To find the load that the braces can safely carry, we therefore proceed as follows: Find the least sectional area of one brace, in square inches, and multiply this by 6,000. The result is the load that can be allowed on each brace; and if we multiply this by the number of braces, we obtain the total load that can be allowed for the braces alone. This is to be added to what the crown-bars can carry, and the sum is the total load that can be allowed on the crown-sheet.

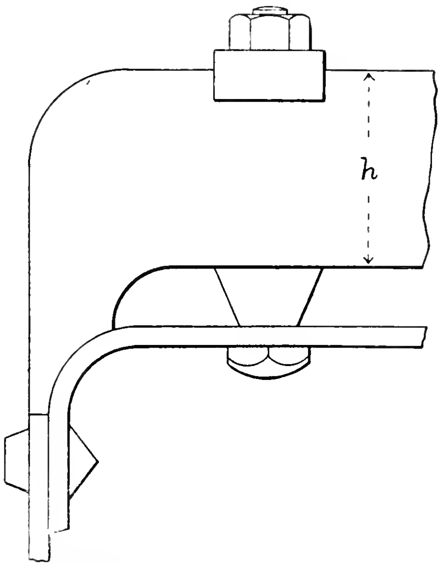


Fig. 6.—Mode of Supporting a Transverse Crown-Bar.

The way in which the braces and the crown-sheet bolts are secured to the crown-bars calls for some little consideration. If holes are drilled vertically through the crown-bar for this purpose, as indicated in Fig. 8, the bar will be seriously weakened; for its effective section will be reduced to that shown by the shaded areas. It is much better to arrange the bars in pairs, as suggested in Fig. 9, which shows an end view of the bars, together with the saddle, bolt, and conical collar by which they are secured to the crown-sheet. If vertical holes like those in Fig. 8 are used for any purpose, the "thickness" used in the rule for calculating the strength of the bar must not exceed the actual effective thickness of the bar after allowance has been made for the diameter of the hole. Bolt-holes drilled through the crown-bar *horizontally*, whether for securing the shell braces or for any other purpose, do not cause any sensible loss of strength, provided they are situated about half way between the top and bottom of the bar, as shown in Fig. 10, and are not more than an inch in diameter. The reason for this is indicated in Fig. 11. This diagram represents a beam that is just giving way under an excessive load. The bottom of the beam is exposed to a severe tension, or pull, which tends to pull it apart; while the top of the beam is exposed, at the same time, to an equally powerful compression, which tends to buckle it as indicated. Half way between the top and bottom there is a line which civil engineers call the "neutral axis," where the fibers of the beam are neither stretched nor compressed. In other words, there is no strain at all along this line, which is shown dotted in Fig. 11, and hence a horizontal bolt-hole at that place does not sensibly weaken the beam. It is precisely the same way with a crown-bar, and hence the best place to attach

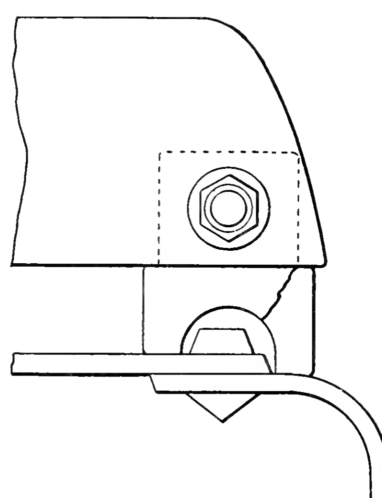


Fig. 7.—Mode of Supporting a Longitudinal Crown-Bar.

the shell braces is at the central line of the crown-bar. This mode of attachment is illustrated in Figs. 12 and 13.

We proceed to illustrate the principles set forth above by means of an example, and for this purpose we shall select the following case: A furnace is 56″ wide and 64″ long, and the crown-sheet is stayed by 20 well-distributed braces, each of which has a net sectional area of 1.25 sq. in. There are also 8 pairs of wrought-iron crown-bars, running cross-wise of the furnace, each individual bar being 1″ thick and 7″ high. It is required to find the pressure, per square inch, that the crown-sheet will safely stand.

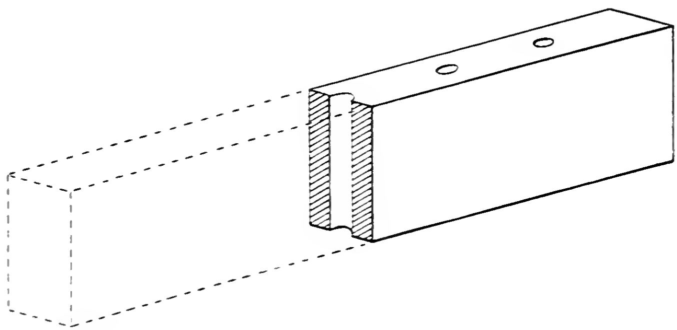


FIG. 8.—CROWN-BAR WEAKENED BY A VERTICAL HOLE.

Beginning with the crown-bars, we find, from the foregoing rule for beams, that the total safe load that can be allowed to each individual bar is

$$\frac{17,300 \times 1 \times 49}{56} = 15,137 \text{ pounds.}$$

(The "49" is the square of the height of the crown-bar.) In some cases the crown-bars are not so high towards the ends as they are in the middle. In most cases of this sort the full height at the middle may be safely used in calculating the strength, since the middle of the bar is by far its weakest point. Returning to our example, we note that there are 8 *pairs* of bars, or 16 individual ones. Hence the combined strength of the crown-bars is

$$15,137 \times 16 = 242,192 \text{ pounds.}$$

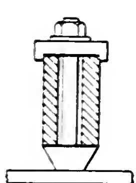


FIG. 9.—END VIEW OF A PAIR OF CROWN-BARS.

Passing now to the shell-braces which assist the crown-bars, we see that since each brace has a sectional area of 1.25 sq. in., the strain that can be allowed to a single brace is 1.25 × 6,000 = 7,500 lbs.; and, as there are 20 braces in all, the combined safe working strain on them all is

$$20 \times 7,500 = 150,000 \text{ pounds.}$$

Adding together the safe loads on the crown-bars and the braces, we find that the total allowable load on the crown-sheet is

$$242,192 + 150,000 = 392,192 \text{ pounds.}$$

Having found the total load that the system of crown-bars and braces can safely carry, it only remains to determine the corresponding pressure of the steam, in pounds per square inch. Now, in calculating the bracing required for staying the flat heads of tubular boilers, it is customary to make some allowance for the stiffening power of the flange by which the head is secured to the shell; and it appears reasonable and proper to make a similar allowance in the case of a locomotive crown-sheet. We shall, therefore, assume that the flanges of the crown sheet are sufficient to stiffen the sheet for a distance of three inches from the sides and ends. The 392,192 pounds that comes on the crown-bars and braces in the present case, therefore, represents the total pressure of the steam against a rectangle that is six inches shorter and six inches narrower than the actual crown-sheet. The crown-sheet in the present case being 56″ × 64″, the rect-

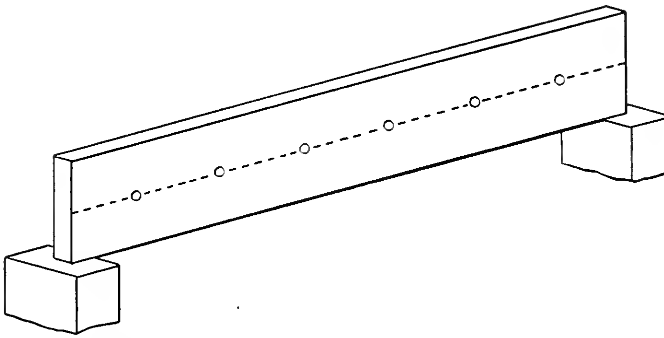


Fig. 10.—Showing the Best Place for Horizontal Bolt Holes.

angle that we have to consider is 50″ wide and 58″ long; so that it contains $50 \times 58 = 2,900$ sq. in. The 392,192 pounds of load on the crown-bars and braces, therefore, represents the total steam pressure against 2,900 square inches; and hence the corresponding steam pressure on *one* square inch is

$$392,192 \div 2,900 = 135.2 \text{ pounds},$$

or, in round numbers, 135 pounds. In other words, the crown-sheet that we have been considering ought to be perfectly safe under a steam pressure of 135 pounds to the square inch.

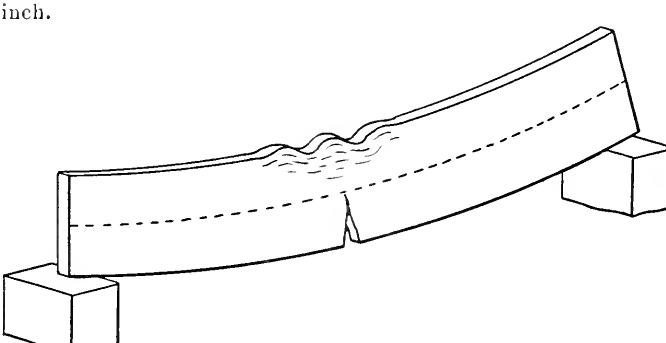


Fig. 11.—Illustrating the "Neutral Axis."

As a further example of the foregoing rule for crown-bars, we may take the following actual case, which came under our observation not long ago, and which is represented in Figs. 12 and 13.* The boiler in question was 60 inches in diameter, and carried 90 pounds pressure. The furnace was 5 feet long and $4\frac{1}{2}$ feet wide, and the crown-sheet was supported by seven pairs of longitudinal crown-bars, each individual bar being 5″ high and $\frac{3}{4}$″ thick. The ends of the bars rested on cast-iron pieces, which are shown shaded in Fig. 12, and one of which is reproduced on a larger scale in Fig. 7. The bars were assisted by 12 braces running to the shell, as shown.

The shell-braces, in this case, each had a net sectional area of 1.56 sq. in., so that, allowing 6,000 pounds as the safe working strain upon each square inch, we find that each brace can sustain a load of

$$1.56 \times 6,000 = 9,360 \text{ pounds.}$$

The twelve braces, taken together, would, therefore, sustain

$$12 \times 9,360 = 112,320 \text{ pounds.}$$

Passing now to the crown-bars, we note that there were seven pairs of these (or 14 in all), that they were made of steel, and that each bar was 60″ long, 5″ high, and $\frac{3}{4}$″ thick. Our rule shows that the safe-working load on each bar is

$$\frac{20,800 \times \frac{3}{4} \times 25}{60} = 6,500 \text{ pounds;}$$

and the united load that could be safely borne by all of them together is

$$14 \times 6,500 = 91,000 \text{ pounds.}$$

Adding the sustaining power of the braces and the crown-bars, we have

$$112,320 + 91,000 = 203,320 \text{ pounds,}$$

which represents the total strength of the bars and braces.

Now, the crown-sheet being 60″ long and 54″ wide, the allowance of 3″ all around for the stiffening action of the flanges leaves a rectangle 54″ long and 48″ wide, which is to be supported by the bars and braces. The area of this rectangle is

$$54 \times 48 = 2,592 \text{ sq. in.;}$$

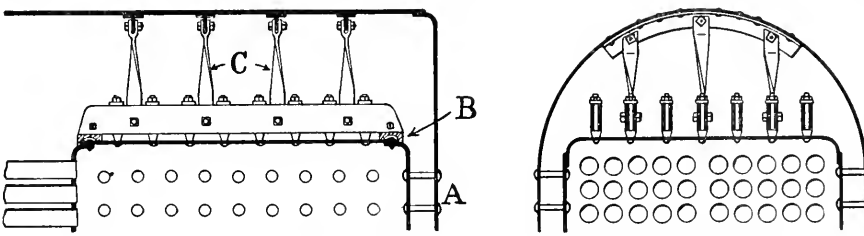
and hence we know that the limit of safety is reached when the total steam pressure against these 2,592 square inches becomes 203,320 pounds. But when the pressure on 2,592 square inches is 203,320 pounds, the pressure against one square inch must be

$$203,320 \div 2,592 = 78.4 \text{ pounds.}$$

The limit of safe working pressure on this crown sheet is, therefore, 78.4 pounds per square inch. As a matter of fact, it was run for a considerable time at 90 pounds; but this has since been reduced.

A brief history of the behavior of this boiler under 90 pounds pressure may be of interest. After it had been run for some time at that pressure, seven of the stay-bolts in the front water-leg, at *A* in Fig. 12, suddenly gave way. The boiler was allowed to cool, and new stay-bolts were put in. As there was no visible reason for the failure, it was thought best to apply hydrostatic pressure before firing up again. The result was that the calking edge along the joint marked *B* opened about $\frac{3}{16}$ of an inch. There was not much leakage, however — probably because the pressure on the crown-sheet held it down firmly against the water-leg where the line of contact came. In order to discover the cause of the trouble, the braces marked *C* were taken out, and it was found that they were *all broken*. In some cases the brace itself had parted, and in others the bolts that secured them to the crown-bars were sheared. New braces were then put in, and larger bolts were used; and when the hydrostatic test was again applied, several of the new braces broke before the pressure reached 40 pounds. The entire system of crown-bars and braces was then taken out, and it was found that the cast iron blocks marked *B* in Fig. 12 were all broken at the front end of the boiler (but not at the back end), the fracture occurring in the manner indicated by the heavy, irregular line in Fig. 7. Similar blocks were then forged up from *wrought* iron, the bars and braces were replaced, the working pressure was reduced to a point much nearer to that indicated by our rule, and there has been no trouble since.

In conclusion, we may say that crown-bar construction calls for a large amount of judgment on the part of the inspector, because so much depends upon the way in which the work is done, and the degree of intelligence shown in the general design of the parts. A trained inspector may sometimes allow a boiler to be run at a pressure slightly higher than that indicated by the rule, when he is satisfied that the design,



FIGS. 12 AND 13.—ILLUSTRATING THE FAILURE OF A CROWN-SHEET.

workmanship, and material are especially good, or he may insist upon reducing the pressure considerably below that point, if he feels that there is some doubt about these matters. This kind of judgment can only be acquired in the hard school of experience, and we cannot give fixed, printed directions to govern our men in these matters. For general practice, however, we believe that the foregoing rule will be found satisfactory.

Inspectors' Report.

JUNE, 1897.

During this month our inspectors made 8,410 inspection trips, visited 16,123 boilers, inspected 6,953 both internally and externally, and subjected 797 to hydrostatic pressure. The whole number of defects reported reached 11,594, of which 1,179 were considered dangerous; 43 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	996	47
Cases of incrustation and scale,	1,974	65
Cases of internal grooving,	175	12
Cases of internal corrosion,	967	30
Cases of external corrosion,	725	24
Broken and loose braces and stays,	103	29
Settings defective,	336	33
Furnaces out of shape,	482	21
Fractured plates,	240	27
Burned plates,	198	6
Blistered plates,	283	12
Cases of defective riveting,	1,420	308
Defective heads,	111	22
Serious leakage around tube ends,	1,768	297
Serious leakage at seams,	307	20
Defective water gauges,	380	50
Defective blow-offs,	201	33
Cases of deficiency of water,	10	5
Safety-valves overloaded,	45	24
Safety-valves defective in construction,	118	34
Pressure-gauges defective,	539	38
Boilers without pressure-gauges,	15	15
Unclassified defects,	201	27
Total,	11,594	1,179

The Locomotive.

HARTFORD, SEPTEMBER 15, 1897.

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

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Regnault's "Memoirs."

Henri Victor Regnault accomplished a great amount of valuable research work in his lifetime, all of which has had its due influence upon the progress of physics and chemistry; but he is known to engineers chiefly through the labors that are set forth in three large volumes of memoirs on the physical properties of gases, vapors, and liquids. The title page of the first of these volumes bears the inscription: "Description of Experiments Undertaken by Order of the Minister of Public Works, and at the Suggestion of the Central Commission of Steam Engines, to determine the Principal Laws, and the Numerical Data, which enter into Steam Engine Calculations. By H. V. Regnault, engineer in the Royal Corps of Mines, and Member of the Academy of Sciences." The second volume, which was published fifteen years later, bears a title substantially similar, the only significant difference being, that in place of the phrase "Steam Engine," we now find the more general term "Heat Engine" used. The third volume, published six years later still, bears the simpler title, "Account of Experiments for Determining the Laws and the Physical Data required for Heat Engine Calculations." The aid extended to Regnault by the State was apparently withdrawn after the publication of his second volume — probably on account of the political changes in France; and the French Academy supplied the funds required for the prosecution of the third series of experiments.

The labors recorded in these three volumes were begun in 1840, at a time when heat was universally beiived to be a material substance; and it was not until they had been some time under way that Colding, Mayer, and Joule pubiished the new doctrine of the mutual convertibility of heat and work. The classical paper of Helmholtz on "The Conservation of Energy," which was the first broad and accurate presentation of the new theory, did not appear, in fact, until 1847, which was the very year in which Regnault's first volume was published. When we consider the transitional state in which the theory of heat stood during these seven years, it appears strange that Regnault should not somewhere commit himself, implicitly at least, to the old doctrine of the material nature of heat, in which he had undoubtedly been educated; but we cannot recall any passage in which such commission occurs. Stranger still, and more inexplicable, is the fact that even after the new view had been well established by the experiments of Joule, Regnault made no attempt to determine the mechanical equivalent of heat, although he could not fail to recognize its fundamental importance as one of the "numerical data which enter into heat-engine calculations," nor to observe, at the same time, the comparative crudeness of Joule's experimental work.

The first volume of the *Memoirs* begins with the following words: "The theoretical calculation of the work done by steam engines is based partly upon certain incontestable principles of mechanics, and partly upon several physical laws which are far from being established, until now [1847], upon sure foundations. The authors who have written upon the theory of these machines have been obliged to adopt, as the bases of their calculations, laws which can only be considered as hypotheses, and which have been derived by extending to vapors those laws [such as Boyle's] which are not rigorously exact even for the permanent gases." Concerning the need of a more definite and accurate study of the properties of steam and other vapors, Regnault goes on to say: "Engineers have long called for a general research which should have for its end the establishment of the true laws of such bodies by a series of direct experiments, executed with all the precision that the present state of the physical sciences will allow. Some time ago I had planned to devote myself to this work, and on several occasions I had made divers trial experiments looking to this end; but they merely served to prove to me that precise results could be had only with extensive apparatus, of which the cost of construction would far exceed the very limited means at our disposition in the physical laboratory. I should have been entirely prevented from carrying out my ideas, therefore, if the Minister of Public Works, at the suggestion of M. Legrand, Under-Secretary of State, had not placed at my disposition, with a readiness which will be appreciated by every friend of science, the funds which were necessary to carry out the long and arduous researches here recorded."

In the first volume there are ten memoirs, occupying 748 pages. They are as follows:

I. On the Expansion of Elastic Fluids. (Including air, nitrogen, oxygen, hydrogen, the two oxides of carbon, and several other gases.)

II. On the Determination of the Density of Gases. (Here he finds the density of various gases as compared with air.)

III. Determination of the Weight of a Liter of Air, and of the Density of Mercury. (Both of these determinations are of great importance; for the first enables us to determine the weight of a given volume of any other gas whose density as compared with air is known, and the second is of constant use in the laboratory, for all sorts of purposes.)

IV. On the Measurement of Temperature. (This is a truly wonderful memoir, considering the time at which it was written. Thermometry, previously a most hazy and unsatisfactory subject, is here put upon a scientific basis for the first time.)

V. On the Absolute Expansion of Mercury. (Another memoir of great importance, whose results give us the density of mercury at every temperature from the freezing point up to 660° Fahr.)

VI. On the Law of the Compressibility of Elastic Fluids. (The compressibility of various gases is here investigated, and Boyle's law is shown to be merely a rough approximation to the truth, even in the case of the so-called "permanent gases.")

VII. On the Compressibility of Liquids, and particularly that of Mercury.

VIII. The Elastic Force of the Vapor of Water at Different Temperatures. (This memoir forms the basis of all, or nearly all, of the standard tables of the temperature and pressure of steam which are now in common use by engineers.)

IX. On the Latent Heats of Saturated Aqueous Vapor under Various Pressures. (This, like the preceding one, is of profound importance to the steam engineer, and has furnished the data for our modern tables of the latent heat of steam.)

X. On the Specific Heat of Liquid Water at Various Temperatures. (There is every appearance that this memoir was worked out with the same care displayed in all of the others; but, unfortunately, its results are inadmissible, because the data given are inconsistent among themselves. See, on this point, a letter by Prof. J. Macfarlane Gray in *Engineering* for January 9, 1885, page 42; also a more extended discussion in the same journal for July 12, 1889, page 57. See also Wüllner's *Lehrbuch der Experimentalphysik*, second volume, *Die Lehre von der Wärme*, new edition, 1896, page 488; and E. H. Griffiths in the *Philosophical Magazine* for November, 1895, pages 432 and 434.)

From 1847, when the first volume was published, Regnault worked without intermission upon the problems that he had laid out for further investigation, until a serious accident which befell him in August, 1856, compelled him to defer for several years longer the publication of his second volume.

"The problem," he says, "which I proposed to solve by these long researches . . . may be stated thus: 'A certain quantity of heat being given, what motive power can be theoretically obtained from it, by the expansion of elastic fluids, under conditions realizable in practice?' . . . At the time when I undertook these investigations [1840] the question seemed to me simpler than it does to-day [1862]. Starting from the ideas then accepted by science, it was easy to define with some precision the various elements of the problem, and I laid out in my mind the methods by which I hoped to master these elements one by one, and to determine the requisite numerical data. But, just as it usually happens in the observational sciences, in proportion as I advanced in my studies, the unknown circle about me enlarged continually; the things that seemed at first to be the simplest turned out to be quite complicated; and perhaps I should never have had the courage to enter upon the subject at all if I had perceived all its difficulties at the outset."

However, the second volume was completed and published in 1862, fifteen years after the appearance of the first one. It contains three memoirs, which occupy 915 pages. The first is on the specific heat of elastic fluids, the second dwells upon the relation between the temperature and pressure of various saturated vapors, and the third discusses the latent heats of a considerable number of vapors, under various pressures.

The third volume of *Memoirs* was published in two parts, of 575 and 380 pages, respectively. The first of these, published in 1868, is entitled "A Memoir on the Velocity of Propagation of Waves in Gaseous Media," and the second, published in 1870, bears the title, "A Memoir on the Expansion of Gases." Each of these is so lengthy that we cannot give an adequate idea of either in the present place. In view of the fact that some readers may fail to see why the memoir on the velocity of sound-waves should interest engineers, it may be well to state that in calculating the velocity of sound through a gas we have to make use of numerous properties of the gas which are hard to measure — as, for instance, the ratio of its two specific heats. Regnault, by determining the velocity of the sound-waves with much accuracy, was enabled to reason backwards, and learn something of those properties of the gas which he could hardly hope to measure directly, with satisfactory precision.

It was Regnault's intention to publish a fourth volume on the expansion of gases, and he had devoted several years to the accumulation of the necessary observations, when his records were all destroyed, as described in THE LOCOMOTIVE of last month. This loss, together with the death of his son, brought an end to his scientific work: but, although it is a matter for the deepest regret that any of his work should be lost or destroyed, we must feel, at the same time, that that which is still preserved to us constitutes a noble and a lasting monument to the memory of a man who has had few peers in the special field which he chose for his activity.

Boiler Explosions.

JULY, 1897.

(148.) — A boiler exploded, on June 30th, in H. J. Lang's mill at Milan, Mo. The proprietor and his engineer were instantly killed, and two other men were seriously scalded. [Received too late for insertion in the proper place in the June list. — ED.]

(149.) — A shocking accident occurred on July 1st on the Kleiber farm, some two miles from Marysville, Ohio. George Noelp had purchased a new threshing machine, and was testing a boiler and engine with which he proposed to run it. The boiler exploded, and Noelp's skull was fractured. The engine was blown 45 feet, and a buggy standing near by was blown 75 feet in the opposite direction.

(150.) — Two crown-sheets collapsed, on July 1st, in boilers "E" on the monitor *Puritan*, while she was moored at the foot of the main street in the Navy Yard at Brooklyn, N. Y. Chief Engineer Cowie was scalded somewhat about the hands. Subsequent inspection showed that all of the *Puritan's* four double-ended boilers had been badly affected, so that extensive repairs will be necessary. The cause of the accident has not yet been made public.

(151.) — The boiler of engine No. 22 of a Chicago & Northern Pacific suburban train running between Blue Island and Chicago exploded, on July 1st, as it was entering Morgan Park. Fireman John Latshaw was fatally bruised and scalded, and John Fogg, William Tapp, Alvin Dietz, James Anthony, August Pearson, Isaac Slimmons, Mrs. Isaac Slimmons, Charles Halliwell, Rudolph Bauer, and a young girl whose name could not be learned, were injured. The locomotive was entirely wrecked. The explosion took place midway between Mount Hope and Morgan Park, nearly opposite the residence of Alvin Dietz. Great masses of iron and other wreckage were hurled through the air, and one of these struck Dietz's residence and tore a hole in the wall. Another piece passed through a window and struck Mr. Dietz on the shoulder, inflicting a painful injury.

(152.) — Calvin Murray and George Sparrow were injured seriously and perhaps fatally, on July 2d, by the explosion of a boiler at Kimmel, near Ligonier, Ind. Several other persons also received lesser injuries from flying fragments of the boiler.

(153.) — On July 3d a boiler exploded at the Naughton & Holt oil well on the Horner farm, at the North Bend of the Hughes river, some two and a half miles west of Harrisville, W. Va. After the boiler had been fired up, a small leak was noted at one of the joints. Thomas Chadwick, the contractor in charge of the work, undertook to calk one of the rivets while the boiler was under pressure, and the explosion followed immediately. Chadwick was blown to pieces, and Joseph Davis, the cook, was injured so badly that he died in the evening, after being taken to Parkersburg.

(154.) — A boiler exploded, on July 3d, in Edward Robertson's corn mill at Syracuse, Morgan county, Mo., some twenty-one miles east of Sedalia. Mr. Robertson was killed instantly, and his wife and an employé named John Wall were fatally scalded.

(155.) — On July 3d one boiler in a battery of four exploded at John A. Beck & Co.'s salt manufacturing plant at Allegheny, Pa. Andrew Pfleuger was instantly killed, and George Krouse died shortly afterwards in the hospital. James Davis and John Ruth were also injured. We have seen no estimate of the property damage, but it must have been large, as the plant was badly wrecked.

(156.) — A threshing-machine boiler exploded, on July 4th, at the Moore farm, on Big Yellow Creek, near Steubenville, Ohio. About seventy bushels of wheat had been threshed, when it was noticed that the machine was not doing its work well, and a stop was made to see what was wrong. The feeder, T. H. Fawcett, had left the separator and was standing near the boiler when the explosion occurred. He was blown about 100 feet and killed instantly. Thomas Hess, Maurice Boyd, and Frederick Householder were all badly scalded, and several others received lesser injuries.

(157.) — A boiler belonging to Mr. Peter Grisham exploded, on July 6th, about three and a half miles from Waverly, Ky. Howard McMurray, John Roberts, Peter Grisham, Engineer Morgan, William Trigg, John Gupton, and Mr. Grisham's son were injured more or less badly.

(158.) — A fearful boiler explosion occurred, on July 6th, on the farm of Squire W. A. Allen, about five miles from Hartsville, Tenn. W. A. Allen, James Allen, Lindsay Allen, William Allen, Mack Tunstill, Asa Barr, Porter Averett, Leonard Barksdale, John Foley, and a boy named Bolton were killed. George Dice and Samuel Wheeler were fatally injured; and Calhoun Stone and Albert Haley were injured seriously but not fatally.

(159.) — A threshing-machine boiler blew up, on July 7th, one mile north of New Haven, near Ridgeway, Ill. Harvey Mitchell was injured so badly that he died next day. Taylor Gill was struck by several fragments of the boiler and will die. A man named Sutton had one leg shattered, but it is likely that he will recover.

(160.) — A boiler exploded, on July 7th, at an oil well on the Frazee farm, in Ritchie county, near Sistersville, W. Va. John Franklin and George Hotchkiss were killed, and Frank Johnson, W. B. Thompson, and John Fields were injured. Natural gas was used for fuel, and owing to an accident to the pumps the engine was stopped, but the gas was not turned off. The safety-valve did not work, and the needle on the steam gauge passed around the dial twice before any one thought of the boiler.

(161.) — The boiler of a threshing outfit belonging to Moore Bros. exploded on July 9th, four miles east of Calhoun, Tenn. Lum Dewitt was instantly killed and John Moore was scalded so badly that there is little hope of his recevery. Dewitt was blown 150 yards, and his body struck and uprooted a cedar tree five inches in diameter. It is said that the explosion was due to an inoperative safety-valve.

(162.) — On July 10th, while John Heath, who oversees the steam thresher of Fitzgerald Bros., was engaged in threshing out the wheat crop of Nicholas Julian, about one and a quarter miles from Princess Anne, Md., the head of the boiler blew out and instantly killed William Lane. John White and John Heath were also injured. The boiler passed directly over George Jones and Robert Smith, but they received no injury.

(163.) — A boiler belonging to Nathan Bennett exploded, on July 12th, at Sebree, near Poole, Ky. Mr. Bennett and his fireman, Abraham Sugg, were fatally injured.

(164.) — On July 12th, a boiler belonging to Cyrus Moring exploded near Stockton, Cal. John Roach, the fireman, was hurled to a distance of 150 feet, and his back was wrenched so badly that for several hours the lower part of his body was paralyzed. His right shoulder was also broken, and he was fearfully scalded, so that his physician pronounces his recovery to be very doubtful. Six other men received lesser injuries.

(165.) — The boiler of locomotive No. 382, on the O. & T. branch of the Fall Brook railroad, exploded, on July 15th, near Cammal, Pa. The branch referred to connects with the Fall Brook line at Cammal, and is used for logging purposes. The explosion was caused by the failure of the crown sheet. Engineer Henry Campbell and Fireman Wilford Hostrander were thrown a hundred feet down the track and severely scalded. The men were removed to the Williamsport Hospital, where Hostrander died in the course of the night, and Campbell died on the following morning.

(166.) — A threshing-machine boiler exploded, on July 16th, on a farm some twelve miles west of Arkansas City, Kan. Three men were injured, and the entire threshing outfit was destroyed, together with 2,000 bushels of wheat.

(167.) — A safety boiler exploded, on July 20th, on the new iron pier at West Brighton, Coney Island, N. Y. Pieces of the boiler were blown in all directions. The fireman was struck by the furnace door and by a piece of one of the tubes. His skull was fractured and several of his ribs were broken. He was removed to the Norwegian Hospital, where his injuries were declared to be fatal.

(168.) — A boiler exploded, on July 20th, in Brewster Bros'. saw-mill on Dry Fork, near Bluefield, W. Va., killing H. J. White and Smith Hicks. White was a sawyer, and Hicks was the engineer.

(169.) — On July 20th, a boiler exploded in the Preston Clark soda water factory at Peoria, Ill. The boiler was torn into three pieces. Nobody was hurt.

(170.) — A boiler exploded, on July 20th, on the Heusch oil lease, about seven miles northeast of Celina, Ohio. Wilson Piper, the pumper, had just gone into the boiler-house to turn off the steam from the pumps, when the explosion occurred. He was blown 30 feet and had one arm and one leg broken. His head was also severely bruised, and he received grave internal injuries. He lived about three hours.

(171.) — On July 25th a boiler exploded in Clark, Kizer & Kipp's mill, at Cortez, about six miles from Punxsutawney, Pa. Peter U. Duff was killed, and seven others were injured. Of the injured men Engineer Geiss is in the most critical condition. The end of the mill in which the boiler stood was wrecked, and the ruins took fire. The total property loss was about $15,000. The dynamos used for lighting the mill, offices, and residences of the members of the company were completely destroyed.

(172.) — A slight boiler explosion occurred, on July 24th, in the county jail at Topeka, Kan. Nobody was hurt, and the damage was small.

(173.) — Charles Menton Montgomery was fatally injured in a boiler explosion, on July 24th, near Luchter, La. He died on the 27th in the hospital at New Orleans.

(174.) — On July 26th the dome blew off of a boiler in Armitage's mill at Casnovia, Mich., and carried the roof of the boiler-house with it. Engineer Falconer had a narrow escape from death, as the 60-pound ball of the safety-valve barely missed him, striking the ground close beside him.

(175.) — The boiler of Horton Bros'. threshing outfit exploded, on July 26th, on the Lindsay place, at Argyle, near Denton, Tex. The engineer, whose name we could not learn, was instantly killed. H. Donham and George Crubaltz were bruised and crushed so badly that it is thought that they will die. William Botts, William Keith, William Smith, Alonzo Horton, Chester Horton, Joseph Bays, and Barnes Horton, were also injured, though less seriously.

(176.) — On July 27th the city of Yonkers, N. Y., was visited by a fire which did about half a million dollars of damage in the center of the business part of the town. Several boilers exploded in the burning buildings.

(177.) — Silas Grimme was killed, on July 28th, by the explosion of a boiler in Brown's mills, in Bland county, near Bluefields, W. Va.

(178.) — A boiler exploded, on July 30th, in a saw-mill at Goshen, near Little Falls, Minn. The part of the mill in which the boiler stood was badly demolished.

The Locomotive.

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On Heating Water by Steam.

One of the most familiar problems in dye-houses and many other industrial establishments, is the heating of considerable masses of water from comparatively low temperatures up to the boiling point; and the simplest and commonest way of accomplishing this end, is by passing live steam into the tank which contains the liquid that is to be heated. This operation, in fact, is met with so universally, that one would naturally suppose that the principles it involves would be thoroughly understood by every mechanic; and yet we find that such is not the case. It is by no means rare to find such tanks piped up for steam in a way which proves that the piper had no very clear idea of how the thing is done.

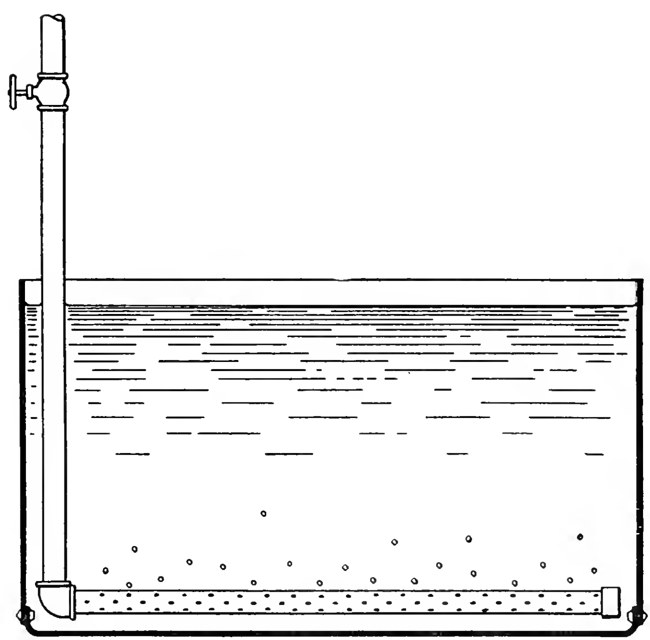

Fig. 1.—Heating by the Direct Injection of Steam.

In arranging a tank for heating water (or other liquids) by steam, we have two general methods between which to choose. We may discharge the steam directly into the liquid to be heated, by means of a perforated pipe, as shown in Fig. 1, or we may lay down a coil of pipe in the bottom of the tank, as indicated in Fig. 2, and obtain the desired heat by conduction through the metal of the pipe. The arrangement shown in Fig. 1 is far more frequently met with than that shown in Fig. 2, probably on account of its greater simplicity. Sometimes, however, it is not permissible or desirable to discharge the steam directly into the contents of the tank — as when working with indigo dyes, for example; and in these cases the method shown in Fig. 2 must be adopted.

In either case it is of the first importance to have the steam pipes lie along the very *bottom* of the tank, in order to ensure good circulation and a uniform temperature throughout the contents of the tank. We often find such tanks put in with the coils (or the perforated discharge pipe) running around the sides of the tank, just below the surface of the liquid contents; but a single glance at such an arrangement ought to show that it is radically wrong. At all ordinary temperatures, water expands upon being heated, and becomes lighter. If the heating pipe is in the *bottom* of the tank, the water that is in contact with the pipe will grow hot and expand, and will rise toward the surface. An undercurrent of colder water will flow down along the sides of the tank, at the same time, to take its place; and so the process will continue, the coldest water always sinking to the bottom and coming into contact with the hot pipes that contain the steam, until the entire contents of the tank is heated to the boiling point. Now if the heating pipes had been placed near the top of the tank instead of at the bottom, the water in contact with them would grow hot and expand, just as before; but being already at the *top* of the tank, it can rise no further, and the result is, that it stays where it is, and grows hotter and hotter until it boils, while the main body of the liquid, below, remains queiscent and almost as cold as it was at first, because there has been nothing to bring it in contact with the steam pipes. That is why it is wrong to put the heating pipes at the top of the tank. Placed at the top they give no circulation; while if placed at the bottom they produce a good circulation, and the whole tankful of liquid is then heated uniformly and regularly, up to the desired temperature.

Now, having decided which of the two methods shown in Figs. 1 and 2 will be best for the purpose in hand, the next question is, how much steam will be required to bring the contents of the tank up to the boiling point? Here, too, we find that mistakes are easily made. It takes a great deal of heat to raise a ton of water up to the boiling point, and pipers very often greatly underestimate the quantity of steam that will be required. A rough rule, which gives pretty good results in general practice, is to allow one pound of steam for every five pounds of the water that is to be heated up to 212°. For the most purposes this will be found to be quite sufficient: but as the more accurate process is quite simple, we shall give that also.

HEAT GIVEN OUT BY A POUND OF STEAM AT VARIOUS PRESSURES, IN CONDENSING INTO A POUND OF WATER AT 212° FAHR.

Gauge Pressure.	Heat Units.	Gauge Pressure.	Heat Units.	Gauge Pressure.	Heat Units.
0 lbs.	965	15 lbs.	976	50 lbs.	991
2 "	967	20 "	979	60 "	994
4 "	969	25 "	982	70 "	997
6 "	970	30 "	984	80 "	999
8 "	972	35 "	986	90 "	1001
10 "	973	40 "	988	100 "	1003

A pound of steam at atmospheric pressure, in condensing into a pound of water at 212° Fahr., gives out about 965 units of heat — that is, the heat that it gives out would be sufficient to raise the temperature of 965 pounds of water by *one degree*. If the steam were originally at a greater pressure than that of the atmosphere, it would give out a little more than this amount of heat; but the difference is not nearly so great as might be expected. Thus one pound of steam at 100 pounds gauge pressure gives out 1,003 heat units upon condensing into water at 212°; and this, it will be seen, is only about four per cent. greater than the heat given out by the same quantity of steam at simple atmospheric pressure. The number of heat units given out by a pound of steam, in condensing into water at 212°, is given, for various gauge pressures, in the accompanying table, which is based on data given by Clausius.

Now let us take a numerical example. Suppose our tank contains 7,500 pounds of water at a temperature of 48° Fahr., and we want to know how much steam must be drawn off from a boiler carrying 70 pounds, in order to heat this water up to the boiling point. Our rough rule, of allowing one pound of steam for every five pounds of water, would call for 7,500÷5=1,500 pounds of steam, or three-quarters of a ton; and while this result does not pretend to any great degree of accuracy, it is near enough to the truth to show how badly deceived a piper would be, if he "guessed" that a hundred pounds or so would be sufficient.

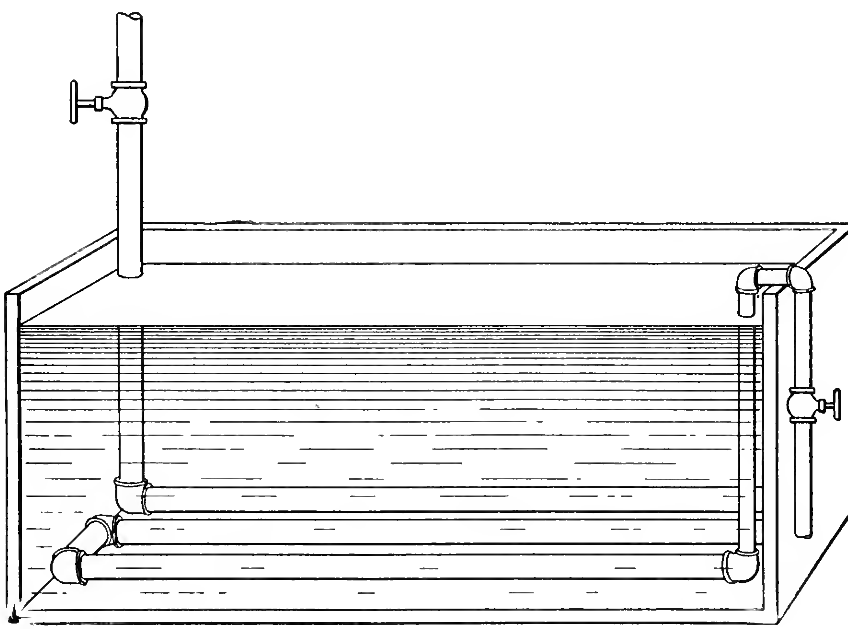

Fig. 2.—Heating by a Closed Coil.

To calculate the amount of steam required, with greater accuracy, we must first find out how many heat units we have got to supply to do the required work. The water in the tank is originally at 48° Fahr., and we wish to heat it up to 212°. We must therefore raise its temperature 212° — 48° = 164°. Now a "heat unit" is the amount of heat that is required to heat one pound of water one degree; and hence it would take 164 heat units to heat one pound of water from 48° up to 212°. But we have to heat no less than 7,500 pounds through this range of temperature; and since every one of these pounds calls for 164 heat units, the total heat supplied must be

$$7,500 \times 164 = 1,230,000 \text{ heat units.}$$

Having found out how much heat will be required, the next question is, How much steam, at 70 pounds pressure, shall we have to use, to obtain this quantity of heat? By referring to the table we see that one pound of steam (at 70 pounds gauge pressure) will furnish 997 heat units, and no more; and therefore, to get the required 1,230,000 heat units, we shall have to use

$$1,230,000 \div 997 = 1,234 \text{ pounds of steam.}$$

This process may be summed up in the following

RULE: To find the weight of steam that will be required to heat a given body of water from a given temperature up to the boiling point, multiply the number of pounds of water in the tank by the number of degrees through which the water is to be warmed, and divide the product by the constant that is given in the table, for the particular pressure of steam that is to be used. The result is the number of pounds of steam that will be required.

[If the contents of the tank is given in cubic feet or in gallons, instead of in pounds, multiply the number of cubic feet of water in the tank by 62.3, and the product will be the weight of the water in pounds; or multiply the number of gallons by $8\frac{1}{3}$, and the product will be the weight of the water in pounds.]

The method of calculation here given is strictly accurate when the steam is blown directly into the liquid to be heated, as in Fig. 1; but when the water of condensation is kept separate from the contents of the tank, and is removed from the coils by means of a drip pipe as shown on the right in Fig. 2, the result obtained by the foregoing rule is merely a close approximation, unless the heating process is so regulated that the condensed water drawn off from the coils is always just at 212°. If the condensed water so drawn off is *below* 212° (as it may sometimes be, when the water in the tank is still quite cold), the rule gives a result slightly too large. It is always very close to the truth, however, and its departure from strict accuracy, in the case of Fig. 2, is due merely to the fact that in making out the table given above we have assumed that the condensed steam cools precisely to 212°. If it should cool a trifle more or less than that, owing to its being drawn off from the coils before the water in the tank is fully heated to the boiling point, the result obtained by the rule will be in error by a correspondingly slight amount.

Inspectors' Report.

JULY, 1897.

During this month our inspectors made 8,047 inspection trips, visited 16,009 boilers, inspected 8,559 both internally and externally, and subjected 706 to hydrostatic pressure. The whole number of defects reported reached 13,202, of which 915 were considered dangerous; 73 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,260	42
Cases of incrustation and scale,	2,558	96
Cases of internal grooving,	131	9
Cases of internal corrosion,	1,144	46

Nature of Defects.	Whole Number.	Dangerous.
Cases of external corrosion,	834	33
Broken and loose braces and stays,	229	50
Settings defective,	523	50
Furnaces out of shape,	590	22
Fractured plates,	267	41
Burned plates,	247	12
Blistered plates,	288	5
Cases of defective riveting,	1,095	44
Defective heads,	233	41
Serious leakage around tube ends,	1,755	212
Serious leakage at seams,	401	21
Defective water-gauges,	347	44
Defective blow-offs,	217	48
Cases of deficiency of water,	6	5
Safety-valves overloaded,	47	14
Safety-valves defective in construction,	70	21
Pressure-gauges defective,	619	48
Boilers without pressure-gauges,	4	4
Unclassified defects,	337	7
Total,	13,202	915

Boiler Explosions.

AUGUST, 1897.

(179.) — A boiler exploded, on August 2d, in Kelley & Lysle's flouring mill, at Leavenworth, Kan. The boiler-house was completely wrecked, but no one was injured, although the entire night force of the mill was on duty at the time. There are six boilers in the place, and all of them were more or less damaged. Fire broke out immediately after the explosion, but the fire department was on hand promptly and soon had it under control. The workmen had a moment's warning of the approaching disaster, and the building was cleared just in time. The loss is estimated at $5,000.

(180.) — A boiler exploded, on August 3d, at Monroe Station, on the Pine City railroad, near Helena, Ark. Engineer Luke and two other men were killed, and two men were also injured.

(181.) — On August 3d, a boiler exploded in Rumley Bros.' mill at Winsteadville, about six miles below Bath, near Washington, N. C. Edward Windley was struck by the man hole cover and instantly killed. Joseph Taylor, Frank Clark, and York Clark were badly injured, and will die.

(182.) — A boiler exploded, on August 3d, in John Hepting's moss factory, at Gretna, near New Orleans, La. Abraham Johnson was badly scalded, and the machinery of the factory was badly wrecked.

(183.) — On August 5th the boiler of a threshing machine outfit, belonging to Hess & Fawcett, exploded on the farm of Alfred Dorrance, near Bergholz, Ohio. T. H. Fawcett was instantly killed, and Thomas Hess, Maurice Boyd, and Frederick Householder were badly scalded. Several other men were also injured to a lesser extent.

(184.) — A boiler exploded at Blackton, Ark., on August 6th, killing two men named Horn and Pettit, and injuring two others.

(185.) — The boiler of the steam launch *Sylvia* exploded, on August 6th, at Pawtucket, R. I. Mr. George H. Bunce, a well-known insurance man, was painfully burned.

(186.) — A boiler exploded, on August 9th, in C. P. Morrison & Co.'s mill, at Mena, Ark. Harry Nelson, the engineer, was instantly killed, and several other employes were injured. The entire building was wrecked.

(187.) — On August 9th a boiler exploded on Capt. B. B. Bradley's tow-boat *Fritz*, near Cairo, Ill. The boat was only fairly under way, when a heavy rain set in. The laborers who were in charge of the lumber barge that the *Fritz* was towing took refuge on the tow-boat, near the boilers. They had been there but a short time when one of the flues in the starboard boiler collapsed, filling the boat with scalding steam. Thomas Boles and Robert Green were scalded so badly that they died shortly afterwards. Nathan Eldridge was fatally injured. Samuel Porterfield, John Wright, Levi Knight, Nashton Reese, Moses Salterfield, Charles Bird, Thomas Stewart, Thomas Thomas, Henry Samuels, James Smith, and Eugene Hunt are missing, and were doubtless killed, though their bodies cannot be found in the river. William Barrett was slightly scalded. The *Ora Lee* towed the *Fritz* into Cairo, after the accident.

(188.) — On August 10th a boiler exploded in Henry Gyr's saw-mill on German Ridge, near Cannelton, Ind. The proprietor of the mill was killed, and four men, named Cox, Gottschalk, Bailey, and Meyers, respectively, were injured. The engineer and one other man escaped injury.

(189.) — A mud drum gave way, on August 11th, in the American Brewing Co.'s plant at New Orleans, La. Patrick Maher and Daniel Marz were painfully injured. The property loss is said to be $4,500. The New Orleans *Picayune* gives a spirited description of the accident, from which we quote the following picturesque passage: "Just a little after nine o'clock in the morning a blinding flash of lightning shot down from the heavens and seemed to pitch into the brewery. Then the thunder cracked, and in the same instant the 100-horse-power boiler that was close to the Bourbon street wall groaned, and the bricks shivered and flew about, steam filled the place, and a cry was heard." It was at first thought that the damage was due to the lightning, but investigation showed that the mud drum had burst.

(190.) — On August 12th a boiler exploded in Douglas Tucker's saw-mill at Diamond, in the town of Worth, near Lorraine, N. Y. Frank Van Brocklin was instantly killed, and Douglas Tucker and Frank Van Auken were injured.

(191.) — A boiler belonging to A. Nichols Shepard, of Jasper, Ind., exploded on August 12th. Joseph Bauer and Stephen Loehr were severely injured. The latest advices report that Bauer is dead, and that Loehr will probably recover.

(192.) — On August 13th a mud drum exploded at the Bessemer works of the Carnegie Steel Company, at Bessemer, Pa. John Gordon was killed.

(193.) — A boiler belonging to Capt. I. Hawkins, exploded, August 14th, on the bank of the Ohio river, opposite Mound City, Ill. Capt. Hawkins was killed, and John Blankinship, Travis Harris, Dunklin McIntosh, and S. M. Fant were fatally injured.

(194.) — On August 14th a boiler exploded in Keohl's cotton gin, five miles north of Huntsville, Texas. Frederick Loskie was killed, and Mr. Keohl and a boy were severely injured. The property loss was also large, although we have seen no definite estimate of it.

(195.) — A boiler exploded, on August 14th, in the Cooper oil field, near Marietta, Ohio, killing Amos Miller and his two-year-old daughter, and fatally injuring his wife.

(196.) — George Sillow was fatally injured, on August 15th, by the explosion of a boiler near La Grange, Ind.

(197.) — On August 18th a boiler exploded in the Indian Creek oil region, at Centerville, near Parkersburg, W. Va. Three men named Cassidy, Dunn, and Duty, and two others whose names we could not learn, were instantly killed, and six men were seriously injured. Eight large oil tanks took fire, and the burning oil ran into the village of Centerville, causing great destruction of property.

(198.) — A boiler exploded, on August 18th, at the Big Muddy coal mine, one mile north of De Soto, Ill., killing engineer John Yates. The boiler-house was destroyed, and the boiler itself was blown a quarter of a mile.

(199.) — A boiler explosion occurred at Oak Mills, near Atchison, Kan., on Aug. 19th. We have not learned particulars.

(200) — William Lipps, James McCullough, and a ten-year-old boy were fatally injured, on August 19th, by the explosion of a boiler at Spring Creek, near Hastings, Neb. All three of the victims were frightfully scalded, so that they died on the following day.

(201.) — A boiler exploded, on August 19th, in the electric light plant at Petersburg, Ind., and the buildings and machinery, costing about $20,000, were blown to atoms. Pieces of the machinery were thrown 500 feet. The plant was run on the moonlight schedule, and never later than midnight. The fireman reports that at 12 o'clock he banked his fires, opened the furnace doors, and left plenty of water in the boiler. The explosion occurred two hours later.

(202.) — A boiler belonging to Lucian Snyder exploded, on August 20th, at Laurel Point, near Fairmont, W. Va. Nobody was hurt.

(203.) — Charles Searles was instantly killed, on August 21st, by the explosion of a threshing outfit boiler on the Edwards farm, near Delaware, Ohio. Searles was the only man near the boiler at the time.

(204.) — Wesley Carter and Leander Moore were fatally injured, on August 23d, by the explosion of a boiler at Pineville, Bell county, Ky.

(205.) — On August 23d a boiler exploded in W. R. Halliday's brick yard, at Cairo, Ill. Riley Bradley, Gideon Ricks, and Henry Schiller were instantly killed, and Edward McCurdy, Proctor McCurdy, Dennis Bland, Jesse Woodford, James Keys, Isaac Thomas, William Curtis, and James Curtis were injured more or less severely. The shock of the explosion was felt nearly a mile away, and the building in which the boiler stood was demolished.

(206.) — A boiler belonging to Col. John A. Kunkel, of Pennington, N. J., exploded on August 24th. Several men were slightly injured.

(207.) — A boiler in the printing office of the *Kentucky Register*, of Richmond, Ky., exploded on August 25th. The immediate damage was small, and nobody was hurt.

(208.) — A threshing-machine boiler exploded, on August 25th, on the Philip Brooks farm, near Abilene, Kan. Engineer W. P. Snoke was fatally injured, and David Coffenberger, Edward Brooks, Thomas Jones, and James Stiles were painfully injured.

(209.) — On August 25th a boiler exploded in the Adams County Lumber Company's mill, at Decatur, Ind., killing Verne Reynolds and fatally injuring William Lewis, who were the only two persons about the place at the time. The boiler-house was wrecked.

(210.) — Edward F. Neal was killed, and Elisha Lockhart was painfully scalded, on August 27th, by the explosion of a boiler at Lawrenceburg, Ky.

(211.) — A boiler exploded, on August 28th, in Kelso's flouring mills, about four miles from Bedford City, Va. One of the brick walls of the building was blown down, and Foreman Thomas Blake was caught beneath the falling bricks and fearfully scalded. He died about two hours later.

(212.) — The locomotive of passenger train No. 8, on the Chicago & Alton railroad, exploded its boiler near Alton, Ill., on August 29th, as the result of an accident which caused the train to go down an embankment.

(213.) — A locomotive boiler exploded, on August 31st, on the Whippany River railroad, near Whippany, N. J. We have not learned particulars.

(214.) — On August 31st a boiler exploded in Replogle's tile mill, at Cowan, Ind. Jacob Replogle, Clinton Replogle, and Amos Replogle were badly injured, and will probably die. The mill was destroyed, and pieces of iron and timber fell a quarter of a mile away.

(215.) — The boiler of locomotive No. 27, on the Cleveland, Akron & Columbus railroad, exploded with great violence, on August 31st, in the village of Fredericksburg, Wayne county, Ohio. Engineer William Thornley and Fireman Louis Brown were instantly killed, their bodies being found 300 to 500 feet away from the scene of the explosion. Brakeman Henry Shank was also badly injured, though he will recover. A portion of the locomotive was found over 1,000 feet from the track.

THE special "Marine Number" of *Cassier's Magazine*, issued in August, 1897, is a marvel, whether considered as a contribution to engineering literature, or as a choice specimen of typography and press-work, or as a collection of excellent engravings (of which it contains more than three hundred). It contains the following articles, which no engineer ought to miss reading: "Specialties of Warship Design," by Sir W. H. White; "Fast Torpedo Boats," by A. F. Yarrow; "The Problem of Steamship Design," by Henry H. West; "The Launching of a Ship," by Robert Caird; "Hydraulic Principles Affecting a Floating Ship," by F. P. Purvis; "Marine Boiler Furnaces," by D. B. Morison; "Steamers for Shallow Rivers," by John I. Thornycroft; "The Design and Building of a Steamship," by Archibald Denny; "Water Tube Boilers for War Vessels," by W. M. McFarland; "The Naval Weakness of Great Britain," by Sir Charles Dilke; "The Modern Marine Engine," by Charles E. Hyde; "American Sound and River Steamboats," by Leander N. Lovell; "The Auxiliary Machinery of an American Warship," by F. Meriam Wheeler; "Shipbuilding and Transportation on the Great American Lakes," by Joseph R. Oldham; "Steel for Marine Engine Forgings and Shafting," by R. W. Davenport; "The Coaling of Steamships," by S. Howard Smith; and "Submarine Navigation," by John P. Holland.

The Locomotive.

HARTFORD, OCTOBER 15, 1897.

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

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

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

WE frequently receive calls, from the technical journals, for the cuts that are used in THE LOCOMOTIVE; and it has been our custom, heretofore, to supply the desired cuts freely, unless there should happen to be some special reason for refusing. We make no charge for this service, but we expect, in return, that the paper that borrows from us will have the courtesy (we had almost said *decency*) to give us credit for their use. THE LOCOMOTIVE gives credit for borrowed matter, and expects other journals to be honest enough to reciprocate. Now we notice, in the September issue of a certain trade journal, that a full-page engraving of the Hartford Steam Boiler Inspection and Insurance Company's setting — made from a new plate, it is true, and yet bearing indisputable evidence of its origin — is presented without the least mark to indicate its source, the journal in question apparently desiring that its readers shall assume that this scheme of boiler setting sprouted in the brain of its own editor. Now this kind of thing is hardly advisable, for several reasons. In the first place, it cannot be supposed to lighten the work of the advertising solicitor who will shortly try to persuade us to renew the page ad. that we now carry in the journal in question; and in the second place, the deception is not likely to work, anyhow, because THE LOCOMOTIVE has a circulation of 30,000, and engineers will make a shrewd guess about the inwardness of our contemporary's article. A further and stronger argument against printing matter of this sort, without credit, might be found in the dishonesty and general moral obliquity of the thing; but we do not advance this argument, because we fear that our contemporary's editor would not grasp it. It could hardly penetrate the callouses which adorn his sense of justice.

ADVICE TO KLONDIMANIACS. — An esteemed contemporary which warns travelers to the Klondike to beware of the deadly effects of frost bites, recalls the necessity for some more special advice of the same kind. While a great many suggestions have been thrown out lately, the people giving the counsels have neglected important particulars. Klondike travelers, for example, should resolutely refuse to start forth without their winter flannels. It is extremely draughty north of Juneau. Eat nothing but food. Take a pair of snow-shoes along, and attach them to your feet. This is important, because attempts to wear snow-shoes elsewhere have never been successful. You need not take a steam derrick, as the ordinary nuggets can be twitched along by mule teams. Anything too large to be handled in this way can be blasted into sections of convenient size. Remember that it is the height of folly to execute a clog dance on a glacier that slopes at an angle of 45°. For winter clothing, wool and fur are preferable, on the whole, to seersucker and cheese-cloth. It is well to hide potatoes or other articles of food in cans of gold dust, where nobody will think of looking for valuables. Finally, bear in mind that the Chilkoot pass is not like a railroad pass, inasmuch as it does not entitle you to free transportation. A few timely hints like these, taken in connection with the many similar ones that have appeared in the daily papers from time to time, will be valuable to the cautious tourist.—*Chicago Record.*

On Heat Engines, and the Source of Motive Power in Animals.

When a new scientific theory is proposed, which appears intrinsically reasonable and affords a natural explanation of facts previously not well understood, it commands instant attention, and is at once probed from all sides in the hope (or fear) that it may develop some unexpected weakness. If it passes the ordeal creditably, and proves itself to be in the main sound, those who had previously questioned it are sure to fly to its support, and give it their approval in terms often far too positive. The inertia of the mind carries it from a condition of previous ignorance *through* the truth, and to a considerable distance beyond: so that some effort is required to bring it back to a sound intermediate position, where it shall discern the precise measure of truth that lies in the new theory, accept that without question, and, which is of no less importance, hold itself open to receive such modifications of the original proposition as experience and further reflection may show to be necessary.

This tendency to over-confidence in our generalizations might be illustrated in every field of science: but we shall be content, for the time being, to point out certain phases that it presents in the theory of heat-engines (thermo-dynamics), which is now so old and so familiar and so securely established that it might be supposed to have passed beyond the extreme stage, and to have reached a more final and conservative form.

Of the two fundamental principles underlying the action of the heat engine, the first and best known is the law of the conservation of energy, which, as ordinarily expounded, teaches that energy is never created nor annihilated, and that all the phenomena that we see in nature are due merely to the *transformation* of energy from one form or condition into another. This law was first established in mechanics. Galileo, meditating upon the simple machines that he had seen, was led to deny the possibility of perpetual motion; and this denial was equivalent to an assertion that energy cannot be *created* by mechanical means. The second half of the law, which states that "neither can it be *destroyed*," was by no means so evident, because there were many cases in which such destruction appeared to be accomplished. The labors of Sir Isaac Newton made it possible to complete the theory, so far as the science of mechanics is concerned, and subsequent writers, notably in astronomy, made great use of it. The extension of the doctrine to *heat*, however, was still unthought of; and the germ of such extension does not appear until the famous experiments of Rumford and Davy were made, at the beginning of the present century. Even these were without immediate results, and the modern views concerning heat were not distinctly propounded until about 1840, when Séguin, Mayer, Colding, and Joule showed by various lines of reasoning that heat and mechanical energy are mutually convertible, in a definite ratio; thus making it possible to extend the law of conservation of energy from the narrow field of mechanics to the whole range of thermal phenomena. A great quickening and broadening of scientific thought followed, and the new ideas proved exceedingly fruitful in every direction in which they could be applied. In 1847 Helmholtz published his classical paper on "The Conservation of Energy," in which the extended doctrine received for the first time a systematic and comprehensive exposition. He treated not only of its applications in mechanics and thermo-dynamics, but also of its bearing upon all the phenomena of chemistry and physics. He believed it to be applicable also to the processes that occur in plants and animals, and yet he treated this part of his subject with characteristic caution, placing it at the end of his paper, and separating it from the rest by a dash.

We have rehearsed these familiar facts of history in order to show how gradually the doctrine of the conservation of energy, as now received, was established. Beginning with Galileo's denial of perpetual motion in mechanics, it was built up and extended, step by step, until in 1847 it reached a form which has not yet been altered in any essential particular.

The great swing of the mental pendulum from ignorance to definite knowledge in this province, therefore, took place about fifty years ago; and, whereas before that time we had no general theory of energy, we have since then become enthusiastic converts to the new doctrine, and have learned to extend it without question, and equally without logical warrant, even into the domain of animal and vegetable physiology. We are too positive in this matter; we should rather imitate Helmholtz, and demand rigid experimental proof of the legitimacy of such extension. Poincaré, in his work on "Thermo-dynamics," shrewdly says of the principle of the conservation of energy that "everybody has believed in it firmly, because mathematicians conceived it to be an experimental fact, while observers thought it was a theorem in mathematics"; and he adds that this principle is now being received more at its true value, and the fact that its basis lies *in experiment and observation* is coming to be universally recognized by the great writers on physics.

In his paper of 1847, already cited, Helmholtz pointed out a valuable test by which we may sometimes judge whether the energies of a proposed system are conserved or not. To apply this test, let the system be protected from external influences, and then, at a given instant, conceive the motion of every one of its particles to be precisely *reversed* in direction. If, when left to itself, the system would then retrace its previous history so that the events of that history would recur in reverse order, the conservation of energy is rigorously fulfilled by it. If, on the other hand, the system would not so retrace its history, we cannot affirm that it is conservative, but must test the point by a direct appeal to experiment. Now, although this crucial condition of *reversibility* is frequently fulfilled in inorganic nature, it would be rash to assert that, if the atoms in a complex organism like the human frame should have their motions reversed, the functions of the body would all be performed in inverse order. We could not make this statement of even the meanest fungus; we could not say that such a fungus would shrink, give back its substance into the ground in the form it originally had, draw in its netted mycelium, and eventually reduce itself to the original spore from which it came. Yet, if we cannot do this, we cannot, from reasoning based upon the inorganic world alone, draw any sound conclusion whatever about the conservation of energy in organic changes. To reach such conclusions for the human animal, we must weigh and analyze the food administered and the excreta given off; we must determine the oxygen absorbed and the carbon dioxide and other products exhaled; and we must measure the heat given out, and the external mechanical work performed. When these things have been weighed, measured, and analyzed, for a sufficient period and with the necessary precision, then, and then only, shall we be competent to affirm or deny the truth of the conservation of energy in the human machine. Owing to the extreme difficulty of such experiments, they have never yet been performed with an accuracy sufficient to establish the truth or falsity of that principle beyond controversy. Such measures as have been made indicate a rough approximation to conservation in the energies of the body, but nothing more. We certainly cannot say that the human machine obeys the laws of energy as precisely as the steam engine does.

Our confidence in the conservation of energy, in its legitimate applications, is now so profound, and the temptation to extend it to unknown vital processes is so great, that the foregoing argument may be deemed too finely drawn for serious consideration; but history teaches that it is in just such matters as this that we overlook great principles in nature, by assuming that we know things of which we are really in dense ignorance. It may be that the vital energies are conserved: it may also be that they are *not* conserved, and that we shall one day find out, through experiments on the animal body, that what we now know as the law of conservation is merely a special case under some grander generalization, whose grasp shall include a vast range of facts now isolated, and of phenomena yet undiscovered. Let us accept the conservation of organic energy as a convenient working hypothesis, subject to increasing confidence, to increasing distrust, to gradual modification, or to instant dismissal, as evidence may accumulate for or against it; but, by all means, let us not be too positive about it, and let us not be blinded against possible discoveries that may even now be crying for recognition.

Admitting, for the present, that the energy of the organic world is conserved, let us pass to a consideration of the *source* of this energy; for this part of the subject touches our pockets as well as our heads. The main question to be considered is, whether the animal body is a heat motor or not. At first sight the problem looks very simple, and a distinguished authority has tried to dispose of it by the following summary argument: "The human machine (for example) has an efficiency at least equal to that of the best steam engines; and if it were a heat engine, it could not have such an efficiency unless its parts showed differences in temperature comparable with those that occur in steam boilers." The inference plainly is, that since such temperatures do not occur, the human body cannot be a heat-motor. This conclusion is certainly in accord with most of the thermo-dynamic teaching of the day, and yet it is entirely unsound and erroneous, as we shall presently show. The argument upon which it rests is based upon certain propositions in the theory of heat, which were given to us by the illustrious Carnot, and which are of incalculable value when rightly interpreted. Writers on thermo-dynamics have accepted these propositions with unreasoning confidence, and have rehearsed them and dinned them into our ears until it has become a sort of heresy to question them, or to demand that they be received merely for what they are worth, and with due regard to the conditions involved in the case to which we propose to apply them. The prevailing ideas concerning Carnot's work are so inconsistent and erroneous, that it may be profitable to state what his real discoveries were, and to point out the limitations of his teachings.

Carnot's first and profoundest contribution to scientific thought is his conception of the *cycle*. In its simplest terms this conception may be described as follows: Let there be a hot body, *A*, from which we can draw heat at pleasure, and a cold body, *B*, to which we can add heat at pleasure. We shall not allow heat to pass *directly* from *A* to *B*, by conduction or radiation or any similar process, but we shall effect the transfer by means of a third body, *C*, which will serve as a sort of go-between. The body *C*, which is technically known as the "working body," is first allowed to receive heat from *A*, and it is then separated from *A* and put in communication with the cold body *B*, to which it gives up a certain amount of heat. The "working body," *C*, is then separated from *B*, and its connection with *A* is restored; and this is done over and over again, so that *C* undergoes a periodic, or *cyclical*, change of condition. The process is roughly analogous to drawing water repeatedly from a faucet into a bucket, and then pouring it down a well. The faucet is the hot body, the well is the cold body, the bucket is the "working body," and the water is the heat that is transferred. Now it would be idle to perform this cyclical operation for the mere purpose of transferring heat from *A* to *B*, for, if this were the sole end desired, it could be attained more simply by placing *A* in direct communication with *B*, and then leaving the system to itself. The real object of Carnot's process is, to cause the "working body," *C*, to be alternately heated and cooled; for every time it is heated it expands with great force, and by making use of this fact we can cause it to do work. Conceive, for example, that the "working body" is a gas or a vapor or a liquid, enclosed in a cylinder with a tight-fitting piston. Then every time that *C* receives heat from *A*, it will expand and push the piston before it; and the motion so produced may be used to turn a shaft or some other device, from which motive power can be taken away for use. When placed in communication with *B*, the "working body" gives up heat and contracts again, the piston being caused to follow it, either by its own weight, or by the inertia of a fly-wheel, or by any other suitable means. Thus every time that the "working body" goes through its cycle, it does a certain amount of mechanical work; and the ratio of this mechanical work to the energy that is received each time from the hot body, *A*, is called the efficiency of the motor. As has been said, we owe this conception of *a cycle with a definite working body* to Carnot; and we owe to him, also, a theorem which states that no engine *which works in this way* can have an efficiency greater than a certain fixed limit, which depends upon nothing but the temperatures of the hot and cold bodies from and to which the "working body" respectively takes and gives up its heat.

Carnot was unable to calculate the limiting efficiency of a cyclical engine running between given temperature limits, but this has been done by later writers, whose methods are given in all the higher treatises on thermo-dynamics. A few of the numerical results so obtained are given in the accompanying table. It will be seen that

TABLE OF THE GREATEST POSSIBLE EFFICIENCY OF A CYCLICAL HEAT ENGINE, RUNNING BETWEEN GIVEN LIMITS OF TEMPERATURE.

Temp. of the Hot Body. (Fahr.)	Temperature of the Cold Body. (Fahr.)							
	32°	50	98°	100°	200	331°	400°	1500°
	%	%	%	%	%	%	%	%
98°	11.8	8.6	0.0	....	....	....	....	....
100	12.1	8.9	0.4	0.0	....	....	....	....
200	25.4	22.7	15.4	15.1	0.0	....	....	....
331	37.8	35.5	29.4	29.2	16.5	0.0	....	....
400	42.7	40.6	35.1	34.8	23.2	8 0	0.0	....
1500	74.8	73.9	71.5	71.4	66.3	59.6	56.1	0.0

an engine of the kind imagined by Carnot, whose working body takes its heat at 400° Fahr. and rejects it at 32°, may, if it be perfect, utilize as much as 42.7 per cent. of the heat energy that it draws from the hot body; but it cannot do more than this. It must waste at least 57.3 per cent. of the energy that is given to it. It will also be observed that a heat-engine of this kind, which takes in its heat at 100° Fahr., and rejects the unused part at 98°, cannot have an efficiency greater than four-tenths of one per cent.

The so-called "proof" that our bodies are not heat motors, follows very simply from the table. The reasoning by which we are supposed to be convinced is something like this: If the mysterious, interior motive apparatus of the body is a heat-engine, taking its heat, say, at 100° and rejecting it at 98° (which is about as wide a range of bodily temperature as we could allow in health), it must be a very wasteful contrivance, since the foregoing table shows that it would necessarily waste *at least* 99.6 per cent. of the energy originally available. But we know that the human body actually has an efficiency many times greater than that here indicated; and hence we are led to the irresistible deduction that it is not a heat motor.

This "proof" melts utterly away when submitted to analysis; for one of the fundamental postulates of Carnot's theory is, as we have endeavored to show and to emphasize, that the engine to which it is to be applied shall be a *cyclical* one, in which the same working body is used over and over again. When this postulate is fulfilled, Carnot's deduction is unquestionably sound, and it is also sound in certain other special instances, notably in the thermo-pile; but in general it may be said that when the foregoing postulate is *not* fulfilled, there is no basis whatever for the famous theorem of a "maximum efficiency which is a function of the temperatures only." This simple fact is almost universally ignored by our standard writers on thermo-dynamics. They have, by overlooking it, plunged into an intellectual quagmire, and dragged us after them, to the great detriment of engineering, as well as of biological dynamics. We have espoused the teachings of the masters too ardently. The powerful and elegant methods discovered and developed by Carnot and Clausius have charmed us to that degree that we have wielded them in all directions, regardless of their limitations.

Returning to our text, let it be said that, so far as we can judge, Carnot's postulate of *a definite working body subjected to a cyclical change of temperature*, is not fulfilled in the human body; for we can find no tissue that is plainly used over and over again, to give power by its alternate expansions and contractions. In fact, we know with something like certainty, from the phenomena of fatigue and hunger, and from the unstable character of protoplasm, that by the act of contraction muscular tissue is used up, in some of its parts at least, so that severe exertion cannot be continued indefinitely, without allowing suitable intervals for repair. We may fairly infer, from what we have learned of physiology, that, whatever the agent immediately behind the observed muscular motion may be, it is subject to a continuous change in composition, losing some of its molecules all the while, and meantime adding others. It is not analogous to Carnot's working body, and his theorem of a limiting efficiency cannot rationally be applied to it. A heat motor whose working body is subject to the changes that occur in our muscles, may have an efficiency greatly superior to the values given in our table; and hence the fact that boiler temperatures do not occur in the human body is no argument against that body being a heat-engine.

Fearing that the force of what has been said may not be appreciated by those educated to the incautious use of Carnot's proposition, we invite attention to the following considerations drawn from steam engineering, in the hope that they may appeal to such readers with greater cogency than the more abstract reasoning that has preceded: Let us assume a system composed of a non-condensing steam-engine, and a boiler carrying steam at ninety pounds to the square inch above the pressure of the atmosphere. The temperature of the contents of the boiler, at the pressure assumed, would be something like 331° Fahr., and there is no doubt that under ordinary conditions the system would run and do good work. But let us further assume that from some extraordinary cause not contemplated in current meteorological theories, there comes a spell of weather so hot that the temperature of the air rises until it reaches 331° Fahr., remaining steadily at that point for a considerable time. When this wonderful state of affairs is established, the fires are to be drawn from the furnace, the boiler thereafter receiving its heat by direct contact with the atmosphere, which has now become as hot as itself. There is steam in the boiler, at ninety pounds pressure; but there is nowhere any difference of temperature. Nevertheless, the engine would run. Steam would be taken from the boiler, expanded in the engine, and rejected into the air; cold water, drawn from a well or elsewhere, being used to supply its place in the boiler. Now according to the table, this system, composed of the engine and boiler, should have an efficiency of zero; because the air from which it draws its heat has the same temperature as the air into which the unused residuum of heat is eventually discharged. In other words, it could not run at all; which is far from being the case. It avails nothing to plead that the temperature of the boiler would quickly fall to a point at which the engine could not run, because we might just as well have assumed the atmospheric temperature to be (say) 1500°, and then this objection could not be urged. Neither does it avail to say that the feed water is here the cold body contemplated by Carnot; for it does not perform the functions assigned to the cold body in Carnot's theory. This is made plain by the fact that the efficiency of the engine would be greater, the higher the temperature of the feed water — a condition quite the reverse of that which would hold for the Carnot cold body. Nor can we, by any other artifice, escape the violation of Carnot's doctrine as usually taught; for Carnot says plainly, in his book on the "Motive Power of Heat," that the efficiency "is fixed solely by the temperatures of the bodies between which is effected, finally, the transfer of the caloric"; and in the present case there can be no doubt that the "caloric" comes from the air, and goes back into the air again.

The difficulty in this hypothetical case is, that *there is no constant working body.* Each cylinderful of steam does its work once, and is then permanently dismissed. Carnot's postulate is not fulfilled; yet the ideas of the "perfect engine," and the "reversible cycle," and the "maximum efficiency," are so firmly rooted in our minds, under the influence of modern teachings, that the confession that all heat engines are not amenable to Carnot's law can be extracted from us only by resistless logic. If the attempt were made to provide the engine here considered with a constant working body, by condensing the exhaust steam and returning it to the boiler, so that *the same water* might be used over and over, we should find it necessary to introduce a veritable cold body into the system, in order to effect the condensation. The cold body so introduced would be the one postulated in Carnot's theory; and the engine, by its agency, would be transformed into a cyclical one, to which the theorem of a limiting efficiency would apply in all its rigor.

There are many men working to-day upon the famous problem of transforming the potential energy of coal into available mechanical energy, by processes more efficient than those now known. The less educated of these workers can hardly succeed, since they have a too imperfect knowledge of physics; but let us not handicap the others by a false and misleading dictum in thermo-dynamics. The animal may yet prove to be a heat-motor, and there are many forms of heat engines that do not fall under "Carnot's law."

The Locomotive.

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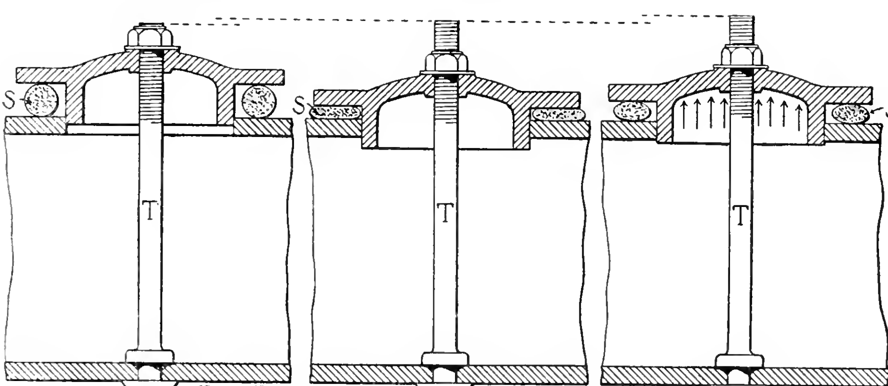
The Strains on Cover Plate Bolts.

It is a common thing, in steam engineering practice, to stop an opening in the shell of a boiler by means of a cover plate which fits the opening on the *outside*, and is held in position by one or more bolts exposed to a considerable tension. Figs. 1, 2, and 3 illustrate such a construction, the steam being supposed to act against the cover plate as indicated by the arrows in Fig. 3. There is some question, in the minds of many engineers, about the tension to which the bolt *T* is subjected when under steam; and to clear up this matter we have prepared the present article.

To understand the nature of the difficulty, let us examine the cuts a little more closely. The cover is first put in place and the nut screwed down until everything is just snug, without any strain, as yet, on either the bolt or the packing. This state of things is shown in Fig. 1. The nut is then screwed down further, so as to compress the packing, the bolt being at the same time subjected to a certain pull or tension, which



FIGS. 1, 2, and 3.— ILLUSTRATING THE STRAIN ON A COVER-PLATE BOLT.

we will call the "initial tension." Fig. 2 shows the condition of things at this stage. Steam is now allowed to act against the cover plate as shown in Fig. 3, and the question is, whether the tension on the bolt is increased or not by the action of the steam; and if it is increased, we wish to determine by what amount. Some engineers hold that the strain on the bolt in Fig. 3 is equal to the "initial tension" *plus* the total upward pressure of the steam against the cover plate. Others maintain that there is no increase in the bolt strain whatever, until the total pressure against the cover plate becomes greater than the total "initial tension" on the bolt.

Before attacking the problem as it actually stands, let us consider the somewhat similar one suggested in Fig. 4. On the left of this diagram we see a spring *S*, designed to resist compression, and another spring, *T*, designed to resist tension. The lower spring, *T*, is attached to a bolt as shown, and the upper end of this bolt is fitted with a nut and washer which bear against the upper end of the spring, *S*. Now let the nut be screwed down for a certain distance, and note what happens. The spring *S* is compressed, and *T* at the same time is stretched. If the two springs are of equal size and stiffness the compression of *S* and the extension of *T* will be just equal; but if there is any difference in the springs, there will be a corresponding difference between the stretch of *T* and the compression of *S*, though for present purposes we do not need to inquire just what the difference will be. After the nut has been screwed down, as shown in the middle of Fig. 4, the tension on the lower half of the bolt is just equal to the tension on the spring, *T*. Now suppose a weight, *W*, to be attached to the bolt as shown, so as to pull it upwards by a certain amount. The spring, *S*, assists the weight, and expands as the bolt moves upward; while *T* opposes the weight and must be forcibly extended. After equilibrium has been attained, as shown on the right of Fig. 4, the spring, *T*, is plainly subjected to a greater tension than before, and therefore the tension on the lower half of the bolt has also been increased.

Now let us return to Figs 1, 2, and 3, where we shall find that the conditions are very similar to those in Fig. 4. When the nut is first screwed up to the position shown in Fig. 2, several things happen, which, though they might be very readily overlooked, are yet of great importance. In the first place, the packing is compressed, as shown at *S*. The bolt is also stretched, as indicated by the dotted lines. The cover plate springs a little, too, and there will be more or less yield in the plate or casting to which the lower end of the bolt is secured. These motions are all slight, it is true, and at first thought they may appear to be too insignificant to affect the problem; but it is right here that we find the cause of the disagreement among engineers about the whole matter. The bolt, *T*, acts just like the spring, *T*, in Fig. 4, and the packing, *S* (together with the spring of the cover plate and the yield of the lower end of the bolt), acts like the spring, *S*. When steam is allowed to act against the cover plate as in Fig. 3, it acts just like the weight in Fig. 4; that is, it tends to stretch the bolt still further. The steam is assisted by the elastic upward push of the packing, just as the weight is assisted by the spring, *S*; and it is opposed by the pull on the bolt, just as the weight was opposed by the spring, *T*. The conditions are precisely the same, in fact, as they are in Fig. 4, except that the motions of the different parts are far smaller; and the conclusion to be drawn is therefore the same — that is, we must conclude that the strain on the bolt is *increased* by the action of the steam on the cover plate.

The correctness of this conclusion may be made more evident, perhaps, by examining Figs. 5, 6, 7, and 8. Fig. 5 represents a cover plate in position, with a soft, elastic packing under it. The nut has been screwed down until the bolt carries a total strain of 1,000 pounds, the packing at the same time sustaining a total *compressive* force of 1,000 pounds. (Of course the compression on the packing acts all around the ring; but for clearness we have shown it as though it were concentrated at the two opposite points where the packing is seen in section. This artifice cannot affect our deductions at all.) The cover plate is now in equilibrium, for the bolt pulls *down* upon it with a force of 1,000 pounds, and the packing pushes *up* on it by an equal amount. Now suppose that steam is admitted under the plate until the total pressure against the plate is 400 pounds. The introduction of this new (and thus far unbalanced) force must be to stretch the bolt by a certain though very small amount. The packing, being supposed to be very elastic, follows the cover plate, and still acts against it (after the slight stretch that occurs in actual practice) with a force that is not sensibly less than it was before the steam was introduced. The forces acting upon the cover plate are now three in number: (1) An upward force of 400 pounds due to the steam; (2) an upward force of 1,000 pounds due to the packing; and (3) a downward force due to the pull on the bolt. When the system is in equilibrium under steam, the total upward force against the cover must be equal to the total downward force against it; for, if this were not so, the cover could not be in equilibrium. Now the total upward force is equal, as we have said, to 1,000 + 400 = 1,400 pounds, and the total downward force consists of nothing but the pull on the bolt. Hence the pull on the bolt must be 1,400 pounds.

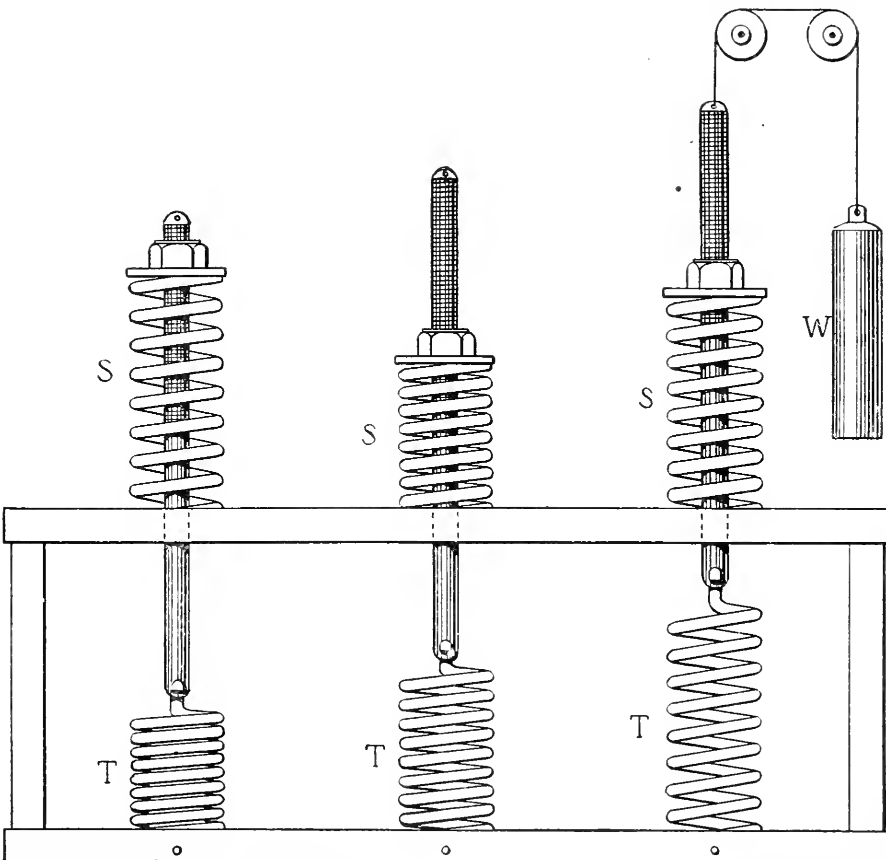
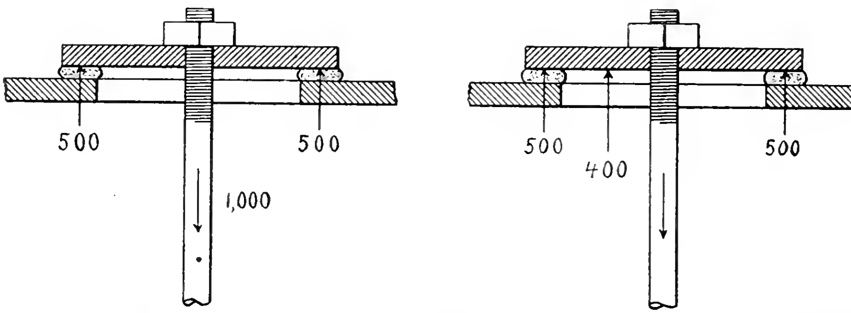


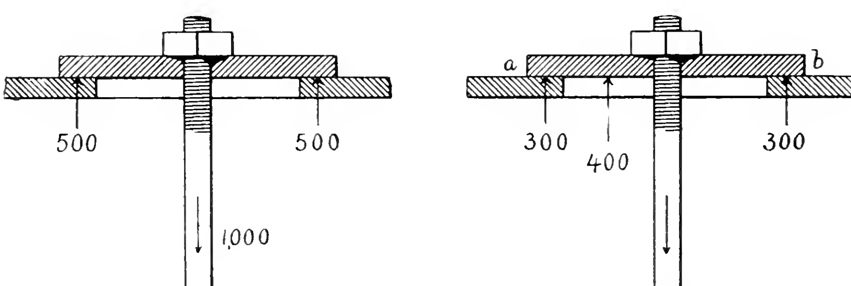
FIG. 4.—ILLUSTRATING THE MECHANICAL PRINCIPLES INVOLVED IN THE COVER-BOLT PROBLEM.

Now let us pass to the other extreme, in which there is either no packing at all, or else an inelastic one like lead or soft copper. This case is suggested in Fig. 7. The initial stress on the bolt we shall assume to be 1,000 pounds, as before; and the total upward reaction of the boiler shell against the cover plate is also 1,000 pounds. Now let us apply to the cover a total steam load of 400 pounds. The addition of this unbalanced force causes the bolt to stretch, just as before; but now it stretches by an amount so small as to be almost immeasurable, for the least conceivable upward motion of the cover plate causes a disproportionately big falling off in the reaction pressure that exists between the cover plate and the boiler shell. Indeed, if the cover plate and boiler shell were *absolutely* rigid and incompressible, an *infinitesimal* stretch of the bolt would cause this reaction pressure to disappear altogether; but absolute rigidity and incompressibility are properties that we never find in nature. Every actual substance is more or



FIGS. 5 and 6.— DISTRIBUTION OF THE STRESSES WHEN AN ELASTIC PACKING IS USED.

less deformable by pressure, and so it follows that to cause the mutual pressure between the cover plate and the boiler shell in Fig. 7 to totally disappear, a *finite* (though very small) stretch of the bolt will be required. Returning to our discussion, we repeat that the unbalanced pressure of the steam against the cover plate will cause the bolt to stretch by a trifling amount, and this will cause the pressures at *a* and *b* to be largely reduced. The increased stress on the bolt, corresponding to the exceedingly small extension that it receives, is insignificant; and hence the entire steam load against the cover plate goes to relieving the mutual pressures at *a* and *b*, between the cover plate



FIGS. 7 and 8.— DISTRIBUTION OF THE STRESSES WHEN A FACED JOINT IS USED.

and the boiler shell, and the resulting distribution of the stresses is as indicated in Fig 8. The total upward stress against the cover-plate is still 1,000 pounds, and hence the downward pull of the bolt must also remain 1,000 pounds. In this case, therefore, we see that there is no appreciable increase in the strain on the bolt.

To find a formula or rule that will show *how much* the strain on the bolt, *T*, increases, in any given case, we must make use of a little algebra. Let *t* be the stretch of the bolt for one pound of additional pull, when the system is in the condition shown in Fig. 2, and let *s* be the amount by which the compressed packing, *S*, would spring upward, if the load upon it were decreased by one pound. Let T_o be the total strain on the bolt in Fig. 2; and, since action and reaction are equal, the compression on the packing must also be represented by T_o. When a *total* steam pressure of W pounds is applied to the cover plate as in Fig. 3, let us suppose that the strain on the bolt becomes T instead of T_o, and that the total compression force exerted on the packing becomes reduced from T_o to S.

This notation being admitted, the reasoning is as follows: When the steam load, W, is allowed to act upon the cover plate, the strain on the bolt increases from T_o to T, and therefore the bolt stretches by the amount $t \times (T - T_o)$. The load on the packing having in the meanwhile fallen off from T_o lbs. to S lbs., the packing (which we here assume to be more or less elastic, or springy), expands vertically by the amount $s \times (T_o - S)$. Now, since the strains on the bolt and the packing ensure that all the joints remain snug, the upward swell of the packing must be just equal to the stretch of the bolt. Hence,

$$t \times (T - T_o) = s \times (T_o - S), \text{ or}$$
$$t\,T - t\,T_o = s\,T_o - s\,S.$$

Adding $t\,T_o$ and $s\,S$ to both sides of this equation, we have

$$t\,T + s\,S = s\,T_o + t\,T_o = (s + t)\,T_o.$$

Now, in Fig. 3 the strain, T, on the bolt, is due to the combined effect of the total steam pressure, W, against the cover plate, and the upward thrust, S, of the packing against the cover plate. Hence, $T = W + S$, or $S = T - W$. We may therefore substitute $T - W$ for S in the foregoing equation; and upon doing so we find that

$$t\,T + s\,T - s\,W = (s + t)\,T_o.$$

Adding $s\,W$ to both sides of this equation, we have

$$(s + t)\,T = (s + t)\,T_o + s\,W:$$

and, upon dividing both members by $(s + t)$ we have, finally, the formula

$$T = T_o + \left(\frac{s}{s + t} \times W\right),$$

where W is the total pressure of the steam against the cover plate, T_o is the strain on the bolt due to screwing up the nut, and T is the actual strain upon the bolt when it is in service under steam pressure. If we know the values of s and t and T_o for any given case, this formula would enable us to calculate the exact strain on the bolt for any given total steam load, W.

A little study of this formula will be of interest. If the bolt is absolutely inextensible (as is usually assumed in calculations of this sort), an additional pound of pull upon it will not stretch it at all: hence, in this case, $t = 0$, and the formula becomes

$$T = T_o + \left(\frac{s}{s} \times W\right) = T_o + W:$$

which shows that in this case the working strain on the bolt will be equal to the original strain due to screwing up, *plus* the strain due to the total steam pressure on the cover plate. (This is the solution of the problem that some engineers hold to be true in *all* cases.) Again, if the cover plate is absolutely rigid and the packing is absolutely without elasticity, then $s = 0$, and the general formula becomes

$$T = T_o + \left(\frac{0}{t} \times W\right) = T_o:$$

which shows that in this case the steam does not bring any additional strain on the bolt until the total steam load exceeds the original strain on the bolt. (This is the solution that other engineers hold to be true in all cases.)

We have now seen that the strain on the bolt in Figs. 1, 2, and 3 is *increased* by the steam pressure, to a greater or lesser extent, except in the one special case in which the cover plate and boiler shell and packing (if there is any) are absolutely devoid of elasticity; we have derived a rule by which this increased strain can be calculated if the elastic properties of the various parts are known; and we have seen that the disagreement about this thing among engineers is due to the fact that they have not appreciated the great importance of taking account of the slight (but undeniably real) yielding of the different parts.

In practice, there is often no actual packing, *S*, its place being supplied by a faced joint. When this is the case, and the cover plate is thick and rigid, we approach very closely to the case in which $s = 0$; that is, we can reasonably expect that when a faced joint is used the strain on the bolt when under pressure will not be materially greater than the strain that was originally placed upon the bolt by screwing up the nut. In cases where thick, springy packing is used, and the bolt is large and not very long, we may look for the reverse condition, and expect the working strain on the bolt to be sensibly equal to the initial tension due to the screwing up, *plus* the total pressure of the steam against the cover plate. For intermediate cases in which there is a packing which is hard and not very elastic, the actual strain on the bolt will be intermediate between these values.

We have not thought it necessary to give a separate discussion of the strains that occur when the cover plate is secured by a number of bolts instead of by a single one, because the principles involved are the same as in the case here treated.

Boiler Explosions.

SEPTEMBER, 1897.

(216.) — A boiler exploded, on September 1st, in Holdridge & West's mill at East Kill, Greene county, N. Y. Fortunately the operatives were all at breakfast, and nobody was injured; but the mill, which is a new one, was damaged to the extent of several thousand dollars.

(217.) — On September 1st the boiler of the steam yacht *Winona*, owned by Delford Holloway of Lansingburgh, N. Y., exploded on Lake Champlain, opposite Fort Ticonderoga. Mr. Holloway was hurled more than forty feet into the lake, and was with difficulty saved from drowning. He may die from his injuries. Mr. and Mrs. J. C. De Baun, Miss O'Sullivan, and Herbert Brewster were severely burned.

(218.) — Mr. Howell Cobb was killed and several other persons were injured, on September 2d, by the explosion of a cotton-gin boiler at De Soto, a small town in Sumter county, Ga.

(219.) — A boiler used in connection with an irrigation plant on the place of A. H. Cox, a prominent farmer, seven miles north of Toronto, Kan., exploded on September 3d, killing Mr. Cox's two children and Mr. H. V. Carlisle. Mr. Cox himself was also injured so badly that he lived but a few hours.

(220.) — On September 5th a boiler exploded in the electric-light plant at Morton, Tazewell county, Ill. Tillie Beyer and Emma Beyer were instantly killed, and Albert Beyer was injured so badly that he died next day. Frank Beyer, Mrs. Louis Moschel.

and Miss Cassie White were more or less seriously injured. The electric-light plant was destroyed. It was valued at $14,000.

(221.) — On September 7th a boiler exploded near Verdi, Nev., scalding the fireman, Gilbert Litzberg, so badly that he died shortly afterwards.

(222.) — A slight explosion occurred, on September 7th, in Miller, Hall & Hartwell's collar factory at Troy, N. Y. Something gave way about the new boiler in the basement, and the noise and the escaping steam gave the operatives a bad fright, and caused a stampede into the street; but nobody was seriously injured.

(223.) — A threshing-machine boiler exploded, on September 7th, at Kent, near Breckenridge, Minn. The fireman was so badly scalded that he cannot live. The engineer was also injured, but not so seriously.

(224.) — On September 7th a threshing-machine boiler owned by Abraham Himebaugh exploded near the Lake township center schoolhouse, just southwest of Hartville, Ohio. The fireman was seriously, but not fatally, scalded. A neighboring barn took fire, and was destroyed.

(225.) — A fearful railroad accident occurred, on September 8th, some three miles east of Emporia, Kan., on the Santa Fé road. At least a dozen persons were killed, and ten or twelve more were injured. The wreck was the result of a head-on collision between the fast mail going east and the California train going west. The Mexico and California train was drawn by two engines, and when the collision occurred the boilers of all three of the locomotives exploded simultaneously, tearing a hole in the track so deep that the smoking-car of the west-bound train went on top of the wreck of the three engines and mail cars, and balanced there without turning over.

(226.) — On September 8th a boiler exploded in a small mill belonging to Graham & McClenaghan, in the town of Pleasant, near Lancaster, Ohio. The explosion occurred during the noon hour, and nobody was injured. The boiler passed upward through the building, carrying the roof with it.

(227.) — A Central railroad locomotive exploded its boiler, on September 9th, at the Mitchell street crossing, Atlanta, Ga. Nobody was injured.

(228.) — The boiler of a small agricultural engine, owned by Willis Parsons of Camillus, near Syracuse, N. Y., exploded on September 10th. Henry Stephens was seriously injured about the body, and the building in which the boiler stood caught fire and was destroyed. The loss was about $6,000.

(229.) — Thomas Fleckner and Charles Greene were fatally injured, on September 10th, by the explosion of a boiler at Bloomdale, near Tiffin, Ohio. Jacob Pullman was also injured in a lesser degree.

(230.) — A threshing-machine boiler exploded, on September 13th, on the Murray farm, near Lisbon, N. D. One man, whose name we could not learn, was instantly killed. Samuel Dale was injured so badly that he cannot recover, and three other men were injured seriously, but not fatally.

(231.) — On September 13th a threshing-machine boiler belonging to Messer & Dunmoresq exploded on George Hesketh's farm, at Rolla, N. D. Joseph Dunmoresq and a boy were killed. Peter Portugee and James Dreever were seriously injured.

(232.) — A boiler exploded, on September 14th, in the canning factory of Fisher &

Robinson, at Milton, near Wilmington, Del., demolishing a portion of the building. We have not learned of any personal injuries.

(233.) — On September 15th a boiler exploded at a Patton farm oil well at Canonsburg, near Washington, Pa. One man was slightly injured. The boiler, in its flight, cut off an oak tree.

(234.) — A boiler belonging to Leonard Meade of St. Helen's, Ore., exploded on September 15th, but fortunately without injuring any one. The local authorities on steam engineering found it impossible to credit *steam* with so much destructive energy: so they devised a dynamite theory, which is thus set forth by the Portland *Oregonian*: "The explosion was caused by a stick of dynamite being inserted in the smokestack, on top of the boiler, during the previous night by some malicious person. People have suspicions as to who perpetrated the deed [they always have!], and the guilty party will doubtless be brought to justice."

(235.) — A threshing-machine exploded, on September 17th, at Spiritwood, ten miles east of Jamestown, N. D., killing Engineer Robert Orange, Fireman Frederick Sission, and Tankman David Wing.

(236.) — A boiler exploded, on September 18th, at Altoona, Iowa, and injured Frank Mell so badly that he died on the 27th.

(237.) — On September 20th a boiler exploded in Joseph Hayward's mill, near Macon, Mo. Charles Heator, Walter Ferguson, and Albert Yost were instantly killed, and William C. Allen was fatally injured. David Flinchpaugh and Henry Terry were seriously injured also, but are likely to recover.

(238.) — A boiler exploded at Argusville, near Fargo, N. D., on September 22d, instantly killing Arthur Slingsby, and fatally injuring his son, Arthur Slingsby, Jr., and the fireman, whose name we have not learned. Five other men were seriously injured.

(239.) — A boiler exploded, on September 23d, at Bainbridge, on the Ohio Southern railroad, near Springfield, Ohio. We have not learned further particulars, except that a large fire followed the explosion, and help was sent by the fire departments of Waverly and Chillicothe.

(240.) — The boiler in Laroe's cotton gin, eight miles east of Kaufman, Texas, exploded on September 23d, and badly wrecked the gin-house and machinery. Fortunately, nobody was near the boiler at the time.

(241.) — By the explosion of an upright boiler on the Bonanza prune ranch at Hanford, Cal., on September 22d, Engineer August Blix was seriously and perhaps fatally injured. T. D. Baird and Earle Ayers were also injured.

(242.) — A boiler belonging to Ferguson & Dex exploded, on September 23d, near Livermore, McLean county, Ky. Amos Goodwin, Wilson Salee, and William Forister were injured, and Salee may die. The buildings near by were wrecked. None of the boiler could be found except a fragment of the shell, which was picked up some two hundred feet from the original site of the boiler.

(243.) — William R. Loan was almost instantly killed, on September 24th, by the explosion of an oil-well boiler near Cairo, W. Va.

(244.) — J. C. Harlow, J. B. Harlow, and John Allison were instantly killed, on

September 24th, by the explosion of a boiler belonging to D. S. Russell, near Asheville, N. C. Abraham Grews and Peter Winfrey were also fatally injured.

(245.) — A threshing-machine boiler, owned by Frank Williams, exploded, on September 25th, on the farm of R. E. Dresser, Minnewaukan, N. D. Engineer William Shorey and Fireman Peter Anderson were instantly killed, and James R. Morris was injured so that he died a few days later.

(246.) — A boiler belonging to Le Gear Bros. of Rolette, N. D., exploded on or about September 27th. We have been unable to learn further particulars.

(247.) — Engineer E. Bennett Mitchell was killed and Fireman John R. Cawley was badly injured, on September 27th, by the explosion of a locomotive boiler on the Northern Central railroad at Georgetown, near Sunbury, Pa. At the time of the explosion the locomotive was traveling at the rate of fifty miles an hour.

(248.) — A boiler exploded, on September 27th, at Powersville, near Unionville, Mo. James Sibole was killed and his father was severely injured. William Rowen and several other persons were also injured more or less severely. It is doubtful if Rowan can recover.

(249.) — On September 28th two boilers exploded at the Hannah furnace of the Mahoning Valley Iron company, Youngstown, Ohio. Fireman Richard Flannagan was fatally injured. The explosion wrecked the boiler-house.

(250.) — The boiler of Fritz Mathwig's threshing-machine exploded, on September 29th, at Tower City, N. D., instantly killing Mr. Mathwig, and badly scalding the fireman.

(251.) — A traction engine boiler exploded, on September 29th, on the farm of Lorey Haworth, five miles northwest of Noblesville, near Arcadia, Ind. Robert Long, who was on the rear platform guiding the machine, was instantly killed, and his body was blown two hundred feet, passing through a stout picket fence.

(252.) — A small boiler owned by Quintus Neff exploded, on September 30th, some twelve miles west of Allentown, Pa. Three persons were badly scalded, and the total property loss is estimated at $5,000.

(253.) — On September 30th a boiler used by Johnson & Finney of Scandia, Kan., for operating a "merry-go-round," exploded, scalding Engineer McNeer.

(254.) — A heating boiler exploded, on September 30th, in Frank Sutton's barbershop at Terrell, Kaufman county, Texas. The boiler passed up through the building like a rocket, narrowly missing two men who were at work upon the roof. The boiler fell into the street, some two hundred feet from its original site. Nobody was hurt.

(255.) — The boiler of locomotive No. 354, on the Canadian Pacific railway, exploded, on September 30th, at White Creek bridge, twelve miles west of North Bend, near Vancouver, B. C. The locomotive was running at full speed. Brakeman George Elson was thrown down a steep embankment, and died almost immediately. The engineer and fireman were scalded, but escaped death.

The Locomotive.

HARTFORD, NOVEMBER 15, 1897.

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

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

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"Insurance in Connecticut."

We acknowledge, with much pleasure, the receipt of Mr. P. Henry Woodward's scholarly history of *Insurance in Connecticut.* It is one of the clearest and most comprehensive works of the kind that has yet appeared, and it gives a very complete survey of the insurance interests of the state, both past and present. One notable feature of the book is, that unsuccessful companies receive their full share of attention, and the causes of their difficulties and failures are pointed out, so far as they are known. This is surely an important feature: for in insurance, no less than in navigation, a rock that has wrecked one enterprise should be marked so that it may be avoided by the next comer. Fire and marine insurance were naturally the first branches to receive attention. As long ago as 1794, Messrs. Sanford and Wadsworth opened an office for insuring houses and other property against fire. Mr. Woodward quotes the text of policy No. 2, issued on the eighth day of February of that year, to one William Imlay. The phraseology is of much interest. "Whereas," says the policy, "William Imlay, Esq., of Hartford, or whom else it may concern, wholly or partly, Friend or Foe, doth make Assurance on his House against Fire, and all dangers of Fire; moreover against all damage which on account of Fire may happen, either by Tempest, Fire, Wind, own Fire, Negligence and Fault of own Servants, or of Neighbors, whether those nearest or furthest off; all extreme Accidents and Misfortunes; thought of or not thought of, in what manner soever the damage by Fire might happen; for the space of one year," etc. "At no point" of this policy, says Mr. Woodward, "can charges of evasion or ambiguity be brought against the document."

Passing to life insurance, Mr. Woodward rightly says that this branch of the business "has come to be a matter of science and equity; its methods have been evolved so as to conform to laws of average which are almost as exact in operation as the laws of physics." It was about the time of the Mexican war that life insurance came prominently before the people of Hartford for the first time, and it quickly became the talk of the town. It met with some opposition, however, on the ground that it was irreverent. This argument may appear strange at the present day, but that it had force with certain men in the '40's, will abundantly appear from the following passage from Mr. Woodward's book: "It was a new subject, and the vigorous presentation of the affirmative side provoked a good deal of curious opposition. Some good people argued that the scheme was irreligious in substituting reliance upon human instrumentalities for trust in Providence. Elder Swan, a revivalist famous for rough eloquence, and for the lurid colors in which he painted the terrors of the law, in a sermon at an annual state convention, resolved to crush the pernicious novelty at a blow. Rising to a climax in denunciation, he said, 'Suppose that Jesus, on His way to the Jordan, had met John among the foothills, and to the question "Whither goest thou?" John had answered, "Behold, all these years have I trusted in the God of Israel, and have been sorely pressed by many troubles. Wist thou not that I go up to Jerusalem to get my life insured?" Would the church, my hearers, have outlived the few and feeble days of infancy had treachery so foul been permitted to occur and to pass unrebuked? If lack of faith was a sin then, it is a sin now. Avoid the snares of a perverse generation, and say to the tempter, "Get thee behind me, Satan."' Prejudice yielded before enlightened discussion: and the act condemned by the good elder as a sin is now classed with the duties."

Passing to the subject of miscellaneous insurance, Mr. Woodward reviews the history of the Travelers Insurance Company and of the Hartford Steam Boiler Inspection and Insurance Company. Each of these companies entered upon its peculiar duties as a pioneer in a field not previously tried in America, and each has made itself a signal success.

Mr. Woodward's work is very well done throughout. He has had special facilities for getting at the facts that he gives, and his text is unusually accurate, so far as we are aware. His style is also interesting, and his book is embellished by numerous full-page plates giving portraits of the men who have been prominently identified with the companies whose history he reviews. It was originally prepared and published as a part of a compendious account of the resources and industries of New England, issued in four volumes by D. H. Hurd & Co., of Boston, Mass., and it was of such interest and importance to the insurance companies of Connecticut that it was immediately republished by the Messrs. Hurd in a separate volume.

The Maidstone Epidemic.

Saint Paul, when he said that "none of us liveth to himself, and none of us dieth to himself," spoke one of those universal "words" that have many applications to human affairs; but seldom does the abstract truth contained in it have such a striking concrete illustration, as it has had within the last two months in England. On the twenty-eighth of August there came to the generally healthy town of Maidstone two hundred hop-pickers from London, bringing along more than three hundred children, as this is the very heart of the hop country. They proceeded to establish themselves in the rude shanties known as hopper-houses, and many of these are situated in a meadow in which is a "catching ground" to gather water that eventually passes into one of the three streams from which the water is supplied to the town. Nothing can be more repulsive than the description of the lack of conveniences or decencies around these houses. Imagine houses in a barnyard and you have the picture, though there are no cattle there; and add to this the fact that the drainage of this meadow slopes directly down to the collecting pipes of one of the three streams that supply the town. There is testimony to the effect that some sick persons came along with the hoppers; and when it is remembered that the severest outbreak of typhoid fever on record was traced to water infected by a person who, though "miserable," pursued his daily avocations and did not "take to his bed" at all, we are not called upon to doubt that it was from this infection a notification of a couple of cases of typhoid fever was made on the 11th of

September, and four more appeared on the following day. Most authorities agree in fixing the period of incubation at from twelve to fourteen days; and in this case we feel warranted in saying, that as soon as the hop-pickers came to a place where no sewers had been provided to make their temporary homes salubrious and decent, they imparted an infection to part of the water supply of a town of 30,000 people; and at the end of nineteen days there had been no less than 1,172 cases, and the trouble was still holding its own, at the rate of seventy-six new patients a day. It was a most fortunate thing that the three different sets of springs and streams of water delivered *separately* to different sections of the town, and the two portions that take no Lutsham water, have nearly no typhoid. Of course some persons in these exempt parts may have easily drunk occasionally of the infected water.

Naturally, the depressed town, where the "market" is suspended and business sadly crippled by the sickness and death, has taken steps to inquire into the mischief, and learn how it has come about that, in this day of sanitary enlightenment, such a disaster has been possible; and an indignant demand is made for the punishment of the water company, who had no business to take water from a source that could be infected, and great indignation is felt against the Urban Council who allowed them to do it. The London *Times* sent a careful investigator to look into the matter, and his account we quote:

"If the Council had not been so niggardly about a regular analysis, the trouble would have been at least detected earlier, if not foreseen. They used to have a fortnightly analysis, but in successive spasms of economy it was reduced to a quarterly function. The company had no fixed date for that analysis, which means that they had none worth mentioning. But the rate-payers are equally and primarily to blame themselves. The whole question is one of money; and if a policy of false and ignorant economy prevails it is because they sanction and approve of it."

The infected supply was cut off on the 20th of September, and it is hoped that a speedy lessening of new cases will be reported; but on the 2d of October, eighty-five were notified, and it was expected that they would increase for a few days from that time. Meantime, great efforts have been made to care for the sick. One hundred beds have been added to the original hospital facilities of the place; there are sixty-seven nurses, of whom thirty-three do district work, *i. e.*, they visit families twice a day and teach the well members of a household how to care for the sick; and some of the younger physicians aid in night-watching.

The course of the town in making no attempt to conceal or minimize or falsify in the crisis is greatly praised, and there is no doubt that the town will not soon forget that unremitting vigilance is the price of health.—*The Independent.*

SLEEPING FISHES.—Professor Verrill has observed that many species of fishes and also the common squid assume special colors at night, while asleep, or at rest, in a feeble light. His observations were made at Wood's Holl, after midnight, when everything was quiet; for fishes sleep very lightly. The gas jets near the aquaria were turned down as low as consistent with distinct vision, and great care was taken not to jar the floor or furniture. With these precautions he was able to detect many species in the act of sleeping, some of which assumed unexpected positions when asleep. The most common change in color consisted in a general darkening of the dark spots, stripes, or other markings, by which they become more distinct and definite. This was seen in various flounders, minnows, the black sea-bass, the sea-robins, the kingfish, etc. Other species showed a much greater change in color, for the pattern of coloration was itself entirely changed. Thus the scup while active in the daytime is of a beautiful silvery color with bright pearly iridescent hues. But when asleep it becomes a dull bronze in hue and is crossed by about six conspicuous cross black bands, a coloration well adapted for concealment in eel-grass, etc. "If awakened by suddenly turning up the gas, it almost instantly takes on its silvery color seen in the daytime. This experiment was tried many times." A common filefish, which is mottled with dark olive green and brown in the daytime, when asleep becomes pallid gray or almost white, while the fins and tail become black. These are nocturnally protective colors. "The filefishes when asleep often lean up obliquely against the glass of the aquaria, with the belly resting upon the bottom in very queer positions." The tautog usually sleeps on one side, often partly buried in sand or gravel, or under stones, much after the fashion of flounders, suggesting, thinks Verrill, the mode in which the flounders may have developed from symmetrical fishes in consequence of this mode of resting becoming, so to speak, chronic.— *Science.*

THE APPLAUSE MACHINE.— "We used to have," said the old circus man, "a very simple applause machine that we made ourselves. It had a wooden axle with a number of pieces of wood attached to it, loosely, like flails. It was operated by power from the b'iler that we had to furnish steam for the calliope. We hooked a small engine on to that and belted it right on to the end of the axle that carried the flails. We had a brake on that so that we could regulate the applause, from a gentle spontaneous outbreak to a regular storm; and we had b'iler power enough so that we could run the calliope wide open at the same time if we wanted to.

"We used this machine only to stimulate dull audiences in towns where they didn't know a good thing when they saw it, without help. Then we'd sort of rouse 'em up with the applause machine, and generally that was enough, but if it wasn't, then we'd turn the whole business loose, calliope and all, and that never failed.

"The arms of the applause machine came down on what we called the sound box, which was about the size of a large dry-goods packing-box and made of oak plank. For light applause we had attached to the axle of the machine a considerable number of small wooden rods that made pleasant pattering when they struck the sound box, and then we had attached to the cylinder with spring fastenings heavier arms that were shorter and did not touch the sound box when the machine was turning slowly, but which, as the machine was turned faster and faster, were thrown further and further out by centrifugal force until they engaged the box. These heavier arms attached by springs were graduated in length and weight. When the machine was going full power the heaviest arms came down on the sound box with the force of crowbars, but when all the arms were in actual use you couldn't distinguish any one of them. It was thunderous applause and it was tremendous, but tremendous as it was, it was perfectly blended; and the machine was graduated so fine, and it worked so perfectly, that you could turn it down into a ripple of applause without a break in less than a minute. It was simple, simple as could be, but really it was one of the most ingenious machines I ever saw.

"Perfect as it was, though, we didn't get it into that shape without a good deal of effort, and at first we had a good deal of trouble with it. I shall never forget one time when the first machine we made got away from us. We were showing in a town that looked on at the great street parade without a cheer. We had the great eighteen-foot giraffe then, and, of course, we had him in the procession, and we had him open and shut blinds on the third story of the houses as we went along, and turn the pointers of the town clock back and forth, and all that sort of thing, but it never stirred 'em a bit, and it was just the same at the afternoon performance. There never was a better show than ours and everybody was right on edge, but we didn't move 'em a hair. They just sat there like wooden people and never even smiled.

"Then the old man gave the order to start up the applause machine, and we did. We had it in a sort of little canvas annex attached to one side of the main tent. We started her up gentle, and she went slick as you're mind to at the start, and all right every way, except that we didn't have in that machine the heavy arms graduated so fine as we got them later, and there wasn't so many of them, so that they did not blend as well. They'd come down on the sound box like so many separate sticks of cordwood. But we had steam enough on to pretty near bust the b'iler, and we turned that shaft until we got the machine making a steady roll, and then we turned the calliope loose. Noise? Humph! But it never started that audience any more than if they'd been stone deaf.

"Then something happened. The brake slipped off the machine, and before the man could get it adjusted again the machine run away. You see the brake was not only to regulate the applause with, but it was a sort of governor on the engine, too, and with that off, and the head of steam we had on, the machine swung around like lightning, and swinging with that greater force, the heavy arms pulled harder and harder on the springs and swung further and further out until finally one of them caught on the main tent and swept that panel of it clean out at one swipe and left the whole outfit in plain view of the audience.

"That did start 'em, and they laughed till the blessed b'iler run out of steam, because nobody could get near enough to it to stop it, for two or three more of the arms had got loose and tangled up and were swinging around in all directions.

"That night they come to the show in great numbers and just bubbling over with fun, and they wouldn't let the show go on till they heard and seen the applause machine."—*New York Sun.*

ALREADY the economy of internal combustion engines, whether operated with gas or with volatile hydrocarbons, is much greater than that of the steam engine and its inevitable boiler, and the lines along which gas engine improvement must be made are fairly well marked out. Of the energy contained in the gas, from twenty to twenty-five per cent. is now converted into effective form, the remainder being carried off with the cooling water, or rejected with the discharge gases, or in radiation. The most recent tests have shown the effective conversion of over thirty per cent. of the energy, most of this gain being from a reduction in the amount of heat rejected with the cooling water, and it is evident that a still greater economy could be attained if mechanical difficulties, such as cylinder wear, lubrication, etc., did not forbid, for the present, the use of higher cylinder temperatures. That such higher temperatures may soon be made practicable, either by improved methods of lubrication or modifications in construction, it is most reasonable to expect; and when the same united efforts that have been made by engineers all over the world for the improvement of the steam engine are given to the extension of the limits of temperature of the gas engine, there is small reason to doubt that we shall begin to realize an economy in the combustion of coal of which we need not be ashamed. It is to this subject almost as much as to the direct generation of electrical energy from coal, that engineers, physicists, and chemists should lend their efforts, for it matters little in what form the energy is developed if only the wastes be reduced; and when to improvements in the motors developments in the production of fuel gas from grades of fuel at present useless, are added some conception of the possible commercial economies may be obtained.— *Cassier's Magazine.*

Inspectors' Report.

AUGUST, 1897.

During this month our inspectors made 8,253 inspection trips, visited 16,677 boilers, inspected 6,220 both internally and externally, and subjected 715 to hydrostatic pressure. The whole number of defects reported reached 11,115, of which 782 were considered dangerous; 62 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	886	60
Cases of incrustation and scale,	1,907	68
Cases of internal grooving,	107	17
Cases of internal corrosion,	663	42
Cases of external corrosion,	727	31
Broken and loose braces and stays,	106	68
Settings defective,	325	18
Furnaces out of shape,	412	11
Fractured plates,	199	29
Burned plates,	179	29
Blistered plates,	206	13
Cases of defective riveting,	1,507	58
Defective heads,	95	21
Serious leakage around tube ends,	1,641	92
Serious leakage at seams,	338	20
Defective water gauges,	293	52
Defective blow-offs,	169	37
Cases of deficiency of water,	9	4
Safety-valves overloaded,	61	35
Safety-valves defective in construction,	53	18
Pressure-gauges defective,	507	30
Boilers without pressure-gauges,	26	26
Unclassified defects,	699	3
Total,	11,115	782

MISCELLANEOUS ACCIDENTS.— The explosion of a gasoline boiler in the Kansas City, Fort Scott & Memphis shops, at Springfield, Mo., on September 1st, caused a fire which destroyed the round-house and ruined five locomotives. The loss is estimated at $55,000.— Charles Grimm, engineer of the new Wheatland flouring mill at Cheyenne, Wyo., was injured so badly by a bursting globe valve, on September 2d, that he died within a few hours. The valve was defective, and burst when the steam pressure came upon it. It was the first day that the mill had been run.— A feed pipe burst, on September 1st, in the Gibraltar warehouse at San Francisco. Samuel Archer and B. McArdle, steam-fitters, were badly scalded, but it is thought that they will both recover.— Eleven persons were killed and many more were injured, on September 10th, by the explosion of a boiler in a brewery at Hoenstaedt, near Olmutz, Austria.— Sixteen persons were killed and several others were injured, on September 27th, by the explosion of a boiler in a sugar factory at Botfalu, Hungary.— The British torpedo boats *Lynx* and *Thrasher* grounded in a heavy fog, on September 29th, off Dodsman bank, near Portsmouth, Eng. A steam pipe bursted on the *Thrasher* after she had grounded, killing three stokers and injuring two others.

The Locomotive.

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Concerning Stay-Bolts.

It is a notorious fact that stay-bolts in water-legs and other similar places are liable to break off without any apparent reason. Sometimes they will last for years, and again they may give way entirely within a month or two. This being the case, it is highly desirable that we should discover the *cause* of the breakage, if possible, so that we may devise some means of preventing it, or, at least, of diminishing it as much as possible.

The usual way of detecting broken stay-bolts, is by sounding them with a hammer. A stay-bolt that is entirely broken off gives a sound quite different from that given by one that is unbroken, and an experienced man will rarely make a mistake in marking the bolts that are broken off. (It is better to make this examination with the boiler

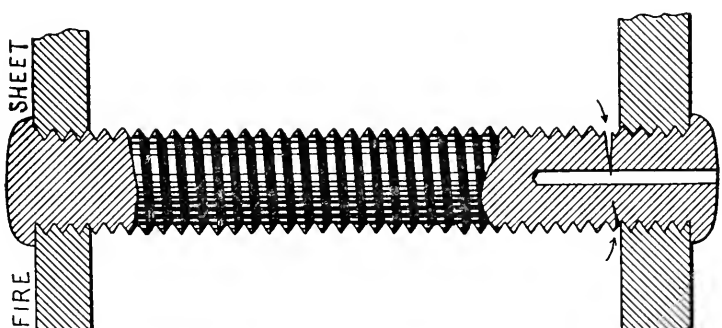

FIG. 1.—A DRILLED STAY-BOLT.

under a slight hydrostatic pressure, so that the broken ends of the bolt may be separated somewhat.) When two inspectors can work upon the same boiler, one of them will often go inside of the furnace and hold a sledge against the inner end of each stay-bolt, while the other one taps the bolt on the outer end. In this way the man inside can tell with great certainty whether the bolt is broken off or not, by the way in which the sledge that he holds responds to the blows. If the bolt is sound, the shock is transmitted to the sledge very plainly; but if it is broken off, the sledge remains passive, and gives little or no response. Still another method, which is often adopted in doubtful cases, consists in the use of the teeth of one of the men, in place of the sledge. In applying this method, the inspector rests one end of a prick-punch or other similar object against the bolt, and brings his front teeth to bear against the free end of the punch. When the stay-bolt is tapped at the other end, this affords a very delicate and certain means of detecting a fracture, if it exists.

These various methods enable skilled men to detect, with almost absolute certainty, all stay-bolts that are broken *entirely off*; but they are all indefinite and unsatisfactory when the bolt is only *partially* broken. A good man will often detect such a partially broken bolt, if the fracture is extensive: but it is evident that there can be no certainty about the test in such cases, and experiment shows, in fact, that the best inspectors cannot detect such partially broken bolts with any precision. This fact is well illustrated in a communication from Mr. T. A. Lawes, presented at the recent meeting of the Railway Master Mechanics' Association, and quoted in the *American Engineer*: "So far as my investigation goes," said Mr. Lawes, "partially broken stay-bolts are never detected by the old methods, and must be regarded with suspicion. For some years hollow stay-bolts and drilled stay-bolts have been used to a limited extent, but for some reason — or no reason — neither one has been put into general use, although, as I believe, the protection afforded is invaluable. To satisfy myself as to an inspector's ability to detect broken and partially broken stay-bolts, I have had the stay-bolts in 13 locomotives drilled during the past year. The plan adopted was to have the inspector locate all the broken stay-bolts he could find, after which the stay-bolts in the fire-box were drilled, including those marked by the inspector as broken. In the first fire-box tested

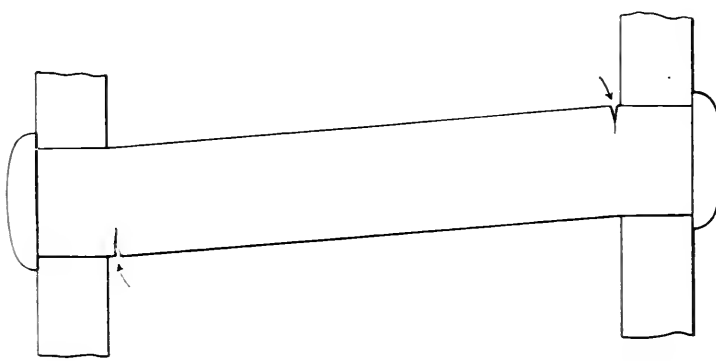

FIG. 2.—ILLUSTRATING THE EFFECT OF THE RELATIVE VERTICAL MOTION OF THE SHEETS.

in this manner the inspector found 39 broken stay-bolts. After drilling and testing under water pressure these were all found to be broken — and in addition to these we found 50 others broken which the inspector was unable to detect by the hammer test. This surprising result led me to examine the broken stay-bolts critically, and I found that those detected by the hammer test were broken entirely off, while the additional ones that were found by drilling holes in the ends were only partially broken off. After testing the stay-bolts in 12 fire-boxes and finding that the ratio of wholly broken stay-bolts to those that were only partially broken ran about the same as in the first fire-box tested, I concluded to try the method of testing under boiler pressure, and having a helper hold on while the inspector gave the hammer test, but with no better results. I desire, now, to direct your attention particularly to the 13th and last fire-box tested for broken and partially broken stay-bolts by the two methods. I consider it the most severe comparative test of all, from the fact that three inspectors in turn did their level best to locate broken and partially broken stay-bolts by the hammer test, after being informed that the stay-bolts were to be drilled when they had completed their examination. They were given all the time they needed, for a careful and accurate inspection.

The result was, that the hammer test located four broken stay-bolts, and the drilling test discovered 46 others that were only partially broken. A careful record of the broken and partially broken bolts detected in 13 engines shows that 440 were discovered by the hammer test, and 619 additional ones by the drilling test. To me these facts constitute conclusive evidence that partially broken stay-bolts cannot be detected by the hammer test, and I believe that great risk is run by not drilling the ends, or using hollow stay-bolts; and I am satisfied that either of these precautions will prevent many boiler explosions where we now hear the verdict, 'Cause of explosion unknown.'"

When we take Mr. Lawes' experiments in connection with the *a priori* probability that partially broken stay-bolts will not be detected by any form of hammer test, we have an amount of evidence which really amounts to a *demonstration* of the inadequacy of the usual methods for detecting stay-bolts that are fractured, but not wholly parted. One of the most striking things about stay-bolt failures is, that the break almost invariably occurs at the *outside* end of the bolt — that is, at the end which is away from the fire-sheet. Occasionally a bolt may give out elsewhere, but the exceptions are so rare that we can hardly doubt that when they do occur they are determined by some accidental flaw in the metal. We mention this peculiarity of stay-bolt failures, because it suggests a cause for such failures, as well as an excellent method of detecting partial fractures, when they do occur. We shall discuss the cause of the trouble presently, but before doing so we wish to refer to the way in which partial breakage may be detected by drilling, as Mr. Lawes has suggested in the passage quoted above. This artifice has been in use for a number of years, though it is by no means generally employed, even at the present day. So far as we remember, it was first tried, about twenty-two years ago, by Mr. Wilson Eddy, who was then Master Mechanic of the Boston & Albany railroad. It consists in drilling a hole, say one-eighth of an inch in diameter, centrally into the end of the stay-bolt, for a distance of about an inch or an inch and a quarter, as indicated in Fig. 1. The stay-bolt is of course weakened to some extent by this proceeding, but the loss of strength is slight. Thus it is easy to show that an eighth-inch hole drilled in this way into a stay-bolt that is $\frac{3}{4}''$ in diameter at the base of the thread diminishes the strength of the bolt by less than 3 per cent. Similarly, a $\frac{3}{16}''$ hole in a stay-bolt that is 1″ in diameter at the base of the thread weakens it only about $3\frac{1}{2}$ per cent. As the stay-bolt almost invariably breaks just inside of the outer sheet, the hole must be drilled into the outer or visible end of the stay-bolt. It will be seen, from Fig. 1, that as soon as a fracture extends inward so as to reach the hole at any point, water will be blown out at the end of the stay-bolt, so that attention will be called to the defect at once.

Coming now to the reasons why stay-bolts break so universally at the outer ends, close up to the sheet, we can only offer a tentative explanation, which may have to be revised in the future, though it appears to agree very well with the facts now known. In the first place, we must admit that there is more or less relative movement between the inner and outer sheets of the furnace or water-leg, due to the variations of temperature to which the two are subjected. That this relative motion does take place is not only evident from the nature of the structure, but it has also been proved, experimentally, that it does occur, and a relative motion of more than a quarter of an inch has sometimes been observed. This relative motion would cause the stay-bolts to "rock" back and forth, somewhat as indicated in Fig. 2. If the sheets are both too thick to "buckle" to any sensible degree, a bending strain would be thrown upon the stay-bolt, which would be most severe at its two ends, as indicated by the arrows. The bolts would therefore be bent backward and forward at these points, every time the furnace sheets moved relatively to each other, and in the course of time, after these bendings had been repeated often enough, we should probably find cracks started at both ends of the bolt. Even if the bending were not severe enough, in itself, to cause these cracks, it would in all probability be sufficient to keep the fibers of the iron constantly opened up to the action of the water, and the iron would be continuously oxidized at these

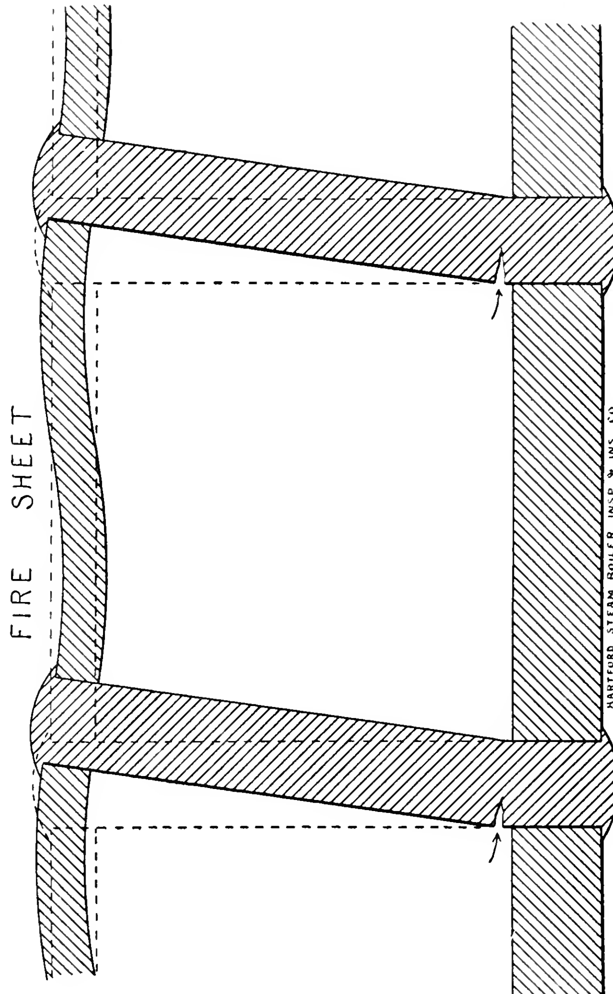

FIG. 3.—SUGGESTING WHY STAY-BOLTS BREAK ONLY AT THE OUTER SHEET.

places, so that the final result would be much the same as though the failure were due directly to the bending strains.

Thus far we have assumed that the two sheets are of equal thickness, and that neither of them is thin enough to "buckle" to any sensible degree. But in actual boiler construction the fire-sheet is almost invariably made considerably thinner than the outside sheet, and we may suppose that the thin, inside sheet *does* "buckle" to some extent, under the varying motions of the furnace, as is suggested, on a greatly exaggerated scale, in Fig. 3. If such a buckling action takes place, the inner ends of the stay-bolts would be thereby relieved of a considerable part of the bending strain that would otherwise come upon them, while the outer ends, being secured to a considerably thicker and stiffer sheet, would be tried just as severely as before. Hence we should expect the failures to occur at the outside ends of the stay-bolts, which is the observed fact.

An objection which is sometimes urged against the form of stay-bolt shown in Fig. 1 is, that although the drilled hole is of no special importance so far as the tensile strength of the bolt is concerned, it does weaken it to some extent, and tends to localize the bending strains at the very point where experience has shown the bolt to be weakest. We do not consider this argument to be of sufficient force to condemn the practice of drilling; for the slightly increased liability of breakage, due to the hole, is far more than counterbalanced by the increased security that the hole affords, against bolts which might otherwise be partially fractured without our knowing it.

Various plans have been proposed for preventing the stay-bolts from bending

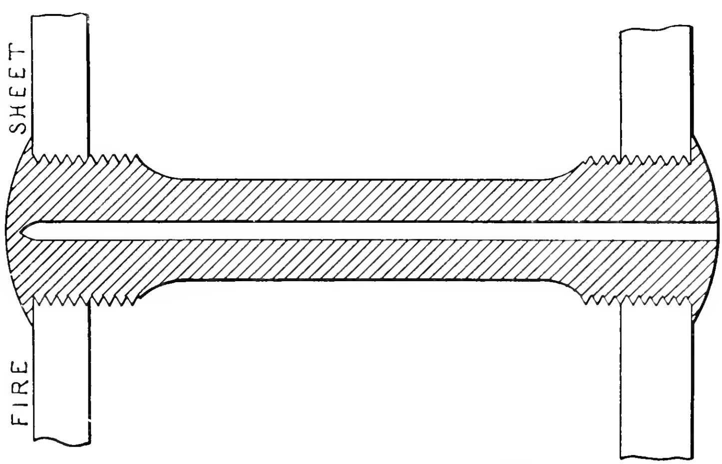

Fig. 4.—Improved Form of Stay-Bolt.

locally near the outside sheet, but most of these involve an initial outlay, in building the boiler, which will probably prevent their general adoption. The form of stay-bolt shown in Fig. 4 meets all the requirements of the case, without being too expensive for practical use. It was recommended by a committee of the Southern and Southwestern Railway Club, in these words: "The committee believes that hollow stay-bolt iron should be used; that the thread should be the U. S. standard, 12 threads per inch; that the inner ends of the holes should not be opened after the stays are headed up, but that the outer ends of the holes should be kept open; that $\frac{7}{8}''$ stays should be turned down, between the sheets, to a scant $\frac{3}{4}$ inch." It will be seen that in this construction there is no *local* weakening of the bolt, due to the hole. Such weakening as there is extends uniformly along the entire length of the bolt. The object of turning down the central portion of the bolt is to make this portion more flexible than the end of the bolt, so that when the bolt is bent by the motion of the sheets, the flexure will be distributed along the entire length of the bolt, instead of being concentrated at the outside end.

We are inclined to believe that better results will be obtained by using larger stock, and turning down the bolt *more*, in proportion to its diameter, than the committee has recommended in the passage cited above. Thus we know of one case in which the stay-bolts of a considerable number of locomotives had given much trouble until they were replaced by others that measured $1\frac{1}{4}''$ over the thread, and were turned down to $\frac{3}{4}''$ in the central part. None of these new bolts have broken, although they have been in use for a considerable time. (In this case neither set of stay-bolts was drilled.)

Inspectors' Report.

SEPTEMBER, 1897.

During this month our inspectors made 9,477 inspection trips, visited 18,282 boilers, inspected 6,710 both internally and externally, and subjected 698 to hydrostatic pressure. The whole number of defects reported reached 10,911, of which 670 were considered dangerous; 56 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	894	31
Cases of incrustation and scale,	2,013	55
Cases of internal grooving,	104	9
Cases of internal corrosion,	603	38
Cases of external corrosion,	634	23
Broken and loose braces and stays,	89	11
Settings defective,	301	25
Furnaces out of shape,	395	15
Fractured plates,	271	42
Burned plates,	238	26
Blistered plates,	151	10
Cases of defective riveting,	1,395	37
Defective heads,	86	23
Serious leakage around tube ends,	1,987	107
Serious leakage at seams,	403	21
Defective water-gauges,	372	59
Defective blow-offs,	163	52
Cases of deficiency of water,	20	6
Safety-valves overloaded,	39	13
Safety-valves defective in construction,	62	19
Pressure-gauges defective,	468	24
Boilers without pressure-gauges,	18	18
Unclassified defects,	205	6
Total,	10,911	670

ACCORDING to *Locomotive Engineering*, several cargoes of coal, mined in China, have recently been sold at a profit in California. "The extremely cheap labor of China enables the coal to be brought to the surface at a very low price. The only obstacle to active Chinese competition in our Californian coal markets, at present, is the want of good transportation facilities in China." The extension of the Chinese railways will provide such facilities, and the Asiatic coal trade will then assume very respectable proportions.

Boiler Explosions.

October, 1897.

(256.)— On October 1st a boiler exploded at M. E. O'Connor's No. 1 oil well, on the Levi Kramer farm, two miles south of Bowling Green, Ohio. Half of the boiler was blown 650 feet in one direction, leveling an oil derrick in its course. The other half was blown to an equal distance in the opposite direction. Six men were at work within fifty feet of the boiler, but none of them was hurt.

(257.)— A boiler exploded on October 2d, at an oil well owned by the Mecca Oil Company, and situated on the William Russell lease, in Big Lick Township, near Findlay, Ohio. S. S. McLaughlin, one of the drillers, was instantly killed, his head being cut off by a section of one of the sheets.

(258.)— By the explosion of a boiler in a feed mill, some twelve miles northeast of Lineville, Iowa, on October 2d, Henry Rouns and James Dyball were so badly injured that they may die. Four other men were also seriously hurt, and the entire building was wrecked.

(259.)— On October 4th a boiler exploded at the little town of Moscow, twelve miles north of Muscatine, Iowa, in a building containing a grist mill and a creamery. W. R. Spears and Frederick Marolf were killed instantly, and William Hunt was fatally injured. J. E. Parker, C. S. Smith, and H. Jacobs were also painfully injured, though they will recover. The building in which the boiler stood was destroyed, and fragments of it were scattered all about, for a distance of 300 yards.

(260.)— A threshing machine boiler exploded on October 6th, on the farm of Curtis Burke, near Chatfield, Minn. We have not received any further reliable information.

(261.)— On October 7th, a boiler exploded in a cider mill at Mt. Erie, near Clay City, Ill., instantly killing George Runyan, the engineer, and slightly injuring several other persons.

(262.)— On the Ohio side of the Sistersville, W. Va., oil field, on Trail Run, the Klondike Oil Company (evidently a new company!) drilled in their Allen No. 1 well on October 10th, and immediately afterwards the boiler used at the well exploded. It was blown to the top of the derrick and entirely demolished. One man was severely bruised, but nobody else was injured.

(263.)— On October 10th, a boiler exploded in the power house at Rockdale, Texas. Antone Strelsky, the fireman, was killed, and Superintendent John Wooldridge was seriously injured. The property loss was about $5,000.

(264.)— The boiler of Mrs. R. C. Hall's cotton gin, six miles south of Irwinton, Ga., exploded on October 11th, while in full operation. Mr. Ira Knight and a son of Mrs. Hall were painfully bruised and scalded.

(265.)— A boiler used for boring a well in Rinaldo County, near Cobb, Ky., exploded on October 14th, seriously injuring W. H. Graham and three of his employes. The property loss was about $1,000.

(266.)— On October 15th the boiler of a threshing machine exploded on the farm of George Hardman, in Tareantorus township, near Marinette, Wis., and about two miles and a half from the Canadian Soo. Both heads of the boiler blew out. David McGill was struck by one of them, and instantly killed. Isaac Jackson was fatally injured, and George Peacock, John Abercrombie, and a man named Simons, were painfully bruised and scalded.

(267.)—A boiler exploded on October 16th, in Nessle's roasting mill, at New Castle, Pa. No person was injured, as there was nobody near the boiler at the time.

(268.)—A boiler exploded, on October 18th, on the Pittsburgh Plate Glass Company's steamer, *George B. Ford*, on the Monongahela river, at Charleroi, Pa. Capt. James Ryan and William Patterson, cook, were instantly killed, and the boat was wrecked. Several of the crew were also painfully injured. Parts of the boiler were found in the woods, more than half a mile away.

(269.)—On October 20th, the boiler of W. H. Moss' threshing machine exploded on Schimmel's farm, near Salem, S. D.

(270.)—The boiler of one of the steam launches of the battleship *Texas* blew up, near Boston, Mass., on October 21st, close beside the battleship. A number of men, including two officers and a surgeon, were injured, but none of them fatally so. The explosion occurred just as the launch reached the side of the ship, after towing down the ship's boats, each full of men who were engaged in the naval parade in honor of the frigate *Constitution*. Thirty-five men were on the launch at the time, and it was marvelous that more of them were not injured or killed. The smokestack and a considerable part of the boiler were blown into the air, and the wrecked launch took fire. The men in the pit with the boiler — John Phillips, an oiler, and John Fisher, a coal passer — were thrown violently against a partition. Fisher was badly injured internally. Phillips escaped with severe bruises. Cockswain Thomas Sullivan was painfully bruised. Dr. Dubose had two front teeth knocked out. Lieut. Delehanty and Ensign Wadhams were bruised and burned about their faces and hands.

(271.)—A boiler exploded, on October 22d, in the Detroit Cabinet Company's works at Detroit, Mich. Laurent Tunney, foreman of the finishing room, and Moses Peltier, the engineer, were fatally injured, and died within a few hours. Herman Demenkowski, Wilbur Krause, John Nonninger, Herman Kreinbring, Carl May, Frank Ehlen, Bernard Trombley, Louis Graumueller, and Joseph Zentarz, were injured. It is thought that Kreinbring may die. The building was considerably damaged, and the property loss was about $10,000.

(272.)—A boiler exploded, on October 22d, in L. M. Plyler's mill, about five miles east of Fisher Station in Poinsett County, near Weiner, Ark. William Plyler (a son of the owner of the mill), J. J. McDonald, James Smith, and William Scroggins were killed, and two other men were injured. The mill was destroyed.

(273.)—One of the boilers in the North Bend mill, in Coos County, near Portland, Ore., exploded on October 22d. Albert Jones was injured, but there were no other personal injuries.

(274.)—On October 25th, a boiler exploded in the Wausau Excelsior works, at Wausau, Wis. Foreman Joseph Brown was slightly injured. The machinery about the place was wrecked, and the walls of the building were shaken so badly that they will have to be torn down and rebuilt. "What caused the explosion," says one of our informants, "is not known; but it is thought that some of the wood used for fuel had been charged with dynamite or some other explosive, by parties who took this means of trying to destroy the company's plant [!]." Here we have the same old idea again. The local authorities, being unacquainted with the tremendous destructive energy of a steam boiler, find it necessary to invent an otherwise baseless dynamite theory, to account for the damage that was, beyond doubt, due to the boiler alone.

(275.)— A boiler belonging to John D. Brough, of Knobnoster, Mo., exploded on October 25th, fatally injuring Aubrey Brough, the owner's son. Young Brough lived only about six hours after the explosion. His body was blown 150 feet, through two board fences.

(276.)— A boiler exploded, on October 26th, on a gravel barge belonging to Bedford, Weikel & Nugent, of Evansville, Ind. Jacob Macer, superintendent of the boat, was killed, and James O'Conner, William Bender, Henry Close, Jacob Beeler, and Charles Jones were injured. The gravel boat was broken in two, and sank in the river where she was anchored.

(277.)— A boiler exploded, on October 26th, in S. F. Dasher's mill, just outside the corporate limits of Fort Valley, Ga. Fragments of the machinery were blown to considerable distances, and the property loss was large. Fortunately, nobody was hurt.

(278.)— A portable boiler belonging to Boyden Brothers, of Susquehanna, Pa., blew up, on October 26th, at Comstock Crossing, Broome County, N. Y. One of the proprietors, Emilius Boyden, was instantly killed. Two other men named Comstock were seriously injured, but will probably recover.

(279.)— A small portable boiler used at the ditches at the pumping station at Austin, Texas, exploded on October 26th. Engineer M. S. Templar was badly bruised and scalded, but it is believed that he will recover.

(280.)— The boiler of an upright donkey engine, in use on the north jetty at Eureka, Cal., exploded on October 28th. Engineer George Wilson was badly scalded about the hands and face, and Harry Gardiner was thrown into the bay. The engine was blown over the pier, and the pile driver that it was operating was wrecked.

(281.)— A boiler exploded, on October 30th, in Texas Valley, near Rome, Ga. Dennis O'Brien, who was the only man near the boiler at the time, was killed. We have not learned further particulars.

"Think deliberately of the house you live in — your body. Make up your mind firmly not to abuse it. Eat nothing that will hurt it. Wear nothing that distorts or pains it. Do not overload it with victuals or drink or work. Give yourself regular and abundant sleep. Keep your body warmly clad. Do not take cold; guard yourself against it. If you feel the first symptoms, give yourself heroic treatment. Get into a fine glow of heat by exercise. This is the only body you will have in this world. Study deeply and diligently the structure of it, the laws that govern it, the pains and penalty that will surely follow a violation of every law of life and health." These words of counsel, which are from the *Medical and Surgical Reporter*, are wise and true; but they are likely to fall on deaf ears. A man who would not pour sand into the works of his watch, will cheerfully treat his own body in an equally careless way.

The Locomotive.

HARTFORD, DECEMBER 15, 1897.

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

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

THE eighteenth volume of THE LOCOMOTIVE is completed with the present issue. The index and title page for the year 1897 will be ready by January 1st, and may be had free of cost, by those who preserve their copies for binding. Bound volumes for the year 1897 will also be ready shortly, and may be had at the usual price of one dollar each.

IT has been the custom of the Hartford Steam Boiler Inspection and Insurance Company, during the past few years, to issue illustrated circulars, from time to time, giving views of the ruin wrought by boiler explosions. The latest circular of this sort, entitled "A Few Recent Boiler Explosions," is now ready for distribution, and copies of it may be had, gratis, upon application at this office, either in person or by mail. It contains photo-engravings illustrating twelve boiler explosions in mills and factories of various kinds, together with the number of persons killed and injured in each case, and the estimated property loss.

History of the Meter.

To France belongs the honor of making the first systematic attempt to break through the customs of antiquity, and to substitute a new metrology for the old. Until the latter part of the eighteenth century there was the same condition of affairs in that country that prevails to day in the United States; and in Méchain and Delambre's *Base du Système mètrique decimal* (Paris, 1806), we read of "le système incohérent de nos mesures," "l'étonnante et scandaleuse diversité de nos mesures," etc. Several ineffectual attempts to reform the French system of weights and measures had been made previous to 1790, but it is from that year that the present "metric system" dates. In May, 1790, M. de Talleyrand proposed to the National Assembly of France that a new system of measures should be devised on strictly scientific principles, and that the units of length and weight in this system should be based on some natural and invariable standard. On the 8th of May the Assembly passed a resolution requesting the king, Louis XVI, to open a correspondence on the subject with the king of England, desiring him to invite the British Parliament to coöperate with the National Assembly of France in fixing the "natural unit" which was to serve as the basis of the proposed system of weights and measures. The work was to be put in the hands of a joint commission of scientific men, half of whom were to be appointed by the French Academy of Sciences, and the other half by the Royal Society of London. In conformity with the resolution, Louis laid the matter before the English king; "but owing to the temper and the public troubles of the times, his overture met with no response. Similar applications to other nations were more successful, and in subsequent proceedings Spain, Italy, the Netherlands, Switzerland, Denmark, and Sweden, participated by sending delegates to an international commission. The system itself was, however, matured by the labors of a committee of the Academy of Sciences, embracing Borda, Lagrange, Laplace, Mongé, and Condorcet, five of the ablest mathematicians of Europe." Lavoisier, though not a member of this committee, contributed largely to its proceedings, and the standards that were afterwards prepared were made under his supervision. Lavoisier, for some reason, has not received the recognition that is due him in this matter, his work being usually credited to Borda.

There were two reasons advanced for basing the new unit of length upon some absolute and invariable quantity in nature. It was said that the selection of an arbitrary unit would violate the most fundamental principle of the proposed reform; for the one distinctive feature of the new system was to be the exclusion of the last vestige of arbitrariness. This argument seems to us to be hardly worth serious consideration, for however satisfactory the unit finally chosen might be, the *selection* of that unit would necessarily be arbitrary, and hence the unit itself would itself be so, in some sense. The other reason advanced for the selection of a natural unit was much more logical. It was urged that a system of weights and measures based on some permanent and invariable natural quantity could be entirely reconstructed, with any desired degree of precision, even though every standard in existence were utterly destroyed.

M. de Talleyrand proposed to adopt, as the fundamental unit of length, the length of a pendulum vibrating seconds in latitude 45°, "ou toute autre latitude qui pourroit être préférée" (or such other latitude as might be preferred). The committee of the Academy of Sciences considered the advisability of adopting the seconds pendulum as the unit of length, but finally rejected it, principally because it involved the conception of *time*. It seemed to them preferable to base the proposed unit on *the length of some object actually existing in nature*: and after much deliberation it was decided to adopt some one of the dimensions of the earth itself. Of the different dimensions proposed, the two that met with the most favor were the equatorial circumference, and the meridian quadrant; and of these two the meridian quadrant was finally selected, because it could be measured with greater accuracy. (The measurement of a *meridian* involves observations of *latitude*, while the measurement of the *equator* involves observations of *longitude;* and before the invention of the electric telegraph, longitude measures were subject to large errors.) In order to guard against possible differences in the lengths of the various meridian quadrants, it was decided to recommend that the new system of measures be based on the particular meridian that passes through Paris. This length (about 6,000 miles) would be entirely out of the question as a practical unit for business purposes. However, a rough calculation showed that a standard having a length equal to one ten-millionth part of this quadrant would be convenient, and the METER (as the new unit was named) was therefore defined to be *the ten-millionth part of the distance from the equator to the north pole, measured along the sea-level, on the meridian passing through Paris.*

The report of the committee, embodying the points explained above and dated March 19, 1791, was approved by the National Assembly, and the work of measuring the meridian passing through Paris was begun. This operation involved immense labor, and seven years were required to complete it. The meridian through Paris strikes the North Sea at Dunkirk, near the Strait of Dover, in latitude 51° 02′ 8.85″, and the

Mediterranean Sea at Montjouy (a small place in the suburbs of Barcelona, Spain), in latitude 41° 21′ 44.96″. The northern half of this arc was measured under the direction of Delambre, and the southern half under Méchain. A brief account of the method of measurement employed, and of the subsequent computations, will be found in the first chapter of Clarke's *Geodesy ;* and the operations and calculations are described in full in Méchain and Delambre's *Base du Système metrique décimale*, to which we have already referred. The unit of length used in measuring the meridian was the *toise*, and the final result of the seven years' work was, that the distance from the Barcelona end of the line to the Dunkirk end was 551,584.7 toises. It will be found from the data given above that the difference in latitude between the two ends was 9° 40′ 23.89″. Now the latitude of the equator is 0°, and the latitude of the pole is 90°; and therefore if the earth were a true sphere the distance from the equator to the pole would be given by the simple proportion 9° 40′ 23.89″ : 90° :: 551,584.7 toises : distance required. The first term of this proportion, when reduced to degrees and decimals of a degree, is 9.6733° ; and if we substitute this value of it, and then solve the proportion by the ordinary rule-of-three we find

Distance from equator to pole = 5,131,922 toises.

In the actual calculation a small allowance had to be made for the fact that the earth is not a perfect sphere (the polar diameter being about 26 miles shorter than the equatorial diameter). It was found that to take this into account it would be necessary to subtract 1,181 toises from the distance as calculated above. Hence, it was concluded that the true distance from the equator to the pole, along the meridian of Paris, is 5,130,741 toises. One ten-millionth part of this is 0.5130741 of a toise, and this, therefore, was to be the length of the new unit, or *meter*.

The next task was to prepare a bar of platinum which should have this length. When this had been done, the length of the bar was verified by the international commission referred to above, and the commission then proceeded in a body to the Palace of the Archives, in Paris, and there they formally deposited the bar of platinum which was to be ever afterward the standard meter of the world. — Extract from a pamphlet entitled *The Metric System*, to be issued shortly by the Hartford Steam Boiler Inspection and Insurance Company.

Smoke Prevention.

One means of obtaining relief from smoke from boiler and other chimneys was, years ago, found in simple forms of apparatus in which the chimney gases were more or less thoroughly washed by sprays of water. These latter were intended to, and in many cases did, remove the particles of soot from the gas currents, and the latter, as they issued from the chimney-tops, were comparatively, if not wholly, free from those characteristics which constitute the smoke nuisance of to-day. The extracted soot was, moreover, not a waste product, but was utilized, in one instance at least, in the manufacture of an excellent quality of ink. At the present time, with smoke suppression as an absorbing topic in many localities, it would seem worth while to practically resurrect some of these old devices a little more frequently than is the case, for in a few places they are in service, in more or less modified and improved shape, and with apparently satisfactory results. The simple theory in the whole matter of smoke always has been that the best way to prevent it is not to make it, and it is along this line that intelligent inventive effort has, of late years, been expended. The fireman, too, as a smoke preventer or a smoke-making nuisance, has attracted attention, and the importance of his function is to-day tolerably well appreciated by most boiler owners. But, after all, there are in every manufacturing district furnaces which owners will not provide, except under compulsion, with possibly expensive smoke-preventing equipment, in the shape of mechanical stokers, for example, however economical in final results, and to these the simple smoke washer, or absorber, did they but know of it, would be an acceptable means of helping to suppress the objectionable chimney discharges.

What has more particularly prompted these lines is the recently published reference to a smoke-absorbing device installed at the boiler station of the South Kensington Museum, at London. Considerable annoyance had been caused there by soot and dust from the boiler-house chimney, and the result was the recent installation of an apparatus invented by Colonel Dulier, from which relief was expected, and will, in all probability, be obtained. With this apparatus the products of combustion, before being permitted to enter the chimney, are taken up one leg of an inverted U-shaped flue, made of galvanized sheet-iron, being assisted in their upward course by a steam jet. The latter assists also in the condensation of the tarry hydrocarbon products and saturates the dust with water vapor. In descending the second leg of the flue, the products of combustion are brought in contact with a large number of upwardly-inclined water sprays, which are intended to thoroughly wash the smoke, moistening all particles of dust. The smoke and water next pass through a chamber containing a helical passage in which they are made to still further commingle, and after all this the gases are allowed to pass into the chimney proper, while the now sulphurous wash water is drained off. The draft in the flue and chimney, measured with a water gauge, is said to have shown no diminution after the erection of the apparatus. Just what the actual results are at South Kensington is not known at the time of writing, but tests with a similar equipment at Glasgow showed in one case a reduction of the soot in the gases from 73½ grains per 100 cubic feet before treatment, to 2 grains after treatment ; and in a second case, from 23.3 to 1.5 grains.— *Cassier's Magazine.*

The Life History of Scientific Ideas.

Scientific ideas are subject to the same general law of evolution which we have expounded as to other ideas in a previous paper ("The Work of Ideas in Human Evolution," *Popular Science Monthly*, August 8, 1885); but being less lasting than other ideas, the study of them is easier. Science does not escape the general laws that regulate the elements of every civilization. These laws, too, are derived from a small number of fundamental ideas variable in different epochs, and which stamp a deep mark on every science. All modern physics rests upon the idea of the indestructibility of energy; biology on the idea of transformation by selection, and pathology on that of the action of the infinitely little. It is a property of scientific ideas that they have a force much less relative than that of religious, political, and moral ideas, but they lack much of being absolute truths; and that is why we see the directing ideas of science usually changing every fifty years. All these ideas are most frequently nothing but provisional hypotheses. The only veracious side of them is that they explain for the given moment the largest number of the facts. Darwin's hypothesis of the evolution of living beings explains more facts than Cuvier's hypothesis of successive creations; and the hypothesis of luminous undulations explains more phenomena than the hypothesis that preceded it.

It does not matter that these great directing ideas are erroneous. If we place ourselves at the point of view simply of the advance of the human mind. it will hardly be a too rash assertion to say that error is infinitely more useful than truth. Absolute truths. or what are considered such. are not discussed any more, and provoke no investigation. Ideas held as hypotheses. on the other hand, provoke much. The researches made for the purpose of defending or attacking the hypothesis of the emission of light and that of undulations begat the finest discoveries of optics. The much-debated hypothesis of evolution has produced more research within a few years past than was made in all the centuries gone before. During the epoch, on the other hand, when what Aristotle and Ptolemy wrote was held for gospel truth, there could be no research; and for several centuries science was contented with traditions, and made no progress. The most fruitful method of investigation is by imagining some hypothesis amd trying to verify it. and by modifying it as new facts come to light. The great advantage of scientific ideas is that their value can be speedily ascertained by experiment, while that of religious. political, and moral ideas is determined very slowly. We should not. however. suppose that they are established and vanish with any extreme rapidity. Their evolution is indeed more rapid than that of other ideas, but it follows the same phases. Its history shows that although they address themselves only to the most enlightened minds. it takes them not less than twenty-five years, and usually much longer, to establish themselves. The clearest of them. the least hypothetical. those most easy to demonstrate. those which would seem least subject to controversy, like the doctrine of the circulation of the blood. have not been accepted in less time. In other respects scientific ideas are established under the influence of the factors we have described as acting with other ideas — affirmation, repetition. contagion, and prestige — and perhaps we may add. since we are dealing with the scientific category. reasoning; but the action of this factor is so weak that we might properly omit it. When it intervenes it is chiefly to refute an accepted idea, not to establish a new one. The new scientific idea is rarely imposed. so far at least as the majority of minds are concerned, by demonstration. It must not be supposed that because a man cultivates science he is released from the yoke of established dogmas. Scientific dogmas are often the most tyrannical of all.

The scientific idea is pre-eminently established by the prestige of the man who imposes it. and rarely in any other way. It might be objected to this assertion that Darwin. who was without title. claim. or authority, had no prestige when he made his investigations. But it would be easy to answer. first. that his example is almost unique; and. second. that Darwin's doctrine was supported in England, as soon as it appeared. by men who had much prestige. I am, moreover. not sure that if Darwin had been born in one of the countries where mental worth is exclusively measured by the number of decorations it wears. the immortal book. the "Origin of Species," would ever have found a reader. The author would soon have been made to understand that not being an academician or professor. he could only make himself ridiculous by taking up questions which had been long treated by the most illustrious specialists. When Charcot introduced to science the phenomena of animal magnetism. which had been described for more than a century by students whose only fault was that they had no prestige, and whose admirable researches had been neglected for that reason by many generations of doctors, shall we suppose that the demonstrations of the professor were what convinced the medical public? Not at all. for the same demonstrations had been repeated thousands of times within a hundred years. The conviction was simply the result of the prestige of the expert, who did nothing but introduce into official science a series of phenomena which were perfectly known before him. After having been established by prestige, the scientific idea goes through the regular course of evolution. It is taken up by apostles who propagate it in a small circle, and it begins to spread. It meets with strong opposition at first, for it strikes forcibly against many ancient and established things. The apostles who have adopted it are excited by this opposition, which only persuades them of their superiority over the rest of men, and they defend it with energy, not, indeed, because it is true — for they generally know nothing about that — but simply because they have adopted it. The new idea is discussed and is accepted in whole by some and rejected in whole by others. Affirmations and negations are exchanged, but very few arguments; the only motives for the reception or rejection of an idea being, for the immense majority of minds, simply those of feeling, in which reasoning has no part. In consequence of these passionate contestations the idea progresses slowly. The young people who become aware of the contest adopt the idea readily, for the single reason that it is contested. To youth, eager to be independent, wholesale opposition to things that are accepted is the most easily accessible form of originality. The idea therefore continues to gain. As it is gradually accepted by official men of science it at length becomes propagated wholly by the mechanism of contagion, and insinuates itself, timidly at first, and then boldly into the classical books. Its triumph is then complete. Like religious dogmas, it becomes a part of the things that are not disputed. We have only to recollect the history of evolution in France (and elsewhere), and how the scandalous heresy has passed into the state of a classic dogma, to observe the successive series of these phases of propagation.

After having prevailed for a considerable length of time, the idea begins to lose its hold and at last dies out. But before an old idea is wholly destroyed it has to go through a series of retrogressive transformations that require many generations for their accomplishment. Before vanishing forever it takes its turn in forming a part of the old hereditary ideas which we qualify as prejudices, but respect nevertheless. The old idea, although it is already nothing but a word, a sound, a mirage, possesses a magical power that still subjects us. At last it dies. After reigning long over a civilization, ideas lose their prestige, fade away, and are extinguished. New discoveries disturb them. Belief in them becomes less general. Men begin to discuss them, and by the mere fact of discussion their death is near. Every great directing idea being generally a fiction, they cannot submit to be discussed except on condition of never being subjected to critical examination. But even when an idea has been violently disturbed the institutions derived from it retain their vitality and are effaced very gradually. When it has completely lost its power, all that is upheld soon falls. It has not yet been given to any people to change their ideas without being at once forced to transform all the elements of their civilization. — Gustave Le Bon, in the *Revue Scientifique*. [Translated for the *Popular Science Monthly*.]

Haulage ropes are generally made of steel wire, but on the continent of Europe the fibre of the aloe has been found an efficient substitute. It is stated that the aloe fibre is stronger and more elastic, but less flexible than Manilla hemp; its chief advantage is that it becomes stronger in damp places. The ropes have to be tarred, but, in spite of this circumstance, the corresponding lengths of rope which would break by virtue of its own weight are 12,000 for aloe and 12,500 for steel. In Belgian mines, haulage by means of aloe ropes is quite common; long lengths are made with decreasing thickness. — *Invention*.

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ARTICLES MARKED WITH A STAR (*) ARE ILLUSTRATED.