HARTFORD STEAM BOILER ★ INSPECTION AND INSURANCE CO. ★

HARTFORD,

CONN.

The Locomotive.

PUBLISHED BY THE

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

NEW SERIES.

Vol. XX.

HARTFORD, CONN.

1899.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XX. HARTFORD, CONN., JANUARY, 1899. No. 1.

On Hooks for Supporting Boilers.

In various parts of the country it is a more or less common practice to suspend boilers over their furnaces by means of hangers that are attached, overhead, to I-beams, or to some equivalent support. The hangers are usually threaded and provided with nuts at their upper ends, where they are secured to the I-beams; but at their lower ends there is more or less diversity in the methods of construction that are in use. By far the commonest mode of attaching the hanger to the boiler, however, is to forge the lower end of the hanger into the form of a hook, which enters an eye, or a loop of wrought-iron or steel, that is riveted to the boiler. This construction is favored, very

FIG. 1. — A FRACTURED BOILER HOOK.

probably, on account of its relative cheapness, as compared with other methods that have been proposed.

We shall not discuss the general subject of the overhead suspension of boilers in the present article, but shall confine our attention to the *hooks* which, as related above, constitute the usual forms for the lower end of the hangers.

The iron from which the hangers are made is almost invariably round, and the hook is formed upon it, in the great majority of cases, by merely bending the lower end of the hanger around into what is conceived to be the proper curve; no attempt being made to give the cross-section of the hook any other form than the circular one that it originally had, nor to increase the diameter of the stock by "upsetting" it at the end, before the hook is formed. It appears to be difficult for boiler-makers and others who may be interested in this matter to get explicit information about the strength of such hooks.

Formulæ are indeed given for designing them, in various books; but a formula is usually regarded by a mechanic either with a feeling akin to terror, or with a certain distrust of his own ability to apply it correctly, owing to the fact that his education and experience have not familiarized him with mathematical modes of expression. Brief tables giving the strengths of hooks that have certain special forms of cross-section may be found here and there, but while these tables constitute a step in the right direction (since they make the results of the formulæ more readily available), they are not of any great service to the boiler-maker who does not wish, if he can avoid it, to go to the expense of forging the hooks up into the special form of section upon which the tables are based, and for which alone they were computed.

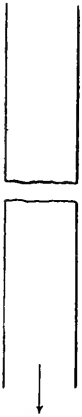


FIG. 2.

When these facts are considered, it is not strange that the hooks that are met with in practice are often smaller than they ought to be. We had occasion, a short time ago, to criticise the size of some of the hanger-hooks that were sent out by a certain boiler-manufacturer, who makes good boilers and means to do the right thing. His reply is before us as we write, and he gives figures intended to justify his hooks, and to show that they are amply strong; but he bases his calculations on the size of the iron of which the hanger is made, and makes no allowance whatever for the weakness in the hook itself, due to its form. As we have said, we are confident that this man means to do the right thing, and that his trouble is, that he does not know how the stresses in a hook are distributed.

When a straight vertical bar is loaded with a load that acts centrally upon it, as indicated by the arrow in Fig. 2, the stress is uniform over the entire cross-section of the bar. There is no *bending* stress whatever, and the tendency of the load is, to break the bar off squarely, as indicated in the cut. In a hook, the case is different. The vertical load has to be supported as before, but in addition to the stress due to the direct vertical action of the load, there is also a *bending* stress, which is greatest at *AB* in Fig. 3, and is due to the fact that the load is not directly under the center of the section *AB*, but off to one side of it. The section *AB* in Fig. 3 is thus exposed to a *compound* stress, part of which is due to the fact that the section *AB* must hold up the load. This portion of the stress is the same, no matter whether the load is directly under the center of *AB*, or away off to one side. The other part of the stress on *AB* is as we have said, a *bending* moment or force, due to the fact that in the actual hook the load does not come under the center of the section *AB*. This bending effect is greater, the further the load is removed from the vertical line through the center of *AB*. It is this bending stress that is overlooked by those who, like the boiler-maker mentioned above, base their estimate of the strength of a hook solely upon the strength of the bar from which the hook is forged. The bending effect, when considered alone, tends to *stretch* the metal of the hook at *A*, and to *compress* it at *B*, just as the load on an ordinary beam tends to stretch the beam at the bottom and to compress it at the top. To obtain the full stress actually existing in the material of the hook, we must combine these bending stresses with the tensile stress due to the direct vertical action of the load. The resultant tensile stress will therefore be greatest at *A*, in Fig. 3, since at this point both of the component stresses are tensions; and the resultant stress will be least at *B*, since at this point one of the component stresses is a tension and the other a compression, so that the two partially neutralize each other. The importance of taking account of the bending stresses in hooks will be evident from the fact (which is easily proved) that these stresses are so great, that at the point *B* (which we may call the "back" of the hook) the stress is *compressive* in all hooks that occur in practice, instead of being tensile, as our aforementioned boiler-making friend took it to be.

The formula for calculating the strength of hooks in general, where the section at AB in Fig. 3 may have any shape whatever, need not be quoted in THE LOCOMOTIVE, as it is too abstruse to be of service to those of our readers who would be likely to find the present article useful. It is given in the first part of Unwin's *Elements of Machine Design*, in the chapter on "Chains and Gearing Chains" (on page 442 of the edition of 1898). When the general formula is applied to the common case in which the cross-section of the hook is everywhere circular, and of the diameter D, it becomes

$$T = \frac{P}{S}\left\{5 + \frac{8l}{D}\right\},$$

where T is the maximum stress in the material of the hook (that is, T is the tension, in pounds per square inch, on the fibers in the vicinity of A in the illustrations); S is the sectional area, in square inches, of a circle whose diameter is D inches; P is the load, in pounds, that the hook supports; and l (see Fig. 5) is the horizontal distance between a vertical line through A, and a vertical line through the point where the load rests upon the hook. (In most cases l will be equal to the inner radius of the hook, as indicated by OA in Fig. 3; but when the hook is not well formed, so that its lower part is too flat, as suggested in Fig. 5, care should be taken to make l in the formula equal to the distance indicated by that letter in Fig. 5.)

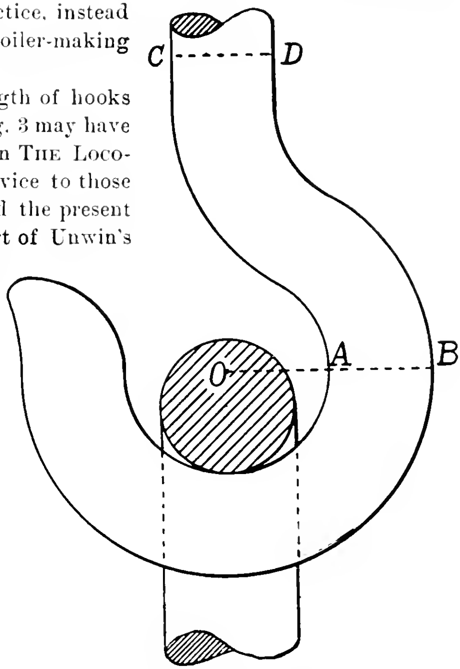


FIG. 3.—COMMON FORM OF HOOK.

As a test of the applicability of this formula to actual practice, let us consider the hook whose lower portion is shown in Fig. 1. This hook was one of a set of four, which supported a boiler weighing 33,000 pounds, when filled with water to the usual height. The hooks were well distributed, so that the load on each may be taken at 8,250 pounds. Two of the hooks broke while the boiler was under steam, and let the boiler fall. Fortunately, it did not explode, but it was considerably damaged where it struck the bridge wall, and also at several other places. The hook broke at the section AB, substantially as suggested in Fig. 4. An examination of the break shows plainly that the fracture started at A, where the stress was greatest, and then extended towards B.

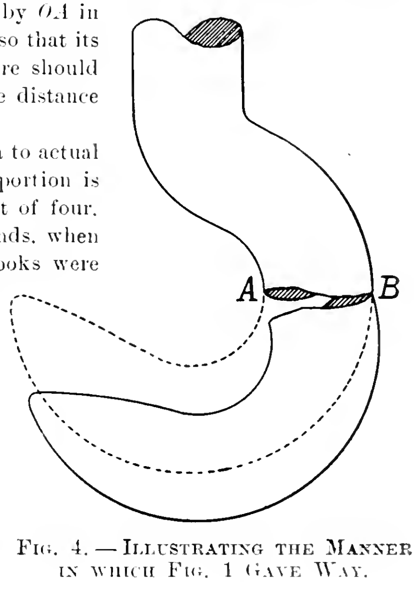


FIG. 4.—ILLUSTRATING THE MANNER IN WHICH FIG. 1 GAVE WAY.

TABLE I. SAFE DEAD LOADS FOR WROUGHT IRON HOOKS OF CIRCULAR CROSS SECTION.

Value of Z. (See Fig. 5.)	Diameter of the Stock (at A B in Fig. 3). 5/8"	3/4"	7/8"	1"	1 1/8"	1 1/4"	1 3/8"	1 1/2"	1 5/8"	1 3/4"
3/8"	470	710	1,070	......	......	......	......	......	......	......
1/2	400	640	940	1,310	1,740	......	......	......	......	......
5/8	350	570	840	1,180	1,580	2,040	2,580	3,180	3,850	......
3/4	310	510	760	1,070	1,440	1,880	2,380	2,950	3,580	4,280
7/8	280	460	690	980	1,330	1,740	2,210	2,740	3,340	4,010
1	260	420	640	910	1,230	1,610	2,060	2,570	3,140	3,770
1 1/8	240	390	590	840	1,150	1,510	1,930	2,410	2,950	3,560
1 1/4	......	360	550	790	1,070	1,420	1,810	2,270	2,790	3,370
1 3/8	......	340	510	740	1,010	1,330	1,710	2,150	2,640	3,190
1 1/2	......	......	480	690	950	1,260	1,620	2,040	2,510	3,040
1 5/8	......	......	450	650	900	1,200	1,540	1,940	2,390	2,900
1 3/4	......	......	......	620	850	1,140	1,476	1,850	2,290	2,780
1 7/8	......	......	......	590	810	1,080	1,400	1,770	2,190	2,660
2	......	......	......	......	780	1,030	1,340	1,690	2,100	2,550
2 1/8	......	......	......	......	740	990	1,280	1,620	2,010	2,450
2 1/4	......	......	......	......	......	950	1,230	1,560	1,940	2,360
2 3/8	......	......	......	......	......	910	1,180	1,500	1,860	2,280
2 1/2	......	......	......	......	......	......	1,140	1,450	1,800	2,200
2 5/8	......	......	......	......	......	......	1,100	1,390	1,740	2,120
2 3/4	......	......	......	......	......	......	......	1,350	1,680	2,050
2 7/8	......	......	......	......	......	......	......	1,310	1,620	1,990
3	......	......	......	......	......	......	......	......	1,570	1,930

TABLE I. — (*Continued.*) — SAFE DEAD LOADS FOR WROUGHT IRON HOOKS OF CIRCULAR CROSS SECTION.

Value of l. (See Fig. 5.)	Diameter of the Stock (at A B in Fig. 3).									
	1⅞″	2″	2⅛″	2¼″	2⅜	2½	2⅝″	2¾″	2⅞″	3
¾″	5,050	5,890	6,800	......	......	......	......	......	......	......
⅞	4,740	5,540	6,410	7,350	......	......	......	......	......	......
1	4,470	5,240	6,070	6,970	7,940	......	......	......	......	......
1⅛	4,230	4,960	5,760	6,640	7,560	8,560	......	......	......	......
1¼	4,010	4,710	5,480	6,310	7,220	8,180	9,220	......	......	......
1⅜	3,810	4,490	5,230	6,030	6,900	7,830	8,830	9,900	11,030	12,230
1½	3,630	4,280	5,000	5,770	6,610	7,510	8,480	9,510	10,610	11,780
1⅝	3,470	4,100	4,790	5,530	6,350	7,220	8,160	9,160	10,230	11,360
1¾	3,320	3,930	4,590	5,320	6,100	6,940	7,860	8,830	9,870	10,970
1⅞	3,190	3,770	4,410	5,110	5,870	6,690	7,580	8,520	9,530	10,600
2	3,060	3,620	4,250	4,930	5,660	6,460	7,320	8,240	9,220	10,260
2⅛	2,940	3,490	4,090	4,750	5,470	6,240	7,070	7,970	8,920	9,940
2¼	2,840	3,370	3,950	4,590	5,280	6,030	6,840	7,720	8,650	9,640
2⅜	2,740	3,250	3,820	4,440	5,110	5,840	6,630	7,480	8,390	9,360
2½	2,640	3,140	3,690	4,300	4,950	5,660	6,430	7,260	8,140	9,090
2⅝	2,560	3,040	3,580	4,160	4,800	5,490	6,240	7,050	7,910	8,840
2¾	2,470	2,940	3,470	4,040	4,660	5,340	6,060	6,850	7,700	8,600
2⅞	2,400	2,860	3,360	3,920	4,530	5,190	5,900	6,670	7,490	8,370
3	2,330	2,770	3,270	3,810	4,400	5,040	5,740	6,490	7,300	8,160

The diameter of the hook at AB was $1\frac{1}{2}''$, and the distance l was sensibly equal to the inner radius of the hook, which was approximately 1". The area of a circle whose diameter is $1\frac{1}{2}''$ is 1.77 sq. in. (See the table in THE LOCOMOTIVE for July, 1898.) Hence our data for use in the foregoing formula are as follows: $D = 1.5$, $l = 1.0$, $S = 1.77$, and $P = 8,250$. Hence the stress T, at the point A, in pounds per square inch, was

$$T = \frac{8,250}{1.77} \times \left(5 - \frac{8 \times 1}{1.5}\right) = \frac{8,250}{1.77} \times \frac{15.5}{1.5} = 48,100 \text{ lbs. per sq. in.},$$

which was undoubtedly close to the actual tensile strength of the iron.

If we wish to use the formula given above for the purpose of computing the load that a given hook can safely support, we may throw it into the form

$$P = \frac{T\,S\,D}{5\,D - 8\,l}$$

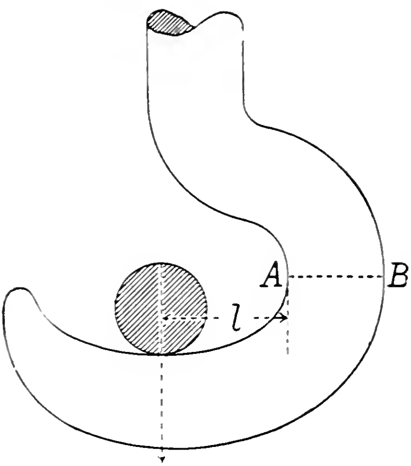


FIG. 5. — A BADLY-FORMED HOOK.

where T is now the working stress that the material can safely bear, per square inch of sectional area.

The value to be assigned to T, in calculating the strength of a hook, will depend upon the use to which the hook is to be put. Where, as in the case we are considering, the load consists in the weight of a boiler and its contents, we may safely treat the load as "dead" — that is, not subject to material alterations of magnitude or direction. For loads of this kind, Unwin gives $T = 15,000$ lbs. per square inch, as the safe limit of working stress upon wrought-iron bars and forgings. With this value as a basis we have computed Table I, which, (assuming the correctness of the formula), gives the limiting value of the dead load that can be safely supported by wrought-iron hooks of circular cross section, and of the proportions indicated in the table.

We are aware that the loads allowed by this table for the various hooks that are there given, are smaller than those that are usually allowed in practice. The loads in the table, however, are in accordance with the general formula that is given for hooks in the standard treatises on applied mechanics and machine design, and the prevalent practice of loading such hooks more heavily must mean, therefore, that it is common to allow a working stress greater than the 15,000 pounds that we have assumed above. If it is desired to limit the maximum stress to this figure, the hooks should be made (if circular in cross section) of the diameters indicated in the table. Thus if a boiler weighing 36,000 pounds is to be supported by four hooks each holding one-quarter of the total weight, each hook will be subjected to a load of 9,000 pounds; and if the design of the hook is such that l, in Fig. 5 is (say) $\frac{1}{2}''$, then the diameter of the hook, at AB in Fig. 3, should be $2\frac{3}{4}''$, if the cross section of the hook is to be circular. To avoid the use of stock of this large size, the hanger may be made smaller, with its lower end upset so as to give a hook of the desired diameter.

One reason that so much stock is called for in the hooks that we have thus far considered is, that the circle is a poor form for the cross-section of the hook, if it is desired to combine strength with economy of material. A better form for the weak section AB,

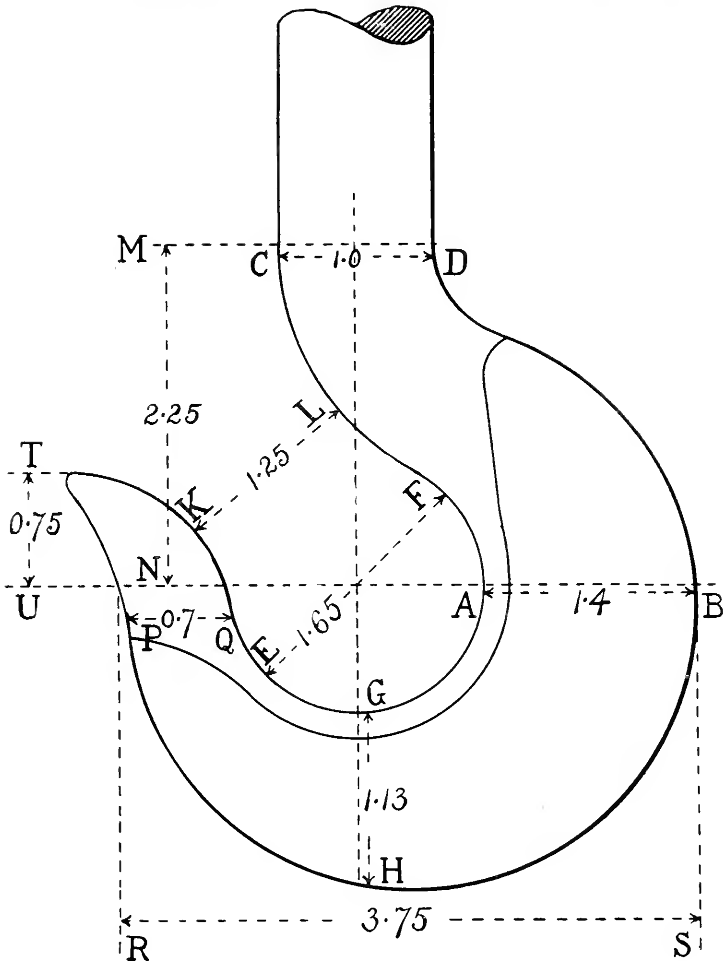


Fig. 6.—Mr. Towne's Form of Hook.

is the one recommended by Mr. Towne in connection with crane hooks, and given by Unwin. The general form of hook that Mr. Towne finds best for this purpose is shown in Fig. 6, where the various dimensions are indicated on the assumption that the hanger bar is one inch in diameter. For other diameters of stock, the various dimensions will all be proportional to those given in the engraving, so that when $CD = 2''$, we shall have $AB = 2.8''$, $GH = 2.26''$, $PQ = 1.4''$, and so on. The shape of cross-section recommended for AB is shown, on a scale twice as great as that of Fig. 6, in Fig. 7, where the letters A and B correspond to A and B in Fig. 6, so that the widest part of the section is directed towards the inside of the hook. The dimensions 0.875 and 0.25 are on the same scale as those in Fig. 6,—that is, in a hook in which $CD = 1''$ the greatest thickness of the hook, at A, is 0.875'', and the least thickness, at B, is 0.25 . To facilitate the construction of hooks of this form, we give, in Table II, the various dimensions

TABLE II. DIMENSIONS AND SAFE DEAD LOAD FOR MR. TOWNE'S FORM OF HOOK (See Figs. 6 and 7).

Diameter of Stock (CD in Fig. 6).	Magnitudes of the Respective Dimensions in Fig. 6, in Inches.								Cross Section at AB.		Safe limit of Dead load on Hook. (Pounds.)
	AB	GH	PQ	EF	KL	RS	MN	TU	Thickness at A. (Figs. 6 and 7)	Thickness at B. (Figs. 6 and 7)	
5/8″	7/8	11/16″	7/16	1″	3/4″	2 3/8″	1 3/8	1/2	9/16	1/8″	590
3/4	1 1/16	7/8	1/2	1 1/4	15/16	2 13/16	1 11/16	9/16	5/8	3/16	830
7/8	1 1/4	1	5/8	1 7/16	1 1/8	3 1/4	2	5/8	3/4	1/4	1,200
1	1 3/8	1 1/8	11/16	1 11/16	1 1/4	3 3/4	2 1/4	3/4	7/8	1/4	1,480
1 1/8	1 9/16	1 1/4	13/16	1 7/8	1 3/8	4 1/4	2 1/2	7/8	1	1/4	1,870
1 1/4	1 3/4	1 7/16	7/8	2 1/16	1 9/16	4 11/16	2 13/16	15/16	1 1/8	5/16	2,420
1 3/8	1 15/16	1 9/16	15/16	2 1/4	1 3/4	5 1/8	3 1/8	1	1 3/16	5/16	2,820
1 1/2	2 1/8	1 11/16	1 1/16	2 1/2	1 7/8	5 5/8	3 3/8	1 1/8	1 5/16	3/8	3,450
1 5/8	2 1/4	1 13/16	1 1/8	2 11/16	2	6 1/8	3 5/8	1 1/4	1 7/16	3/8	3,910
1 3/4	2 7/16	2	1 1/4	2 7/8	2 3/16	6 9/16	3 15/16	1 5/16	1 1/2	7/16	4,720
1 7/8	2 5/8	2 1/8	1 5/16	3 1/8	2 3/8	7	4 1/4	1 3/8	1 5/8	1/2	5,370
2	2 13/16	2 1/4	1 3/8	3 5/16	2 1/2	7 1/2	4 1/2	1 1/2	1 3/4	1/2	6,080
2 1/8	3	2 3/8	1 1/2	3 1/2	2 5/8	8	4 3/4	1 5/8	1 7/8	1/2	6,900
2 1/4	3 1/8	2 9/16	1 9/16	3 11/16	2 13/16	8 7/16	5 1/16	1 11/16	2	9/16	7,700
2 3/8	3 5/16	2 11/16	1 11/16	3 15/16	3	8 7/8	5 3/8	1 3/4	2 1/16	5/8	8,490
2 1/2	3 1/2	2 13/16	1 3/4	4 1/8	3 1/8	9 3/8	5 5/8	1 7/8	2 3/16	5/8	9,460
2 5/8	3 11/16	2 15/16	1 13/16	4 5/16	3 1/4	9 7/8	5 7/8	2	2 5/16	5/8	10,500
2 3/4	3 7/8	3 1/8	1 15/16	4 9/16	3 7/16	10 5/16	6 3/16	2 3/16	2 3/8	11/16	11,400
2 7/8	4	3 1/4	2	4 3/4	3 5/8	10 3/4	6 1/2	2 1/8	2 1/2	3/4	12,400
3	4 3/16	3 3/8	2 1/8	4 15/16	3 3/4	11 1/4	6 3/4	2 1/4	2 5/8	3/4	13,600

of hooks of different sizes, based on the proportions indicated in Figs. 6 and 7, to the nearest sixteenth of an inch, together with the safe working load for each size of hook, based on the same estimate as before, of the limit of safe working stress in wrought-iron forgings subjected to a dead load — that is, on 15,000 pounds per square inch of cross-section.

As we have already intimated, we are well aware that in boiler practice, hooks are often loaded more heavily than these tables would indicate. Every now and then some of these hooks break and let their boilers fall, with results more or less serious, according to circumstances; yet it cannot be denied that at times wrought-iron hooks will sustain, for years, dead loads that the usual formulæ of mechanics would indicate to be far beyond their safe sustaining limit. The one oracle that must speak for us in such matters is *experience*: and when, as in this case, the principles of mechanics appear to be at variance with experience, we may rest assured that the formulæ that we have used are incorrect or incomplete in some particular. There can be no serious disagreement between practice and *good* theory; and every time such disagreement appears to exist, the trouble is, that the theory needs improvement. In the present article we cannot discuss the hook formulæ upon which our tables are based, but the subject is of such interest that we hope to return to it in the near future.

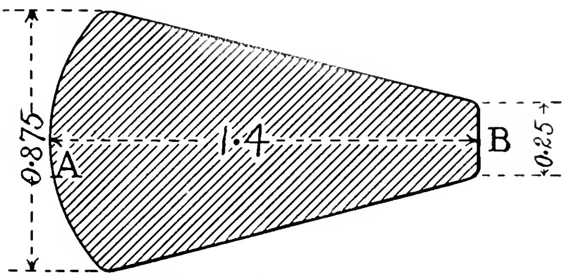


FIG. 7. — SECTION OF MR. TOWNE'S HOOK (AT *AB* IN FIG. 6).

WE have received a copy of Mr. F. W. Shillitto's *Hand-Book of Corliss Steam Engines*, published by the American Industrial Publishing Company of Bridgeport, Conn. It contains about 200 pages, and gives what appears to be a very good account of the erection of Corliss engines and of the adjustment of Corliss valves. It also gives descriptions of nearly a dozen different types of what Professor Sweet (we think it was he) once called the "hyphen-Corliss" engine; that is, engines which are designed along the general lines indicated by Corliss, but built by other firms. Mr. Shillitto's book is well illustrated and clearly printed; and its author is a working engineer of Meriden, Conn. (Published in three styles of binding: ordinary cloth, $1.00; cloth, pocket-book form, red edge, $1.50; leather, pocket-book form, gilt edge, $2.00.)

THE "*Practical Engineer*" *Pocket-Book*, for 1899, has been received at this office from the publishers, The Technical Publishing Company, Limited, of Manchester, England. This little book is very well and favorably known in England, and although it represents English practice rather than our own, yet it contains a great deal of useful matter, and should be known in this country more widely than it is. It is, perhaps, not quite up to our standard in the clearness of its typography; but, as it contains 400 pages and sells for seventy-five cents, perfection in this respect could hardly be looked for. The agents for the United States are The D. Van Nostrand Company, 23 Murray street, New York City.

The Locomotive.

HARTFORD, JANUARY 15, 1899.

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

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

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

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

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

The Story of an Old Boiler.

The general opinion of the public, when a boiler explodes, is, that unless the engineer allowed the water to run low, the cause of the explosion is a mystery. Whether the boiler was strong enough to hold the pressure, appears to be a point to which no particular importance is attached. The truth of the matter is, as nearly as we can discern it, that it is a mystery why *more* boilers do not explode. For example, here is the story of a boiler which *ought* to have exploded long ago, according to all reasonable lines of argument and methods of prognosis; yet it is still running, after nearly half a century of service, the total outlay for repairs during all that time being, as will be seen, one old-fashioned copper cent.

About 1853, Mr. Chauncey Pease, of Cooperstown, N. Y., had a steam boiler built in New York city, by a builder whose name is long forgotten. It is a horizontal tubular, with a dome, and is rated at 15-horse power. It is nine feet long and 36 inches in diameter, with 37 two-inch tubes. It is made of iron, in three courses, and single-riveted, with the rivets pitched two inches from center to center. There is no glass water-gauge on it, but there are three try-cocks. When it was to be installed, it was sent by rail to Fort Plain, N. Y., and transported thence by teams over the country to Cooperstown (a distance of perhaps 30 miles), where it was in use two years by Mr. Pease. It was then sold to Messrs. Barnes & Fox, who moved it by team to the town of Maryland, on the Delaware & Hudson Railroad, some 15 or 20 miles from Cooperstown, and used it for ten years in a sash and blind factory. At the end of this time Mr. F. M. Fox, the present owner, bought the factory, and moved the boiler a few miles to Colliersville, where for thirty-three years more it has done service in his sash and blind factory, and is still in daily use. Thirty years ago it leaked slightly, where the dome was riveted to the boiler. The hole was hardly large enough to insert a fine knitting-needle, and Mr. Fox enlarged it to a diameter of one-eighth of an inch, and plugged it with a copper rivet made from an old-fashioned copper cent. With this exception, no repairs have ever been made on the shell or tubes of the boiler. The fuel with which the boiler has been fired has been the waste of the mill, with a little coal when there was not waste enough for that purpose. The safety-valve has been kept set at 80 pounds, but the actual pressure used in all these years has been (and is still) 60 pounds. No one has been inside the boiler, except on one occasion, some eighteen years ago. It is cleaned out as well as it can be without getting into the boiler every three weeks, the tubes being cleaned oftener. There has never been a regular engineer car-ing for the boiler; it has had all its attention from the proprietors and the men about the mill. The first engine used with it was of ten horse-power, but a change was made thirty years ago and a thirty-five horse power engine substituted, running at 60 strokes to the minute, under 60 pounds of steam. After a time Mr. Fox modified the engine so as to make it run at 90 strokes to the minute under 60 pounds of steam, and it is now working at this speed under the personal supervision of Mr. F. M. Fox, who is hale and hearty at nearly seventy years of age.

We have given this history at some length, in order to show what boilers will do,—*sometimes*. We might, on the other hand, relate instances in which men were killed and maimed, and thousands upon thousands of dollars' worth of property was destroyed, by boilers only two or three months' old, and which were supposed to be in perfect condition. It is the old story, so aptly expressed in Professor Sweet's article on "The Unexpected which Often Happens," quoted in THE LOCOMOTIVE for April, 1898. "The unexpected comes upon us," he says, "both by things not working when we think they ought, and by their working when common reasoning would indicate that they ought not." So it is with boiler explosions; for they do *not* always occur when we think they ought to, and they often *do* occur when common reasoning would indicate that they ought not. A man may smoke a T. D. pipe in a powder mill for a long term of years without his subsequent experiences being worthy of special mention; but it isn't a good plan to do that way. Neither is it a good plan to neglect your boiler because some other man has succeeded in running one on that basis for half a century or so. Reason is against it; and reason was given to man to guide him, and not to be shoved aside on a shelf.

Running a Straw-Burner.

The delights of close communion with a straw-burning threshing-machine are well exemplified by the experiences of John Cowan, who came back a couple of days ago, after an exciting season with a threshing outfit. Cowan used to hold a commission in the Canadian mounted police, having served in E troop under Col. French. He hammered his way through the Riel rebellion and half a dozen minor affairs in which the police were concerned, but he wishes it made plain that there never was any police duty half as risky as running a straw-burner. "You see," said the big ex-cavalryman, "thresher operators don't want the expense of certificated engineers to run old straw-burning threshers, so it has come to be the accepted belief that any man with a pair of hands and lots of nerve can run a steamer. I was up in the Park river country looking for a job, when a thresherman came to me and wanted to know if I could run a straw-burner. Having read something of the vagaries of this particular breed, I considered discretion the better part of valor and told the man I couldn't.

"'Well,' he said, 'it's dead easy; any fellow can run one if he's just got horse sense. Of course, if you fall asleep she's liable to burst, but otherwise, all ye've got to do is to poke straw into the box and blow her off once in a while, when she gets too gay. Want to try it?'

"Now, under some circumstances, I don't believe I should have tackled that job, but the $4 a day sounded tempting, and, moreover, I wanted something under my belt. It was night when the old man engaged me, so, of course, the first thing on the bill was supper, a fact that didn't displease me at all. Then the boss wanted to show me how a straw-burner ought to be run, and we went down to the setting by moonlight.

Even then I could see that the particular straw-burner I was fated to operate had been in service fifteen years or so. She was one mass of scaling rust from end to end, and a more melancholy looking kettle I never clapped eyes on.

"'Ain't she a dandy?' said the old man. Upon my word he believed it, too. He got to telling me how much better the old-time machines used to be than these new-fangled affairs full of crooked pipes. The more I looked at the old rattletrap the less I liked my job, and when we turned in half an hour later, I had strong misgivings as to what would happen in the morning.

"About two hours before dawn they were hustling about, down below stairs, and the old 'un was yelling at the top of his voice, 'Time to fire up — time to fire up.' I went down and built a roaring straw fire under that boiler, filled the tank with water, and sort of familiarized myself with the various handles and stop-cocks. After a little experimenting I found out which handle to turn when I wanted to blow off steam, and, as that seemed the most important thing to know, I went to breakfast. Half an hour later everything was set. The feeder was at his post, there were three fellows in the straw-stack, the oiler was chasing himself around the separator like a flea in a fit, and the sacker was holding a bag all ready for business.

"'Let 'er go,' says the old man, and I let her go. For the first couple of minutes I thought the old girl was going to rattle herself into scrap iron right there on the spot, but after the straw began to take hold, she steadied down and I began to congratulate myself after two hours' work, that everything would be all right. I had been punching straw into the firebox at a terrific rate, and that kept me so busy that I hadn't time to think of anything else, and there was so much noise, what with the engine and the cylinder, that a man couldn't hear himself think, anyhow.

"All of a sudden I saw the old 'un waving his arms and shouting, 'water, water,' at the top of his lungs. At that instant it dawned on me that the old machine had to have water as well as straw. The crew were acting queerly. The whole outfit had left the separator and were spread out all over a quarter section watching me. I concluded the first thing to do was to let off steam, seeing that my water had run so low, but I guess it was too late for that. Just as I got my hand on the little dingus that lets steam out, off she went. I can't tell which end of her went out first, but I do know that I was blown clean into the top of the strawstack. I found out afterwards that the crew had searched all over for me, and being unable to find any trace, concluded that I had gone to a better land all standing. Of course, there was no more threshing that day, and hours afterwards I emerged from that strawstack just in time for dinner. There wasn't a scratch on me, but I wouldn't take the same chances again for any man's money." — *Minneapolis Journal.*

[The substantial accuracy of this account is vouched for by the gentleman who forwarded it to us. — EDITOR.]

MORE LIVES THAN A CAT? — Frank Sinkule, of the Superior Mills, Ypsilanti, Mich., apparently has a charmed life. He has been through six bad accidents, all at the Superior Mills. Among his various injuries he counts a severed temporal artery, two broken ribs, severe burns and scalds, and a compound fracture of the leg. He has been buried under four feet of brick and mortar by a boiler explosion, and once had a calender weighing three tons fall on him, crushing him into a fourteen-inch space. — *Detroit Journal.*

Kipling in the Engine Room of a British War-Ship.

NO. 2 WELSH COAL.

"Isn't it scandalous? Isn't it perfectly damnable?" said an officer after we had got under way, pointing to the foul, greasy columns of smoke that poured from every funnel. "Her Majesty's Channel Squadron, if you please, under steam, burning horse-dung."

Truthfully, it was a sickening sight. We could have been seen thirty miles off, a curtain of cloud, spangled and speckled with bits of burning rubbish and lumps of muck. The first lieutenant looked at the beach of clinkers piling up on his hammock nettings and blessed the principality of Wales. The chief engineer merely said, "You never know your luck in the navy," put on his most ancient kit, and was no more seen in the likeness of a Christian man. Fate had hit him hard, for, just as his fires were at their pink of perfection, a battle-ship chose to get up her anchor by hand, delaying us an hour and blackening the well-cherished furnaces. "No. 2 Welsh" (this must have been an Admiralty jest) needs a lot of coaxing.

CHIMNEY SWEEPS ON THE HIGH SEAS.

But we were not quite such an exhibition as the *Arrogant*. She showed like a chemical works in full blast as we swept out of Bantry and headed south for the Scillies. Then up came the *Blake*, a beautiful ship, giving easily to the swell that was lifting us already, and she dodged about left and right till we asked: "What are you trying to do?"

"Trying to get out of your smoke," said she, vomiting cascades of her own the while. Meantime the fleet rams were doing their best to blind and poison us, and the battle-ships sagged away to leeward looking like wet ricks ablaze. It was not the ignominy of the thing — the mere dirt and filth — that annoyed one so much as the thought that there was no power, in the state which owes its existence to the navy, whereby a decent supply of state-owned, state-dug coal could be assured to us. There had been a strike, and while masters and men were argle-bargling ashore, Her Majesty's ships were masquerading in the guise of chimney-sweeps on the high seas. The delay, the disorder, the cruel extra work on stokers, not to mention the engineers, who at all times are worked pitilessly, is, in peace, no more than merely brutal. In war it would be dangerous.

FOUR HOURS AT FULL SPEED.

As if that were not enough, the swell that the battle-ships recorded in their logs as "light" (Heaven forgive them!) began to heave our starboard screw out of the water. We raced and we raced and we raced, dizzily, thunderously, paralytically, hysterically, vibrating all down one side. It was, of course, in our four hours of full speed that the sea most delighted to lift us up on one finger and watch us kick. From 6 to 10 P. M. one screw twizzled for the most part in the circumambient ether, and the chief engineer — with coal-dust and oil driven under his skin — volunteered the information that life in his department was gay. He would have left a white mark on the assistant engineer, whose work lay in the stokehold among a gang of new Irish stokers. Never but once have I been down in our engine-room; and I do not wish to go again till I can take with me their designer for four hours at full speed. The place is a little cramped and close, as you might say. A steel guard, designed to protect men from a certain toothed wheel round the shaft, shore through its bolts and sat down, very much as a mudguard sits down on a bicycle wheel. But the wheel it sat on was also of steel, spinning 190 revolutions per minute. So there were fireworks, beautiful but embarrassing, of incandescent steel sparks, surrounding the assistant engineer as with an aurora borealis. They turned the hose on the display, and at last knocked the guard sideways, and it fell down somewhere under the shaft, so that they were at liberty to devote their attention to the starboard thrust-block, which was a trifle loose. Indeed, they had been trying to wedge the latter when the fireworks began — all up their backs. The thing that consoled them was the thought that they had not slowed down one single turn.

THE NAVAL ENGINEER.

"She's a giddy little thing," said the chief engineer. "Come down and have a look."

I declined in suitable language. Some day, when I know more, I will write about the engine-rooms and stokers' accommodations — the manners and customs of naval engineers and their artifices. They are an amazing breed, these quiet, rather pale men, in whose hands lie the strength and power of the ship.

"Just think what they've got to stand up to," says Twenty-one, with the beautiful justice of youth. "Of course they're trained at Keyham and all that, but fancy doing your work with an eight-inch steam-pipe in the nape of your neck, an' a dynamo buzzin' up your back, an' the whole blessed shoot whizzin' round in the pit of your stomach! Then we jump about an' curse if they don't give us enough steam. I swear, I think there're no end good men in the engine-room!"

If you doubt this, descend by the slippery steel ladders into the bluish copper-smelling haze of hurrying mechanism, all crowded under the protective deck; crawl along the greasy foot-plates, and stand your back against the lengthwise bulkhead that separates the desperately whirling twin engines. Wait under the low-browed supporting columns till the roar and the quiver has soaked into every nerve of you; till your knees loosen and your heart begins to pump. Feel the floors lift below you to the jar and batter of the defrauded propeller as it draws out of its element. Try now to read the dizzying gauge-needles or find a meaning in the rumbled signals from the bridge. Creep into the stokehold — a boiler blistering either ear as you stoop — and taste what tinned air is like for a while. Face the intolerable white glare of the opened furnace doors; get into a bunker and see how they pass coal along and up and down; stand for five minutes with slice and "devil" to such labor as the stoker endures for four hours.

HIS HOURLY RISK.

The gentleman with the little velvet slip between the gold rings on his sleeve does his unnoticed work among these things. If anything goes wrong, if he overlooks a subordinate's error, he will not be wigged by the Admiral, in God's open air. The bill will be presented to him down here, under the two-inch steel deck, by the power he has failed to control. He will be peeled, flayed, blinded, or boiled. That is his hourly risk. His duty ships him from one ship to another, to good, smooth, and accessible engines, to vicious ones with a long record of deviltry, to lying engines that cannot do their work, to impostors with mysterious heart-breaking weaknesses, to new and untried gear fresh from the contractor's hands, to boilers that will not make steam, to reducing valves that will not reduce, and auxiliary engines for distilling or lighting, that often give more trouble than the main concern. He must shift his methods for each, and project himself into the soul of each; humoring, adjusting, bullying, coaxing, refraining, risking, and daring as need arises. Behind him is his own honor and reputation — the honor of his ship and her imperious demands; for there is no excuse in the navy. If he fails in any one particular, he severs just one nerve of the ship's life. If he fails in all, the ship dies — a prisoner to the set of the sea — a gift to the nearest enemy. And, as I have seen him, he is infinitely patient, resourceful, and unhurried. However it might have been in the old days, when men clung obstinately to sticks and strings and cloths, the newer generation, bred to pole-masts, know that he is the king pin of their system. Our assistant engineer had been with the engines from the beginning, and one night he told me their story, utterly unconscious that there was anything out of the way in the noble little tale.

NO END GOOD MEN.

It was his business so to arrange that no single demand from the bridge should go unfulfilled for more than five seconds. To that ideal he toiled unsparingly with his chief — a black sweating demon in his working hours, and a quiet student of professional papers in his scanty leisure.

"An' they come into the ward-room," says Twenty-one, "and you know they have been having a young hell of a time down below, but they never growl at us or get stuffy or anything. No end good men, I swear they are."

"Thank you, Twenty-one," I said. "I'll let that stand for the whole navy if you don't mind." — RUDYARD KIPLING in the *New York World*.

Inspectors' Report.

AUGUST, 1898.

During this month our inspectors made 8,324 inspection trips, visited 15,982 boilers, inspected 6,413 both internally and externally, and subjected 886 to hydrostatic pressure. The whole number of defects reported reached 12,059, of which 1,114 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,	927	47
Cases of incrustation and scale,	2,072	75
Cases of internal grooving,	88	7
Cases of internal corrosion,	682	25
Cases of external corrosion,	582	39
Broken and loose braces and stays,	110	35
Settings defective,	311	35
Furnaces out of shape,	352	16
Fractured plates,	234	39
Burned plates,	251	21
Blistered plates,	130	6
Cases of defective riveting,	2,321	18
Defective heads,	100	35
Serious leakage around tube ends,	1,823	426
Serious leakage at seams,	317	26
Defective water-gauges,	201	46
Defective blow-offs,	153	55
Cases of deficiency of water,	6	3
Safety-valves overloaded,	55	25
Safety-valves defective in construction,	134	29
Pressure-gauges defective,	342	24
Boilers without pressure-gauges,	82	82
Unclassified defects,	786	0
Total,	12,059	1,114

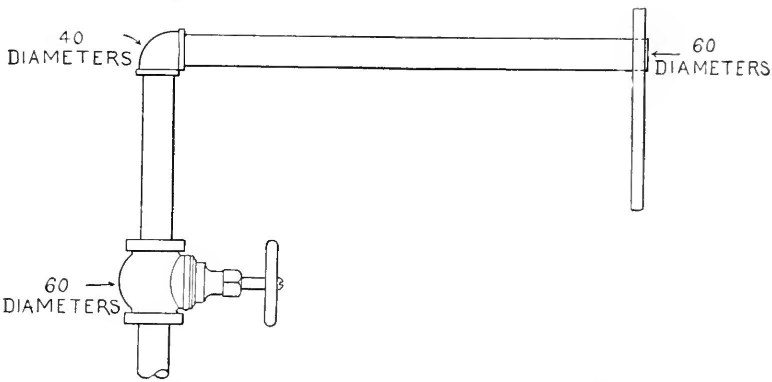
The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XX. HARTFORD, CONN., FEBRUARY, 1899. No. 2.

On the Flow of Steam through Pipes.

One of the commonest problems in engineering practice is that which relates to the quantity of steam that will pass through a given pipe, under given conditions. Before entering upon the discussion of this problem, it should be clearly understood that there must *always* be a "drop" in pressure in a pipe conveying steam; because if the pressure were precisely the same at both ends, there would be nothing to make the steam flow through the pipe in either direction. Steam, like water, always tends to flow from a place where the pressure is higher to another place where it is lower; and it will not flow at all unless such a difference in pressure exists. In many cases (as, for example, in piping up engines) it is desirable to have the "drop" in pressure, between the two ends of the pipe, as small as it can be made to be, without using a pipe that is unreasonably large. In other cases (as, for example, in heating a tank full of water by injecting



Briggs's Allowances for Valves, Elbows, and Inlet.

steam into it), it may be desirable to allow a large drop in pressure, in order that a small pipe may be caused to deliver a large quantity of steam in a given time. With these facts in mind, we are ready to consider the general problem, which may take any one of three forms. (1st.) We may want to know the size of the pipe, in order that it may transmit a certain amount of steam for a given "drop" in pressure between the two ends of the pipe. (2d.) We may want to know what drop in pressure may be expected when a given size and length of pipe transmits a given amount of steam per minute. (3d.) We may want to know what amount of steam a pipe will transmit per minute when we know the size and length of the pipe and the "drop" in pressure between its two ends.

To obtain a good rule, or formula, for solving these questions is not so easy as might be supposed. It is quite possible to form a complete theory of the flow of steam in pipes. Such a theory is given, in outline, in Poincaré's treatise on thermodynamics;* but the trouble with this theory is, that like many another theory relating to steam engineering, it merely suffices to show the general nature of the solution that we are seeking, and it does not give us the numerical data that we need for applying the theory to the actual conditions that prevail in practice. It has, therefore, been found to be necessary (up to the present time, at any rate) to make use of some one of the various formulæ that have been given for the flow of water and other liquids, after introducing such modifications as appear to be necessary in order to make the formula come into a reasonable agreement with such experimental data as we have on the actual flow of steam through pipes.

We do not need to review the various formulæ that have been proposed for this

TABLE I.—FLOW OF STEAM THROUGH STRAIGHT PIPES, IN POUNDS PER MINUTE.
(Length of Pipe = 100 Feet. Loss of Pressure = 1 Pound.)

Initial Pressure by Gauge. (Lbs. per Sq. In.)	Nominal Diameter (or "Size") of Pipe.					
	1″	1½″	2″	2½″	3″	3½″
1	0.90	3.07	6.23	10.3	18.5	28.1
2	0.92	3.16	6.42	10.6	19.0	28.9
3	0.95	3.25	6.60	10.8	19.5	29.7
4	0.97	3.34	6.77	11.1	20.0	30.5
5	1.00	3.42	6.94	11.4	20.5	31.3
6	1.02	3.50	7.10	11.7	21.0	32.0
7	1.05	3.58	7.26	12.0	21.5	32.7
8	1.07	3.66	7.42	12.2	22.0	33.4
9	1.09	3.73	7.57	12.5	22.4	34.1
10	1.11	3.80	7.71	12.7	22.9	34.8
12	1.15	3.95	8.00	13.2	23.7	36.0
15	1.21	4.15	8.41	13.8	24.9	37.9
20	1.30	4.46	9.05	14.9	26.8	40.8
25	1.39	4.75	9.64	15.9	28.6	43.4
30	1.47	5.02	10.2	16.8	30.2	45.9
40	1.61	5.52	11.2	18.4	33.2	50.5
50	1.75	5.98	12.1	19.9	35.9	54.6
60	1.87	6.39	13.0	21.3	38.4	58.4
70	1.98	6.78	13.8	22.6	40.7	62.0
80	2.09	7.15	14.5	23.9	42.9	65.3
90	2.19	7.49	15.2	25.0	45.0	68.4
100	2.28	7.82	15.9	26.1	47.0	71.4
120	2.46	8.43	17.1	28.1	50.6	77.0
150	2.71	9.26	18.8	30.9	55.6	84.6

purpose, since a very intelligent discussion of the better known ones has been given by Mr. Arthur J. Martin in a recent issue of London *Engineering*.† After reviewing these

* H. Poincaré. *Thermodynamique;* Paris, Carré, 1892; p. 157.

† "The Flow of Gas or Steam through Pipes," by Arthur J. Martin: *Engineering*, March 19, 1897, page 361. (The "*a*" in the denominator of his formula, on p. 363, is a misprint: it should be "*d*.")

various formulæ carefully, Mr. Martin concludes that Unwin's formula is probably as satisfactory as any, if a slight change is made in one of its constants. The formula, as modified by Mr. Martin, may be stated thus:

$$p = \frac{w^2 L (d + 3.6)}{7{,}000 D d^6}$$

where p = "drop" in pressure in the pipe, in pounds per square inch;
w = weight of steam delivered, in pounds per minute;
d = actual internal diameter of the pipe, in inches;
D = weight, in pounds, of a cubic foot of the steam; and
L = the length of the pipe, in feet.

Table I.—Flow of Steam Through Straight Pipes, in Pounds per Minute.
(Length of Pipe = 100 Feet. Loss of Pressure = 1 Pound.)

Initial Pressure by Gauge. (Lbs. per Sq. In.)	Nominal Diameter (or "Size") of Pipe.					
	4″	5″	6″	8″	10″	12″
1	39.7	73.4	120.	251.	458.	765.
2	40.9	75.6	124.	259.	472.	787.
3	42.0	77.7	128.	266.	485.	809.
4	43.1	79.7	131.	273.	497.	830.
5	44.2	81.7	134.	280.	510.	851.
6	45.2	83.6	137.	286.	522.	871.
7	46.3	85.5	140.	293.	533.	890.
8	47.3	87.3	143.	299.	545.	909.
9	48.2	89.1	146.	305.	556.	928.
10	49.2	90.9	149.	311.	567.	946.
12	51.0	94.3	155.	322.	588.	981.
15	53.6	99.1	163.	339.	618.	1030.
20	57.7	107.	175.	365.	665.	1110.
25	61.4	114.	187.	388.	708.	1180.
30	64.9	120.	197.	411.	749.	1250.
40	71.4	132.	217	451.	823.	1370.
50	77.3	143.	235.	488.	891.	1490.
60	82.6	153.	251.	522.	953.	1590.
70	87.6	162.	266.	554.	1010.	1690.
80	92.4	171.	280.	584.	1065.	1780.
90	96.8	179.	294.	612.	1120.	1860.
100	101.	187.	307.	639.	1165.	1940.
120	109.	201.	331.	689.	1260.	2100.
150	120.	221.	363.	757.	1380.	2300.

The "weight, in pounds, of a cubic foot of steam" is not a perfectly definite quantity, inasmuch as it varies from one part of the pipe to another, as the steam expands in passing from a region of higher pressure to a region of lower pressure. Mr. Martin says concerning this point: "Where the loss of pressure in a pipe is but a small proportion of the original pressure, no great inaccuracy will result from using the density due to the original pressure, or preferably that due to the mean of the original and terminal pressures, if both are known; but in long mains, where the loss of pressure is very great, a considerable error may result from this course." For this reason, and for the additional reason that the foregoing formula does not take account of what is called the "head due to velocity," neither the formula nor the tables that we present herewith should be used for extreme conditions. They are merely intended to approximately cover the conditions that are likely to occur in practice, and must be used with a reasonable regard to the conditions of the case.

Although the formula given above is not particularly complicated, yet it is too much so for convenient use; and therefore it becomes desirable to tabulate its results, so that they may be conveniently used without unnecessary labor of calculation. To tabulate the formula completely, so that every problem that might arise could be solved at once by a direct inspection of the table, would require a prohibitive amount of space; but the results of the formula can easily be presented in *two* tables in such a way that any problem that is likely to arise in practice can be solved by means of a simple multiplication or division.

In Table I we give the number of pounds of steam that would be discharged in one minute through various sizes of pipe, and for boiler pressures up to 150 pounds per square inch, on the assumption that the pipe is 100 feet long, and that the "drop" in the pressure of the steam, in this length of pipe, is one pound. In calculating this table we have taken account of the fact that the *actual* diameter of steam pipe is not quite equal to its "nominal" diameter (or "trade size"); and we have made all necessary allowance for this fact. It will rarely happen that the precise problem that is in hand can be solved by this table alone, since it is quite unlikely either that the actual length of the pipe would be precisely 100 feet, or that the "drop" in pressure would be precisely one pound. To allow for variations from these conditions, we have calculated Table II, which gives the factor by which the numbers in Table I must be multiplied to allow for various conditions of length of pipe and drop of pressure.

To illustrate the use of these tables, let us take the following problem: A pipe is given, of the size known in the trade as "two-inch" pipe. It is 90 feet long, and we wish to know how many pounds of steam will flow through it in one minute from a boiler carrying steam at 90 pounds by the gauge, when the "drop" in pressure between the two ends of the pipe is five pounds. To solve this problem, we first look in Table I, in the column headed 2", and opposite the pressure 90 pounds we find the number 15.2. This means that if the pipe were 100 feet long, and the "drop" in pressure were one pound, the pipe in question would discharge 15.2 pounds of steam per minute. To take account of the fact that the length of the pipe is 90 feet instead of 100, and that the "drop" in pressure is five pounds instead of one, we turn to Table II, and in the column headed five pounds, and opposite the length 90 feet, we find the factor (or multiplier) 2.36. To take account of the actual length of the pipe, and the actual drop in the pressure, we therefore have to multiply the 15.2 pounds already found by 2.36. We have $15.2 \times 2.36 = 35.872$, which means that the actual flow of steam through the given pipe, under the given conditions, will be 35.872 pounds per minute. Owing to the uncertainty, both of the formula and of the experimental data on which it is based, it is useless to retain more than the first two or three significant figures for any results that are calculated from it. Hence, we shall throw away the last two figures of the foregoing result, and consider that the said result, as far as it can have the least claim to accuracy, is simply 35.9 pounds per minute. In a test made under these conditions at Sibley College, Professor R. C. Carpenter found that 36.4 pounds per minute were discharged by such a pipe. The agreement here between the formula and the fact is closer than can be expected in most cases.

To illustrate the application of the tables to a different form of the problem, let us take the following case: A certain "two-inch" pipe is 90 feet long; and it is known

TABLE II.— FACTORS FOR CORRECTING THE PREVIOUS TABLE.

Length of Pipe, in Feet.	Drop in Pressure. (Pounds per Square Inch.)									
	1	2	3	4	5	6	7	8	9	10
20	2.24	3.16	3.87	4.47	5.00	5.48	5.92	6.32	6.71	7.07
25	2.00	2.83	3.46	4.00	4.47	4.90	5.29	5.66	6.00	6.32
30	1.83	2.58	3.16	3.65	4.08	4.47	4.83	5.16	5.48	5.77
35	1.69	2.39	2.93	3.38	3.78	4.14	4.47	4.78	5.07	5.35
40	1.58	2.24	2.74	3.16	3.54	3.87	4.18	4.47	4.74	5.00
45	1.49	2.11	2.58	2.98	3.33	3.65	3.94	4.22	4.47	4.71
50	1.41	2.00	2.45	2.83	3.16	3.46	3.74	4.00	4.24	4.47
55	1.35	1.91	2.33	2.70	3.01	3.30	3.57	3.81	4.04	4.26
60	1.29	1.83	2.24	2.58	2.89	3.16	3.42	3.65	3.87	4.08
65	1.24	1.75	2.15	2.48	2.77	3.04	3.28	3.51	3.72	3.92
70	1.20	1.69	2.07	2.39	2.67	2.93	3.16	3.38	3.59	3.78
75	1.16	1.63	2.00	2.31	2.58	2.83	3.06	3.27	3.47	3.66
80	1.12	1.58	1.94	2.24	2.50	2.74	2.96	3.16	3.35	3.54
85	1.08	1.53	1.88	2.17	2.43	2.66	2.87	3.07	3.25	3.43
90	1.05	1.49	1.83	2.11	2.36	2.58	2.79	2.98	3.16	3.33
95	1.02	1.45	1.78	2.05	2 30	2.51	2.72	2.90	3.08	3.24
100	1.00	1.41	1.73	2.00	2.24	2.45	2.65	2.83	3.00	3.16
110	.95	1.35	1.65	1.91	2.13	2.34	2.52	2.70	2.86	3.01
120	.91	1.29	1.58	1.83	2.04	2.24	2.42	2.58	2.74	2.89
130	.88	1.24	1.52	1.75	1.96	2.15	2.32	2.48	2.63	2.77
140	.85	1.19	1.46	1.69	1.89	2.07	2.24	2.39	2.54	2.67
150	.82	1.15	1.41	1.63	1.83	2.00	2.16	2.31	2.45	2.58
160	.79	1.12	1.37	1.58	1.77	1.94	2.09	2.24	2.37	2.50
170	.77	1.08	1.33	1.53	1.72	1.88	2.03	2.17	2.30	2.43
180	.75	1.05	1.29	1.49	1.67	1.83	1.97	2.11	2.24	2.36
190	.73	1.02	1.25	1.45	1.62	1.78	1.92	2.05	2.18	2.30
200	.71	1.00	1.22	1.41	1.58	1.73	1.87	2.00	2.12	2.24
225	.67	.94	1.16	1.33	1.49	1.64	1.77	1.89	2.01	2.12
250	.63	.89	1.10	1.26	1.41	1.55	1.67	1.79	1.90	2.00
275	.60	.85	1.04	1.20	1.35	1.48	1.60	1.71	1.81	1.91
300	.58	82	1.00	1.15	1.29	1.41	1.53	1.63	1.73	1.83
325	.55	.79	.96	1.11	1.24	1.36	1.47	1.57	1.66	1.76
350	.53	.76	.93	1.07	1.20	1.31	1.41	1.51	1.60	1.69
375	51	.73	.90	1.03	1.16	1.26	1.36	1.46	1.55	1.63
400	.50	.71	.87	1.00	1.12	1.22	1.32	1.41	1.50	1.58

that it discharges 44.3 pounds of steam per minute when the boiler pressure is 84 pounds by the gauge. What is the "drop" in pressure in the pipe? To solve this problem, we first look in Table I, where we find that under the conditions stated at the head of the table a two-inch pipe would discharge 14.5 pounds per minute with a boiler pressure of 80 pounds, and 15.2 pounds with a boiler pressure of 90 pounds. The actual given pressure (84 pounds) is not found in the table; but since it is about halfway between 80 pounds and 90 pounds, we may take the average of 14.5 and 15.2 as the discharge corresponding to this pressure. The average of 14.5 and 15.2, to one place of decimals, is 14.8; so that we conclude that a two-inch pipe, 100 feet long, may be expected to deliver about 14.8 pounds of steam per minute, when the "drop" in pressure is one pound and the original boiler pressure is 84 pounds. We next divide the given discharge (44.3 pounds) by the discharge so found, and we get $44.3 \div 14.8 = 2.99$. We then look for this number, 2.99, in Table II, on the line opposite 90 feet (which is the length of the actual pipe). We do not find it precisely, but in the column corresponding to a "drop" of eight pounds, we find the number 2.98, which is practically identical with 3.01. Hence, we conclude that under the given conditions the "drop" in pressure in the pipe may reasonably be expected to be about eight pounds. Professor Carpenter found that the actual drop in pressure, under these conditions, was 7.3 pounds.

In applying the tables in practice, it must be remembered that they apply only to *straight* pipes, without elbows or valves, and that they also take no account of the drop in pressure which is always found where the steam first *enters* the pipe. The drop in pressure at the entrance to a pipe (except when the pipe is provided with a special bell mouth) consists of two parts, one of which represents the pressure expended in giving the steam its initial velocity of flow, while the other is due to the resistance offered by the mouth of the tube. This initial "drop" in pressure was considered many years ago by the veteran engineer, Robert Briggs, in a paper contributed to the Institution of Civil Engineers, and since republished by the D. Van Nostrand Company, of New York, under the title *Steam Heating*. Mr. Briggs's conclusion is that the total loss of pressure at the entrance of a pipe is equivalent to the resistance offered by a section of straight pipe of the same size, whose length is sixty times the pipe's diameter. In the same paper Mr. Briggs concludes that the resistance offered by a sharp, right-angled elbow may be allowed for in the same manner by treating such an elbow as equivalent to a section of pipe whose length is forty times the pipe's diameter; and he also estimates the resistance of a globe valve as equal to a section 60 diameters long. We have tabulated these estimates in Table III, for the various diameters of pipe that are given in the previous tables. We also present, in the same table, the lengths of pipe that Prof. R. C. Carpenter considers to be equivalent to a square elbow and a globe valve, respectively.* Professor Carpenter's allowances, it will be seen, are far larger than those given by Briggs, and they appear to us to be excessive. He does not give the experimental data upon which his formula is based, and hence we cannot judge to what extent they may tend to justify so great an increase in the allowance. Briggs's estimates, on the other hand, have been considered as standards in engineering for many years, and, so far as we are aware, none of the failures that have been recorded in the pipe systems of heating plants and steam plants generally can be attributed to the use of his data in laying out the plant. We are still inclined, therefore, to favor Mr. Briggs's estimates of the allowance to be made for elbows and globe valves.

---

* See his paper on *The Flow of Steam through Pipes*, read before the American Society of Mechanical Engineers in December, 1898.

To make the use of the third table plain, let us take the following problem. A four-inch pipe, 150 feet long, has three elbows and one globe valve. To what length of straight pipe, of the same diameter, is it equivalent? By referring to Table III we see (taking Briggs's values) that one elbow is equivalent, in a four-inch pipe, to 13.4 feet of the straight pipe. Three elbows would, therefore, be equivalent to 3 × 13.4 = 40.2 feet of the pipe. Again, we see that one globe valve, on a four-inch pipe, is equivalent to 20.1 feet of the pipe; and we see that the resistance at the inlet is also equivalent to 20.1 feet of straight pipe. The total allowance to be made for the three elbows, the globe valve, and the resistance at the inlet is, therefore, 40.2 + 20.1 + 20.1 = 80.4 feet of straight pipe, — or, say, 80 feet in round numbers. This is to be added to the actual length of the pipe; so that the total *effective* length of the pipe is 150 + 80 = 230 feet. In figuring the flow of steam through the given pipe, with its three elbows and one globe valve, we are, therefore, to treat the pipe as though it were *straight*, and had a length of 230 feet instead of its actual length of 150 feet.

TABLE III.— LENGTH OF PIPE EQUIVALENT TO ELBOWS AND VALVES.

Nominal "Size" of Pipe.	Actual Inside Diameter.	Length of Straight Pipe Equivalent to Elbows and Valves.				
		According to Briggs.			According to Carpenter.	
		Inlet.	Globe Valve.	Square Elbow	Globe Valve.	Sq. Elbow
Inches.	Inches.	Feet.	Feet.	Feet.	Feet.	Feet.
1	1.048	5.2	5.2	3.5	14.	10.
1½	1.610	8.0	8.0	5.4	29.	22.
2	2.067	10.3	10.3	6.9	44.	33.
2½	2.468	12.3	12.3	8.2	59.	44.
3	3.067	15.3	15.3	10.2	83.	61.
3½	3.548	17.7	17.7	11.8	104.	76.
4	4.026	20.1	20.1	13.4	125.	92.
5	5.045	25.2	25.2	16.8	173.	128.
6	6.065	30.3	30.3	20.2	224.	165.
8	7.982	39.9	39.9	26.6	324.	238.
10	10.019	50.0	50.0	33.3	434.	319.
12	12.180	60.9	60.9	40.6	553.	407.

In conclusion, we wish to emphasize the fact that these tables cannot be expected to give results that are even approximately correct, except within the limits of usual practice. Thus it would be manifestly absurd to use them to calculate the flow through a 12-inch pipe, 20 feet long, with a difference in pressure of ten pounds between its two ends. The absurdity of this particular case must be quite evident; and other similarly unreasonable extremes must also be avoided. In particular, it may be said that the tables assume that there is no material amount of condensation in the pipe; and, in the case of long pipes, this amounts to the assumption that the pipe is covered, and protected, as a steam main ought to be, against radiation losses. As we have already said, it is theoretically possible to deduce a formula upon which these various limitations need not be imposed; but such a formula has never yet been given, and, if it were given, it would be so complicated, in all probability, that it would be of no value for practical use.

The Locomotive.

HARTFORD, FEBRUARY 15, 1899.

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.

Second-handed Boilers in England.

A recent boiler explosion at Norwich, England, leads *Engineering* to make a few remarks on the general subject of buying second-handed boilers without knowing whether they are good for anything or not. Much of what is said is as applicable to this country (and doubtless to all others) as it is to England.

From time to time (says the article in question), we have reported the occurrence of explosions from miserable little boilers fit only for the scrap heap, but which have been sold and re-sold, over and over again, with an utter disregard of the fact that they were dangerously defective, and that on being set to work they might explode at any moment with the most serious consequences. Given a practically worn-out boiler, a dealer desirous of effecting a sale, and a purchaser on the lookout for a cheap bargain and too ignorant or too penurious to have an examination made to ascertain whether or not the boiler he proposes to purchase is safe to work, and we have all the essential elements of mischief. We have met, from time to time, with many cases in which worthless boilers have been purchased at second, third, or fourth hand; and, whatever the dealers may have known, the purchaser, in each case, has been entirely ignorant of the danger that existed, although probably the low price that he paid should have given him warning, and led him to suspect that all was not right. Some time ago a boiler of weak and antiquated construction, which had seen long service and certainly deserved oblivion, was condemned by an examiner of undoubted ability, and was pulled out and sold to a dealer in machinery. The dealer did not cut it up, — far from it; but he gave it a coat of paint, put in a few new rivets here and there, and sold it to a respectable shipping firm, who set it neatly in brickwork at the basement of their large warehouse, situated in the heart of a populous city. An insurance company was called in to make an examination before starting work, and the inspector at once recognized in the boiler his old acquaintance which he had condemned some months previously, but which had been sold to the new firm, doubtless in the belief that they were getting a serviceable article. Needless to say, the boiler was again condemned and was removed by the dealer, who returned the purchase money when a suit at law was threatened. This is by no means a solitary case, and others have occurred in which the danger has not been revealed until too late for a remedy.

The explosion at Norwich (which, as we have already said, served as the text for the article that we are here quoting) is an illustration of the unfortunate carelessness which too often accompanies the transaction of buying second-handed boilers. A Manchester contractor was in want of a boiler to drive a mortar mill in connection with the erection of a new technical school at Norwich, and seeing an advertisement in which a boiler and a mortar mill, described as "strong," were offered, he corresponded with the firm that had them for sale, and at length purchased them. They were brought to Norwich, and on the first day that steam was got up the boiler exploded, killing a lad and injuring several other persons. The boiler, which was stated to be of considerable age, was a small one of vertical construction. The crown of the fire-box was not efficiently stayed, and had bulged downwards some four or five inches. This defect was noticed by two or three of the men who were engaged in connecting the boiler to the engine, and at the official investigation these men stated that they had duly reported the fact to those most concerned. No notice of it appears to have been taken, however, and the warning passed unheeded. It is true that a water pressure of 100 pounds was applied with a view, it was stated, "of detecting leakage"; but no examination of the fire-box was made, either before, during, or after the test, so that it was utterly useless, and possibly misleading. When set to work the boiler gave a practical protest by bursting, the weak fire-box collapsing with the serious results we have mentioned. The Board of Trade's inspector informed the commissioners that the pressure at which the boiler exploded was 95 pounds, and that if it had been submitted to examination by the Board of Trade, "it would not have been passed to work at any pressure whatever." The purchaser, through his counsel, endeavored to convince the Court that when he saw the word "strong" used in the advertisement, he understood it to apply to the boiler. The dealer, on the other hand, said it applied *only to the mortar mill*, and that it was the duty of the purchaser to have the boiler examined and to assure himself of its safety. After an exhaustive inquiry, lasting three days, the presiding commissioner took the dealer's view of the matter, and practically exonerated every one except the purchaser, who, he said, had displayed great negligence in not having an inspection of the boiler made by a competent person. The purchaser, he said, was seriously to blame, although he had not acted from any unworthy motive: and he was ordered to pay the sum of five hundred dollars towards the cost of the investigation.

We accept this ruling (continues *Engineering*), and are quite prepared to believe that both the seller and the purchaser were unaware of the dangerous condition of the fire-box crown. But we submit that ignorance is by no means a valid excuse, that both parties were seriously to blame, and that both should have shared the penalty. A dealer, even in ignorance, has no moral right to sell to a purchaser, equally ignorant and careless, an article which, on being used, may fail and deal death and destruction around. The dealer in this case displayed great earnestness and shrewdness in urging on the purchaser that he would get a good bargain, as the mill was a very strong or "heavy" one. How was it, then, that he had been so lamentably careless in buying so defective a boiler, and in subsequently offering it for sale in its dangerous condition without any examination, without a word being said as to the fitness to drive the "heavy" mortar mill, and without advising the purchaser to make his own examination and obtain his own guarantee of safety. One would have thought that common sense would have led the dealer, and also the purchaser, to ascertain beyond all doubt that the boiler was fit to effectively drive the "strong" mill, which, being admittedly heavy, would naturally require a fair pressure of steam. But there was no common sense in the transaction; the question of safety or of a safe-working pressure does not appear to have been considered, and the fact that the mortar mill was a strong one monopolized the attention of both parties. The case appears to be full of unintentional misunderstanding, but the purchaser has had to pay dearly for the omissions of which he was guilty. In future those who contemplate buying second-handed boilers would do well to remember that, according to the ruling above stated, the onus of proof of safety rests upon themselves.

Inspectors' Report.

SEPTEMBER, 1898.

During this month our inspectors made 8,728 inspection trips, visited 18,325 boilers, inspected 6,642 both internally and externally, and subjected 830 to hydrostatic pressure. The whole number of defects reported reached 10,699, of which 1,107 were considered dangerous ; 38 boilers were regarded unsafe for further use. Our usual summary is given below :

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	766	43
Cases of incrustation and scale,	1,835	60
Cases of internal grooving,	93	5
Cases of internal corrosion,	673	185
Cases of external corrosion,	442	37
Broken and loose braces and stays,	126	44
Settings defective,	288	28
Furnaces out of shape,	307	30
Fractured plates,	193	46
Burned plates,	284	27
Blistered plates,	124	7
Cases of defective riveting,	382	131
Defective heads,	114	31
Serious leakage around tube ends,	3,001	190
Serious leakage at seams,	334	37
Defective water-gauges,	224	54
Defective blow-offs,	145	60
Cases of deficiency of water,	18	5
Safety-valves overloaded,	38	17
Safety-valves defective in construction,	52	11
Pressure-gauges defective,	465	53
Boilers without pressure-gauges,	6	6
Unclassified defects,	789	0
Total,	10,699	1,107

OCTOBER, 1898.

During this month our inspectors made 9,017 inspection trips, visited 16,981 boilers, inspected 6,077 both internally and externally, and subjected 757 to hydrostatic pressure. The whole number of defects reported reached 9,890, of which 893 were considered dangerous: 41 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	802	44
Cases of incrustation and scale,	1,968	97
Cases of internal grooving,	76	5

Nature of Defects.	Whole Number.	Dangerous.
Cases of internal corrosion,	465	24
Cases of external corrosion,	380	31
Broken and loose braces and stays,	222	147
Settings defective,	246	25
Furnaces out of shape,	350	14
Fractured plates,	248	33
Burned plates,	186	23
Blistered plates,	157	5
Cases of defective riveting,	1,255	61
Defective heads,	102	25
Serious leakage around tube ends,	1,817	108
Serious leakage at seams,	370	44
Defective water-gauges,	253	57
Defective blow-offs,	132	33
Cases of deficiency of water,	12	4
Safety-valves overloaded,	137	51
Safety-valves defective in construction,	70	18
Pressure-gauges defective,	412	39
Boilers without pressure-gauges,	5	5
Unclassified defects,	225	0
Total,	9,890	893

November, 1898.

During this month our inspectors made 8,984 inspection trips, visited 17,363 boilers, inspected 6,156 both internally and externally, and subjected 673 to hydrostatic pressure. The whole number of defects reported reached 12,267, of which 979 were considered dangerous; 33 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	846	46
Cases of incrustation and scale,	2,291	61
Cases of internal grooving,	87	6
Cases of internal corrosion,	531	22
Cases of external corrosion,	512	40
Broken and loose braces and stays,	128	21
Settings defective,	305	15
Furnaces out of shape,	289	16
Fractured plates,	457	27
Burned plates,	287	24
Blistered plates,	130	3
Cases of defective riveting,	1,600	61
Defective heads,	81	21
Serious leakage around tube ends,	3,192	416
Serious leakage at seams,	369	25
Defective water-gauges,	208	36
Defective blow-offs,	134	42
Cases of deficiency of water,	17	9

Nature of Defects.	Whole Number.	Dangerous.
Safety-valves overloaded.	45	11
Safety-valves defective in construction.	74	25
Pressure-gauges defective.	341	30
Boilers without pressure-gauges.	22	22
Unclassified defects.	321	0
Total,	12,267	979

DECEMBER, 1898.

During this month our inspectors made 9,658 inspection trips, visited 19,714 boilers, inspected 6,123 both internally and externally, and subjected 641 to hydrostatic pressure. The whole number of defects reported reached 9,842, of which 922 were considered dangerous: 46 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment.	689	30
Cases of incrustation and scale.	2,140	72
Cases of internal grooving.	80	8
Cases of internal corrosion.	553	25
Cases of external corrosion.	483	27
Broken and loose braces and stays.	146	76
Settings defective.	228	21
Furnaces out of shape.	372	6
Fractured plates,	226	40
Burned plates,	255	22
Blistered plates,	149	3
Cases of defective riveting.	1,098	48
Defective heads.	58	21
Serious leakage around tube ends.	2,038	314
Serious leakage at seams.	361	45
Defective water-gauges.	257	52
Defective blow-offs.	142	35
Cases of deficiency of water.	14	5
Safety-valves overloaded.	63	17
Safety-valves defective in construction.	78	22
Pressure-gauges defective.	298	27
Boilers without pressure-gauges.	6	6
Unclassified defects.	108	0
Total,	9,842	922

Summary of Inspectors' Reports for the Year 1898.

During the year 1898 our inspectors made 106,128 visits of inspection, examined 208,990 boilers, inspected 78,349 boilers both internally and externally, subjected 8,713 to hydrostatic pressure, and found 603 unsafe for further use. The whole number of defects reported was 130,743, of which 11,727 were considered dangerous. A summary of the work by months is given below, and the usual classification by defects is likewise given :

Summary, by Defects, for the Year 1898.

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	10,606	505
Cases of incrustation and scale,	26,083	848
Cases of internal grooving,	1,190	107
Cases of internal corrosion,	7,864	545
Cases of external corrosion,	6,422	444
Defective braces and stays,	2,783	648
Settings defective,	3,369	315
Furnaces out of shape,	4,152	198
Fractured plates,	3,276	474
Burned plates,	3,041	283
Blistered plates,	1,833	113
Defective rivets,	15,827	1,060
Defective heads,	1,177	280
Leakage around tubes,	24,100	3,140
Leakage at seams,	4,440	412
Water-gauges defective,	2,685	579
Blow-outs defective,	1,761	531
Cases of deficiency of water,	157	74
Safety-valves overloaded,	691	263
Safety-valves defective,	913	251
Pressure-gauges defective,	4,889	410
Boilers without pressure-gauges,	213	213
Unclassified defects,	3,271	34
Total,	130,743	11,727

Summary by Months, for 1898.

Month.	Visits of inspection.	Number of boilers examined.	No. inspected internally and externally.	No. tested hydro-statically.	No. con-demned.	Number of defects found.	Number of dangerous defects found.
January,	9,605	18,888	6,130	497	74	10,119	1,053
February,	7,858	15,545	4,720	494	40	8,373	834
March,	10,208	19,297	6,369	955	53	12,539	945
April,	8,619	17,223	6,581	653	82	10,605	1,072
May,	7,874	15,635	6,789	568	54	10,283	1,197
June,	8,618	16,812	7,437	845	42	10,760	617
July,	8,635	17,225	8,912	914	44	13,307	994
August,	8,324	15,982	6,413	886	56	12,059	1,114
September,	8,728	18,325	6,642	830	38	10,699	1,107
October,	9,017	16,981	6,077	757	41	9,890	893
November,	8,984	17,363	6,156	673	33	12,267	979
December,	9,658	19,714	6,123	641	46	9,842	922
Totals,	106,128	208,990	78,349	8,713	603	130,743	11,727

We append, also, a summary of the work of the inspectors of this company from 1870 to 1898 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 general 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
1897	105,062	206,657	76,770	7,870	131,192	11,775	588
1898	106,128	208,990	78,349	8,713	130,743	11,727	603

Comparison of Inspectors' Work during the Years 1897 and 1898.

	1897.	1898.
Visits of inspection made,	105,062	106,128
Whole number of boilers inspected,	206,657	208,990
Complete internal inspections,	76,770	78,349
Boilers tested by hydrostatic pressure,	7,870	8,713
Total number of defects discovered,	131,192	130,743
" " of dangerous defects,	11,775	11,727
" " of boilers condemned,	588	603

The following table is also of interest. It shows that our inspectors have made over a million and a quarter visits of inspection, and that they have made more than two and a half millions of inspections, of which nearly one million were complete internal inspections. The hydrostatic test has been applied in over one hundred and forty thousand cases. Of defects, more than a million and three-quarters have been discovered and pointed out to the owners of the boilers; and over two hundred thousand of these defects were, in our opinion, dangerous. More than eleven 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, 1899.

Visits of inspection made,	1,304,157
Whole number of boilers inspected,	2,592,692
Complete internal inspections,	997,767
Boilers tested by hydrostatic pressure,	143,024
Total number of defects discovered,	1,891,339
" " of dangerous defects,	219,548
" " of boilers condemned,	11,654

Abstract of Statement—January 1, 1899.

ASSETS.

Cash in office and bank,	$100,790.72
Premiums in course of collection (net),	246,726.68
Loaned on bond and mortgage, first liens,	301,000.00
Bonds and stocks, market value,	1,682,591.00
Real estate,	58,432.91
Interest accrued,	6,982.67
Total assets,	$2,396,523.98

LIABILITIES.

Premium reserve,		$1,329,202.73
Losses in process of adjustment,		16,984.27
Capital stock,	$500,000.00	
Net surplus,	550,336.98	
Surplus as regards policy-holders,	$1,050,336.98	1,050,336.98
Total liabilities, including capital and surplus,		$2,396,523.98

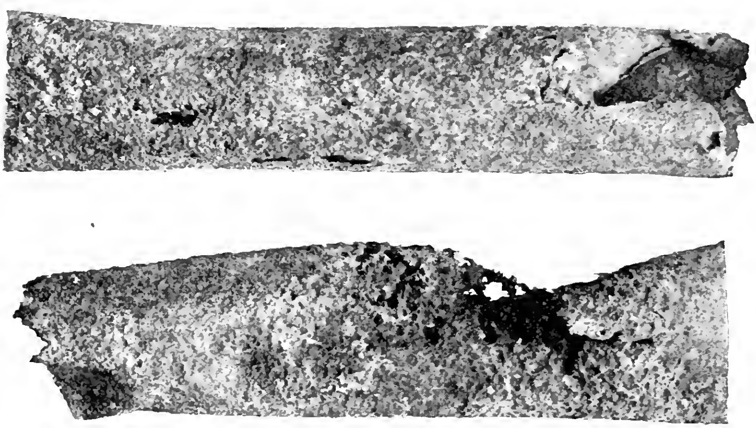
The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XX. HARTFORD, CONN., MARCH, 1899. No. 3.

A Tale of a Yarrow Boiler.

In selecting a type of boiler for use on board ship, the designer does not have the freedom of choice that his confrere has who is about to select one for use on land. The marine engineer must be guided, to a large extent, by the weight and bulk of the boiler; for economy in these respects is exceedingly important, where the total volume and weight that are available for boilers, machinery, fuel, and all other items, are strictly limited by the size and carrying capacity of the vessel. Hence, it often happens that the marine engineer is forced, by the nature of his profession, to make use of a



FIGS. 1 AND 2.— WASTED COPPER TUBE, FROM A YARROW BOILER.

boiler tnat, perhaps, he would not recommend for use on land, where increased weight and bulk are of far smaller importance.

These remarks are called forth by an incident of the recent war with Spain, which occurred on one of the smaller vessels of the United States Navy, in connection with a Yarrow water-tube boiler. As the Yarrow boiler is designed and built with especial reference to the exigencies of the marine service, and is seldom used on land, our readers may not be familiar with its construction. To make matters entirely clear we therefore present, in Fig. 3, a diagram of this type of boiler, showing its general features sufficiently for our present purposes. As will be seen, it consists essentially of a steam drum, to which two banks of small straight tubes are attached, one of which extends obliquely downward on either side of the fire. The upper ends of these tubes are expanded into the steam drum, and the lower ends of each bank are similarly expanded into a plate which is flat, or nearly so, and which forms the cover of a sort of water chamber or mud drum. In the particular boiler which serves as the text of the present article the tubes were of copper, one inch in diameter, and were arranged in such a manner that the cover-plate of each mud-drum or lower water chamber presented the general appearance shown in Fig. 4. Each bank, as will be seen from Fig. 4, contained 365 tubes; and hence in the entire boiler there were 730 tubes. The vessel is equipped with four of these boilers, so that the total number of tubes in all her boilers is 4 × 730 = 2,920. Each tube is expanded at the top and bottom, as has been already said; and therefore the total number of expanded tube-ends in the four boilers is 2 × 2,920 =

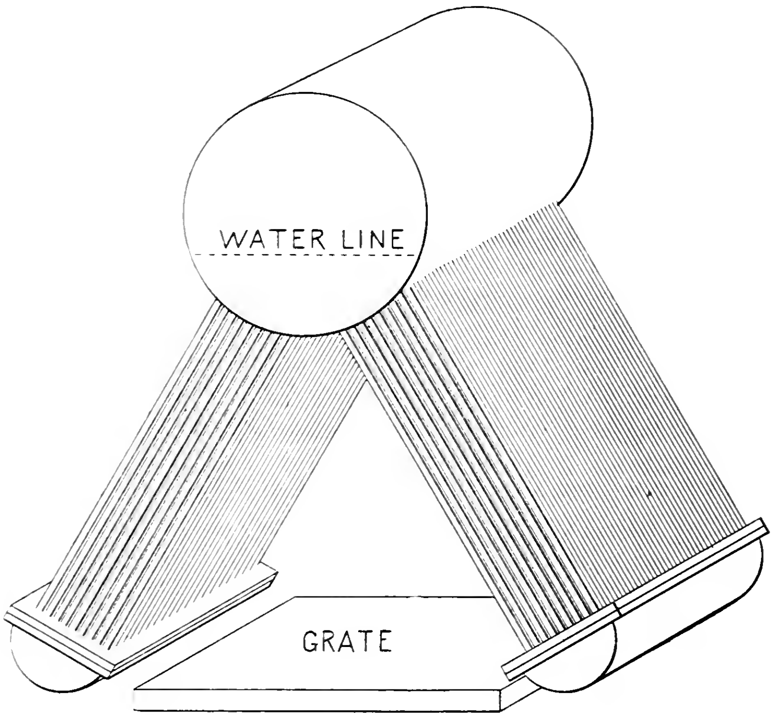


FIG. 3.—DIAGRAM OF A YARROW BOILER.

5,840. Although this may appear to be an excessive number of joints to make tight and keep in proper condition, it is by no means large in comparison with those that are found in many other naval vessels that use this type of boiler. In the Russian torpedo-boat destroyer *Sokol* (which, in English, means "Hawk") Mr. Yarrow states that there are 8,000 such tubes, and that their aggregate length is over six miles. The Russian engineers on the *Sokol*, therefore, have 16,000 expanded tube-ends under their charge, or nearly three times as many as there are on the American vessel under discussion.

When a builder introduces such an enormous number of expanded joints in his boiler, it is not too much to say that he invites trouble to come. And, as may easily be imagined, the invitation is often accepted. We do not wish to be understood as condemning the Yarrow boiler for the special purposes to which it is put, and we therefore hasten to say that Messrs. Yarrow & Co. are known throughout the world for their great experience in these matters, and that the present type of the Yarrow boiler has been evolved as the result of this experience, in the effort to provide a form that shall meet the exacting demands of naval service as nearly as possible. One of the chief reasons for the adoption of this type is to be found in its extraordinary lightness per horse-power developed, as much as 120 horse-power having been obtained from a boiler of this kind, per ton of weight (including all the fittings and the water). Another very important fact to the naval engineer is that steam can be raised from cold water very quickly, the advantage of which is that the vessel can be put in service very quickly, to meet any emergency that may arise. Yet, notwithstanding these valuable features, which have led to so general an adoption of the Yarrow boiler, the practical fact remains that a structure containing such a large number of parts is always liable to give out somewhere, at a critical time, owing to the natural perverseness of inanimate things, and the unavoidable imperfection of human workmanship and supervision.

The tube shown in Figs. 1 and 2 was taken from a minor vessel of the American navy, after a service of some months on the Cuban blockade. It was of copper, and at the time the vessel in question put into the navy yard for repairs it had been in use for precisely thirteen months. The tubes in the boiler were staggered, as shown in Fig. 4, and they were set so closely that it was hardly possible to see between the rows, either in the direction of the length of the bank or perpendicularly thereto. In the course of the repairs it was thought desirable to renew some (or all) of the tubes, and when they were taken out it was found that they were considerably pitted and corroded on the outside, so that in a number of places the tubes were entirely perforated, as can be seen in various places in Figs. 1 and 2, which are made from a photograph. The particular tube here shown was corroded so badly, in fact, that five inches of its length was entirely gone, the free ends being worn down to the thinness of paper. (In order to exhibit the ends on as large a scale as possible we have shown them separately. It should be understood that as the tube was originally taken from the boiler, a space of some five inches intervened between the right hand end of the upper figure and the left hand end of the lower one.) Despite the extent of the corrosion here noted, the engineer in charge of these boilers was unaware of the existence of any serious defect in them, although he had steamed into the navy yard with a pressure of 240 pounds to the square inch upon this very boiler, the spaces between the tubes being so solidly obstructed by a stony scale, in the vicinity of the break, that no leakage was remarked.

Marine boilers of this type are supposed to be run wholly with pure, fresh water, for the production of which an adequate distilling apparatus is supposed to be provided. Yet it is a fact that salt water is often pumped into them directly, either because of a temporary shortness of the supply of fresh water, or for some other

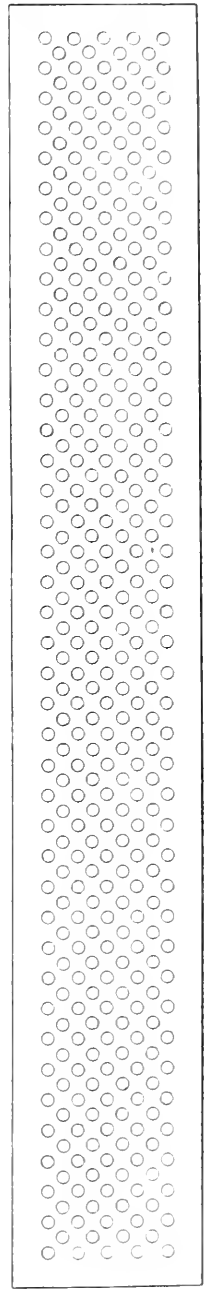


Fig. 4.—Diagram of Flat Tube Sheet.

reason. As a consequence of this, it is no uncommon thing for the tubes to become coated, on the inside, with a deposit of sea salt, which may cause them to become overheated and burned. A small crack or other opening is then liable to appear, or perhaps the tube-ends spring a-leak, and the saline contents of the boiler ooze out. The sea-salt, thus carried to the outside of the tubes, is deposited upon them, mingled, doubtless, with a certain proportion of soot and ashes, and the solid matter so formed goes on accumulating until it may plug up the fire-spaces so thoroughly, in the vicinity of the leak, that further leakage is impossible. In the present case the action was probably quite similar, except that the wasted tube, to all appearances, was not encrusted on the inside. The initial leak probably came from one of the expanded tube-ends, or else from one of the pits

Figs. 5 and 6.— Pieces of Scale from the Fire Space of a Yarrow Boiler. (Nearly Full Size.)

that have perforated it from the outside in various places. The scale between the tubes was quite hard and stony, and two fragments of it are shown, nearly full size, in Fig. 4. The 2,920 copper tubes in these boilers were all taken out and thrown away, and were replaced by one-inch seamless-drawn iron tubes.

The inference might possibly be drawn that these boilers were safe because they were scaled so perfectly, and a readable but not very valuable article might be written, if one were in the mood for it, on the advantages of salt feed-water as an all-around automatic stopper-up of holes and healer of leaks; but we must confess that we had rather be on deck, serving as a target for a Spaniard (as the thing turned out !) than to be shut up in the fire room with a lot of thinned and pitted tubes, and nothing but a chunk of scale between our valuable selves and 240 pounds of steam.

Boiler Explosions.

October, 1898.

(264.) — On October 1st, a boiler exploded in Costner & Summey's steam distillery, at Gastonia, near Charlotte, N. C. C. W. Costner was scalded on the left arm and ankle, Wert Summey was scalded and bruised, and William Manney received painful injuries by being thrown through a wire fence. The boiler passed through the distillery, and also tore down the warehouse.

(265.) — On October 1st, a boiler exploded near Canton, N. D., killing one man and injuring three others. One of the injured men, named John Rogers, has since died.

(266.) — A boiler exploded, on October 1st, in Simpson's saw-mill, in the Huntsville mountains, near Marion, N. C. The engineer was severely injured by steam and flying debris, and the mill was badly damaged.

(267.) — On October 1st Henry King was killed by a boiler explosion in the Gilsonite mines, at Dougherty, near Wichita, Kan. We have not learned further particulars.

(268.) — A boiler exploded, on October 2d, at Union Lake, some seven miles south of Northfield, Minn. Frederick Gilbert was killed, and Jacob Sartor and another man were painfully injured.

(269.) — On October 2d, a locomotive boiler exploded on Vandergriff & Co's lumber railroad, which connects with the Durham division of the Norfolk & Western railroad at a point about one and a half miles south of Roxboro, N. C. Several of the employes of the lumber road were returning from Roxboro, when the boiler exploded with the most serious results. One of the men was thrown forty yards over the tops of some trees, and another was thrown twenty yards. These two were instantly killed. Three other men were injured so badly that it is believed that they will all die.

(270.) — A boiler exploded, on October 4th, in Laherty & Lee's mill, six miles from Verdi, near Reno, Nev. Engineer J. S. Herrick and a man named Mitchell were killed, three men were badly injured, and two others received slight injuries. The mill was destroyed.

(271.) — On October 5th a boiler exploded in the city delivery company's ice-making plant, at Birmingham, Ala. Virgil Martin and Walter Robinson were injured so seriously that it is believed they cannot recover. The boiler-house was almost completely wrecked.

(272.) — On October 9th a boiler exploded in the water-works plant at Warsaw, Ind. Nobody was injured. A newspaper published in Goshen, Ind., and apparently none too friendly towards some of the Warsawites, says : "It is to be regretted that the Warsaw newspaper liar was not astride the safety-valve when the blow-up occurred : he is too tough to kill, and he might have learned something."

(273.) — Mr. Samuel Horner's mill, at Clover Hill, near Richmond, Va., was demolished by a boiler explosion on October 10th. After the explosion, the place looked as though a cyclone had visited it ; but none of the several men that were near were injured.

(274.) — A small boiler belonging to David Smith, of Heno, near Middletown, O., exploded on October 12th, seriously injuring Daniel Shartle.

(275.) — On October 13th a small boiler exploded at Kingston, N. Y., scalding Irving Stoddard very seriously, and also injuring Peter Snyder to a lesser extent.

(276.) — A boiler exploded, on October 13th, in Belcher's cotton gin, in Bossier parish, a few miles south of Shreveport, La. One man was injured so badly that little hope is entertained of his recovery. One side of the boiler-house was blown out.

(277.) — Two boilers exploded, on October 13th, in the Michigan asylum for dangerous and criminal insane, at Ionia, Mich. Henry Hamlin and John Corey were killed, and John Hogan and James Hand were fatally injured. The building in which the boilers were located was across the river from the main portion of the asylum, and it was blown to fragments.

(278.) — On October 15th, a boiler exploded in a workshop at the Hickory Ridge colliery, near Shamokin, Pa. Samuel Gottschall, Paul Krieger, and William Russell, were painfully scalded and bruised.

(279.) — On October 15th the boiler of a Wilmington & Northern locomotive exploded near Birdsboro, Pa. William Herflicker, George Mills, Henry Suydan, and Willis Woodward were killed. The destruction of the locomotive was complete, and fragments of the wreckage were found a quarter of a mile away. Trees several inches in diameter were felled by flying scraps of metal.

(280.) — A boiler exploded in the gas plant at the works of the American Waltham Watch Company, at Waltham, Mass., on October 18th. The building in which the boiler stood was badly wrecked, and three of the workmen were injured.

(281.) — A boiler exploded, on October 18th, in McDonald's cotton gin, at Jefferson, Texas. The explosion occurred while the operatives were at breakfast, and nobody was injured.

(282.) — A threshing-machine boiler exploded, on October 19th, on Henry Burkhart's farm, at Bareville, Lancaster County, Pa. A portion of the fire was thrown into a straw-stack, igniting it and setting fire to a large barn, which was totally destroyed.

(283.) — A boiler exploded, on October 20th, in Thomas Noltemeyer's mill at Freelandsville, near Vincennes, Ind. Engineer Frank Jarrell was killed, and George Broyer and William Robbins were badly injured. (The same mill was badly damaged by a boiler explosion some time ago, the explosion killing one man in that instance, just as in the present one.)

(284.) — On October 20th a safety water-tube boiler exploded on the Torpedo boat *Davis*, while she was on her official trial trip off Portland, Oregon. Charles Maneely, Paul Luithle, Henry Wood, William Wood, James Ryan, Alexander Johnson, and Albert Buehl were scalded to death.

(285.) — A small boiler exploded, on October 21st, at Annelly, near Newton, Kan. Charles Gear was thrown some forty feet. He was terribly bruised, but will recover.

(286.) — On October 21st a boiler exploded in the factory of the Pentwater Bedstead Company, at Pentwater, Mich. L. O. Tupper and Miller Sorensen were instantly killed, and Timothy L. Palmer was so badly scalded and bruised that he died on the following day. Frederick Gerard and Otto Green were severely injured, and several others received minor injuries. The stack was blown down, the power house was completely wrecked, and a large opening was blown in the side of the main building, near the power house.

(287.) — A boiler exploded, on October 21st, on the towboat *Rescue*, owned by C. Jutte & Co., about two miles above Elizabeth, on the Monongahela river, near Pittsburgh, Pa. The boat was completely wrecked, and the hull sank before rescuing parties from other boats could reach the spot. Captain Charles H. Seidell was killed, and Simpson Morgan, Milton Morgan, James Dawson, Frank Smith, H. Rose, Hugh Gallegher, James Rodney, and George Bailey were more or less seriously injured.

(288.) — On October 24th a crown sheet failed on the tug boat *Arthur D.*, near Manistee, Mich., instantly killing Arthur Pontwood, and badly scalding a man named Peppler.

(289.) — A boiler exploded, on October 25th, on Slade, Gorton & Co's. wharf, at

East Gloucester, Mass. Engineer James L. Hart was severely scalded and bruised, and a boy who chanced to be near received slight injuries. The top of the boiler-house was blown off, and the machinery was wrecked.

(290.) — A heating boiler exploded, on October 25th, in the reformatory at Green Bay, Wis. The damage was not large, and nobody was injured.

(291.) — On October 25th a boiler exploded in the factory of the Valley-Desk Company, at Grand Rapids, Mich. William Bunk was fatally injured. James E. Rainouard, John Reitberg, Frank Roy, and Leonard Swedyk were also injured, though they will recover. The entire side of the building was carried away.

(292.) — Engineer Thomas Marriott was severely scalded, on October 25th, by the blowing out of a manhole plate in one of the boilers of the Elk Rapids Iron Company, at Elk Rapids, Mich.

(293.)— On October 25th a boiler belonging to Humphrey Gaunt exploded at West Marion, Ind. The plant was completely wrecked. James Moore was killed, and Daniel Adams and William Swafford were fatally injured.

(294.) — A boiler exploded, on October 26th, in the Handley Hotel, at Cherryvale, Kan., tearing up the floor of a dining-room, and making a large hole in one of the walls. J. W. Barker, the proprietor, was slightly injured.

(295.) — Grover Dill was instantly killed, on October 28th, by the explosion of a boiler at Salem, Queen Anne County, Md.

(296.) — On October 28th a boiler exploded in the Calumet and Hecla Stamp Mills, at Lake Linden, near Houghton, Mich. John Gillies, William Nellon, and William Boiere were killed, and Daniel Lafrenier was badly injured.

(297.) — On October 29th a boiler exploded in Trullinger's electric light plant, at Astoria, Ore. Two sides of the building were blown out, but the three men who were within it escaped without injury. A residence in the vicinity was riddled with bricks and other wreckage, but the family was fortunately absent at the time.

(298.) — On October 31st a boiler exploded in M. Foley's saw-mill at Ashland, some nineteen miles east of Welch, W. Va., instantly killing the engineer, and injuring a fireman and two other employes.

A Bad Case of Neglect.

In The Locomotive for January last we told of the adventures and experiences of a boiler nearly half a century old, which has received little or no care, yet which continues to serve its owner with great faithfulness. A correspondent sends us an account of another case of the same sort, except that the present candidate for honors is probably not so ancient. "We have read your article entitled 'The Story of an Old Boiler,' with interest and considerable amusement," says the letter; "and we herewith cite a similar case which for good luck can hardly be excelled. Why it hasn't blown up is a profound mystery. The boiler in question is made of iron, and is forty inches in diameter and twelve feet long. It has never had any steam gauge, but it has a common lever safety valve, whose weight is hung in the 100-pound notch. Three try-cocks screwed into the end of the boiler afford the only means of knowing the height of the water; and as the position of the water-line was considered to be of small importance, these cocks were seldom used, as will appear further on. A cast-iron blow-off was attached to the bottom of the boiler; but as it leaked somewhat, the trouble was remedied by simply driving a two-inch wooden plug into the nipple by which the blow-off entered the shell. As the boiler had to furnish power for only about two or three hours a day, it was not considered necessary to go to the expense of providing a pump or injector for feeding it. Before starting up, the weight on the safety-valve was removed, the valve was raised, and a hose was poked in until the boiler was almost full. (A few inches of water, more or less, did not matter!) The boiler was then fired up, and the engine run for all it was worth. The engine was a vertical one, of ten horse-power, and she would jump and hop around on her foundation, till the whole load was on, in a scandalous way. When things had once got well in motion, no further attention was paid to the boiler, during the two or three hours' run, except to fire it up occasionally — no heed being given to the water, and no suspicion being entertained that there might be any danger whatever. On one occasion one of the men about the place remarked that 'there certainly ought to be more steam than there is, because the boiler is red-hot.' (It *was* red-hot, from lack of water.) About this time it dawned upon the help that something out of the ordinary was going on, and they called out the proprietor, who at once ordered the fires drawn, and told the men of the danger. One of the men promptly seized the hose and turned a stream of water on the hot boiler, and you can imagine what a scramble ensued; but everything passed off without anything more serious than a lot of excitement. This is a fair sample of the care the boiler had, and it was run in this manner for over fifteen years, during which time it was never entered for cleaning, — in fact, it was never entered at all, except to drive the wooden plug into the blow-off. This plug got charred and burned after a time, but it never leaked, because it was soon covered with a heavy scale. Owing to the increase of business, the poor old boiler was traded off, after a service of fifteen years, as a partial payment on a new one. It was not cut up for scrap, as you might suppose, but was sold for further use in a saw-mill; and its condition is not so very bad, in spite of the hard experiences it has had. We think it hardly possible that a steel boiler of modern make could stand such protracted neglect and misuse."

We should like to see the inside of this boiler. Unless the feed-water is extraordinarily pure, the boiler must be half full of scale. Suppose this old boiler is thrown away some day. (Of course, we don't suppose it *will* be. It will probably go on running for a thousand years or so, while nice new boilers all around it crack and blow up and raise Ned generally; for that is the way things sometimes go. But, just for the sake of the argument, suppose that it *is* thrown away some time during the course of the next hundred years or so. It will be forgotten, and the winds and the rains of heaven will beat upon it full sore, until all the iron about it has been eaten away, and an elegant stone boiler is left, formed of the scale which now lines the present boiler all over on the inside. If we work our imaginations a little harder still, we can think of some old pumpkin-headed scientist digging it up, a couple of million years from now, and ciphering over it, and trying to make out what it was in the days when it was young. Then, when he finds out that it is just the size and shape of the iron things that used to form part of the steam engine that cut such a big figure back in those barbarous times (as he will easily discover by taking down some ponderous volume from his library shelves), he will be greatly impressed, and he will write a learned paper on "The Lost Art of Making Stone Boilers." Our gift of second-sight isn't working well enough to trace the consequences of this thing any further, so we'll leave that to the reader. The story is a true one (up to the year 1899, anyhow), and the boiler is now running in one of these broad United States; though *which* State it is, shall be (to the general public) a conundrum liable to forty-four answers, since we don't care to specify its location more closely than to say that it isn't running in the same State with our office, and that we are glad of it.

The Locomotive.

HARTFORD, MARCH 15, 1899.

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.

ON page 20 of the February issue of THE LOCOMOTIVE we said, in lines 22 and 23, that "the actual diameter of steam pipe is not *quite* equal to its nominal diameter, or trade size." We should have said, "not *exactly* equal." The change is unimportant, except that the original phrase might lead the unwary reader to believe that the actual diameter is *smaller* than the nominal diameter; whereas the case is precisely the reverse for most sizes, as is shown by the table on page 23, in the article cited.

The Metric System.

Anything that Professor John E. Sweet writes is well worth reading, whether the reader sides with the Professor, or against him. We take pleasure, therefore, in reproducing an article on "The Metric System," which he contributes to a recent issue of *Machinery.* We take particular pleasure in doing this, too, because we would not have it appear that we are over-zealous in advocating the metric system, just because we have published a book about it, which is having a good sale at a dollar and a quarter a copy. We don't want to spoil the effect of his article by criticising it to death, either; because there are certainly two sides to this question, just as there are to any other one. But we think that we can touch upon just one point that appears to bother him, without laying ourselves open to such a charge. That point is, the *decimal subdivision* of the meter and the other units. We cannot conceive of any very good reason why we couldn't use halves and quarters of the new units, just as well as we can use these fractions in our present system. Anyone in civilized continental Europe would know just what a half a liter is, or what a quarter of a meter is; and we do not see how the use of such fractions would damage international trade in any appreciable degree. But the *foot* and the *quart* and the *pound* are so radically different from the metric units that are now so widely adopted, that they are almost past comprehension to the foreigner. With this much by way of preface, we append Professor Sweet's article.

"Twenty years ago," he says, "a pestilence of serious magnitude threatened the industrial activities of the country. It originated at the intellectual center, was disseminated by virus sent broadcast through the educational channels, glistened in the eyes of the learned doctors like stars in the firmament; and could it have been seen by the popular millions that were to be affected by it, it would have been a lowering cloud. Just before the day of dawning there appeared a man, a giant, who, by one stroke of the pen (an essay of twenty minutes' length), hurled the pestilence back. It disappeared and was buried for fifteen years. That pestilence was the Metric System; the essay, a paper read at the first meeting of the American Society of Mechanical Engineers; and the man was Dr. Coleman Sellers, who, by this one act, did more for the country than any other one man during that fifteen years. [This paper, which is printed in the first volume of the *Transactions* of the American Society of Mechanical Engineers under the title, "The Metric System — Is it Wise to Introduce It into our Machine Shops," was referred to in our article on the metric system, in the issue of THE LOCOMOTIVE for September, 1898, where we heartily commended it "to the attention of over-zealous advocates of the compulsory adoption of the metric system."]

"The pestilence is again threatening the country, but this time it is a canker gnawing at the nation's heart. There is a bill before Congress proposing to make the Metric System the only legal standard of weights and measures. This law ought not to be enacted, because it cannot be enforced, and a people who disregard obnoxious laws become indifferent to good ones. The law ought not to be enforced, ought not to be obeyed, because the proposed system is not as good as our present one. It would impose a great burden upon the many millions who could not by any possibility receive any benefit from it, if it was ever so much better, and the millions (or say two millions at the utmost), who would be benefited by it, would have to shoulder none of the burdens whatever.

"Its advocates claim the Metric System to be scientific and more convenient. It is true that it was devised by a board of scientists, but utterly fails to justify its claim to be scientific,* and as to its convenience — that is only true so far as relates to mathematical calculations. The mistake was made when the matter of its evolution was entrusted to a board of scientists instead of a board of men who knew something about weighing and measuring in the industrial and commercial sense.

"The Metric System is an ideal one so far as mathematical calculations are concerned, an ideal system for the man who deals in ideas; but history and experience show it to be the reverse of convenient in the practical uses of life. The decimal system was in the beginning and will be to the end the method of notation, still kept up by those nations who neither weigh nor measure, but every civilized nation, in the development of its industries and commerce abandoned the dividing by ten and adopted the biennial [*i. e. binary*] system. Whether a bushel, a stone, a pound, or a yard, they divided their units into halves and quarters and eighths, and it is so with us to-day, even with our boasted money system; we divide our dollar into halves and quarters, and so long as we had the coin to represent them we stuck to the York shilling and sixpence. When we were forced into using the dime, we cut that in two with a nickel, and though mills are in the law and the books, no one uses them. The men on 'Change, our merchants and the sportsmen, cut the cent into halves, and quarters, eighths and sixteenths; this is the best thing to do, and the natural thing to do, because it is the best. No rule or scale-beam ever graduated is or can be as easily or reliably read if divided into tenths, as in halves, quarters, and eighths; nor is it possible to construct a rule or square on the metric system comparable as a tool to the two-foot rule of the machinist, or the steel square of the carpenter.

"When the nations began to emerge from barbarism, and began to use and deal in weights and measures, each worked out units of their own. In lineal measure a comparison made by Mr. Partridge† showed nearly all had one unit very nearly like the

* As shown by the eminent engineer, Charles T. Porter, in a paper published in *Locomotive Engineering*. [This paper of Mr. Porter's was also noticed and reviewed at some length in THE LOCOMOTIVE for September, 1898.]

† In a paper read before the American Society of Mechanical Engineers, in 1881

English inch, and another like the English foot, which shows (if any such evidence shows anything) that they are natural units, and with which there is nothing in the metric system corresponding. Further evidence that the inch is a natural unit, is the fact that all tables of French sizes, such as tools, bar stock, pipes, and things of that kind, conform as near to the inch and its multiples and subdivisions as is practical with a unit not commensurate.

"The advocates of the Metric System, failing to show that it is based on any scientific ground and abandoning the argument that it is either a natural or convenient one to use, still have the claim that it is to be the system of the world, and that it has already been adopted by all nations but England, Russia, and America. The advocates in Russia say that England and America are falling into line, the advocates in England say that Russia and America are falling into line, and the advocates here tell the same story about England and Russia. They leave out two important facts in their repretentations — that the three countries mentioned are a good half of the civilized world, and that people using the English unit do as much weighing and measuring as all other people aspiring to accuracy put together. Again they assume or carry the idea that all the people of the countries whose governments have legalized the Metric System use it. This is not half true! No nation uses it exclusively, not even the French. In the workshops of Belgium and Sweden, two progressive nations, both the English and French systems are used extensively, and the cost of double sets of all sorts of tools and gauges is and always will be imperative. In some of the countries scarcely more has been done to establish the metric system than was done here more than a third of a century ago — the enactment of a law making the metric a legal system of weights and measures.

"Allowing that all the advantages claimed for a universal system exist, it would be much easier for the nations now using the Metric System to change to the better English one, as they will in time to the English language, because half of them already have the English measures, using them still to a considerable extent; and the change, if worth while at all, would be easier. Why the nations who had no standard of their own adopted the Metric System in place of the English, was because it was settled by the men who use the pencil rather than those who do the weighing and measuring.

"As an evidence that the manufacturers in this country do not favor it, letters of inquiry were sent out to about seventy of the leading manufacturers, and of over forty replies received, only three favored it, one or two allowed that they would adopt it when compelled, and the rest were utterly opposed to it, and would not adopt it, and yet nearly all these manufacturers are doing a large foreign trade. Whoever will take the trouble to investigate will at once conclude that the cost, as stated by Dr. Sellers, as 'millions upon millions,' is not overestimated. The cost affects all industries, from the few dollars of the farmer to the tens of thousands of the manufacturer, and what will it save? A lot of figuring claimed by its advocates! While, as a matter of fact, for a time in many cases the figuring will be multiplied tenfold. All drawings will have to be made anew, or refigured; all tables changed, the engineers' private notes translated; all the constants in formulæ will be wrong; records for estimates will have to be corrected, and, worst of all, every book now printed in the English language, where reference is made to weights and measures, will need to be translated by posterity before they can get a realizing sense of the magnitude of the thing mentioned. What a blessing to posterity, who, it is claimed, are to be the greatest beneficiaries.

"A lead pencil will figure just as well in the Metric System as in ours; but the reformers in this case, as is usual, seem to hit upon a plan that puts the burden and bother of the change on other people, and none upon themselves."

The following editorial, which appeared in the New York *Sun* on January 16, 1899, may be read with advantage in connection with what Professor Sweet has said, although (as its last paragraph shows) it was not written in advocacy of the compulsory adoption of the metric system:

"The contractors for a large amount of ironwork for bridge building in Norway recently placed their order for the material in Antwerp, though they had been in the habit of patronizing British manufacturers. When the question was asked why they transferred their business to Belgium they replied that they would gladly have placed the order in England, but they had been unable to induce British manufacturers to supply the work on the basis of the metric system of measurements: and the necessary measurements were so numerous and complicated that they did not think it worth while to work them all out into British feet and inches. Thereupon the British Board of Trade published the facts, expressed its 'deep sensibility of the injury done to British trade by the delay in the adoption of the metric system of weights and measures by this country,' and urged 'the Government and all public bodies to aid in making the system familiar to the public by making use of it in their various contracts, returns, and reports.'

"About two-thirds of the people living under Christian governments use the metric system. Seventy million more use it in part, and in this country another 70,000,000 are authorized by law to transact their business by metric standards if they so desire. Our Bureau of Foreign Commerce frequently prints with '*The Consular Reports*' most of the metric tables of weights and measures with English equivalents, but strangely omits some important items. For instance, the bureau does not give the metric equivalent of a square mile, though practically every European newspaper, book, and map outside of England and Russia gives areas in square kilometers. It is easy enough to deduce square miles from square kilometers if a person knows the formula: and a line or two devoted to this matter in the comparative tables which our Government takes so much pains to issue would frequently assist the average reader or student.

"The metric system was devised for the purpose of removing the confusion and impediment of business arising from the large number of standards of weights and measures used in different countries. It is not necessary for us to adopt the system out and out, but we can drill our school children so thoroughly in the practical use of the metric standards that they may easily employ them when occasion requires."

Commenting upon this same instance of loss of trade through British adhesion to the foot and pound, London *Engineering* (issue of January 6, 1899,) says: "Throughout Germany the makers of iron pipes, bars, girders, etc., have adopted schedules of dimensions and weights based on the metric system, and these are now followed by engineers in nearly all other Continental countries. This is greatly to the disadvantage of British makers, who must follow the British weights and measures for their home and colonial customers, and cannot at the same time make similar goods based on the metric weights and measures, for Continental buyers. Not many months ago, the British consul at Amsterdam reported that a large order for water pipes had been placed in Belgium, instead of England, simply because the English makers would not comply with the specification, which was based on the metric system. Our competitors are making good capital out of the metric system, as it is practically impossible for British makers and traders to adopt this system, while they must at the same time follow another system for their home and colonial trade. The only way to stop the mischief now being done to our foreign trade in many countries, is to make the adoption of the metric weights and measures compulsory, as was strongly recommended by the Select Committee of 1895. The Committee on Coinage, Weights and Measures, of the United States, has unanimously reported in favor of the metric system being adopted on January 1, 1901."

The little book on *The Metric System* that was recently published by the Hartford Steam Boiler Inspection and Insurance Company doubtless owes much of the success that it has had to the fact that it appears at a time when the problems suggested above are attracting an unusually large share of public attention — or, as Professor Sweet would prefer to put it, when the "metric pestilence" has become so active a "canker gnawing at the nation's heart." For the benefit of those who have not seen the more extensive review published in our September issue (a copy of which will be forwarded to any person upon application to our main office at Hartford, Conn.), we may say that the book contains an account of the origin of the metric system; an explanation of what the meter really is, and of how the other units were obtained from it; and the most complete set of tables that has ever been published, for comparing all sorts of metric units with their equivalents in our own system of weights and measures. The book is of convenient size for the pocket, and it is well printed, and substantially bound in flexible sheepskin, with red edges. It is sent, postpaid, to any address, upon receipt of one dollar and twenty-five cents. (All orders should be addressed to the HARTFORD office of this Company.) We also publish it in another form, at $1.50: the only differences being that the more expensive edition is printed on tough bond paper, and the binding is still more substantial, with the edges in gold. The book has everywhere been received with the warmest expression of commendation.

The *Boston Journal of Commerce* says: "We should advise those who have not already procured a copy, to do so at an early date."

The New York *Commercial Bulletin* says: "It is a great convenience, and to scientific men and engineers it will prove invaluable;" and in a second notice the same journal adds that "the volume is more than worth its price to those interested in the subject."

Machinery says: "A good work has been done in preparing this volume."

The *Scientific American* says: "The first part of the book is devoted to the history of the metric system. This is the best history of the system that we have seen. . . . It should command a considerable sale, as it contains everything that a more expensive book would have."

The *Independent* says: "It will be of the greatest use to engineers and scientific workers. The history of the meter and its original adoption by France, and the other historical and practical information given, is very interesting reading, not alone for engineers, but for the every-day citizen."

Fibre and Fabric says: "This work is arranged, and the calculations made and presented, with the neatness and accuracy which characterize whatever is sent out from the office of this well-known firm. . . . We believe that this book will do a great deal toward educating us on the subject."

The *American Machinist* says: "The book opens with an account of the inception of the metric system, which is put in such shape as to make the system more tangible than it now is, to many minds. . . . It should serve a very useful purpose."

The *American Wool and Cotton Reporter* says: "The treatment of the subject is exhaustive, the tabulations are very complete, and the whole work is compiled with admirable accuracy. It is, in fact, one of the most valuable publications of the kind yet given to the public."

The *Electrical World* says: "The most striking features of the tables are simplicity of arrangement and clearness of type, both of which will render the work of value to the busy man."

The *Engineering News* says: "Of the many metric conversion tables issued, this is by far the best and most convenient that has ever come to our notice. . . . The great usefulness of this little book has already been proven in the short time it has been in this office."

These are only a few of the many good things that the technical press has said of this little book; and out of all the reviews and expressions of personal opinion that we have received concerning it, *in no case whatever* has any adverse criticism been made.

Liquid Fuel in the Navy.

Ever since the discovery of petroleum in Pennsylvania, in 1859, experiments have been made for utilizing some of its products as fuel, and these have been so far successful that there are now numerous forms of burners which are efficient and reliable, both for crude petroleum and for the reduced oil. The conditions on board ship require that the oil shall have a high flash-point, so that there shall be no danger from volatile gases; and this restricts the possible fuel [for marine use] to petroleum refuse, called astatki in Russia, and to "reduced oil," or fuel oil, in the United States, which is practically the same thing.

The advantages of liquid fuel are well known, and have been repeatedly stated, the best presentation of the subject being Colonel Soliani's article before the Engineering Congress at Chicago in 1893. From the Italian experiments there described one very important fact is deducible, which is worth noting, as it corrects a very common but mistaken notion, namely, that the use of steam for atomizing the oil is inadmissible on account of the large amount that would be required. In these experiments it was found, repeatedly, that the steam used for atomizing was less than two per cent. of the amount vaporized.

Inasmuch as the evaporative power of fuel oil is from 1.5 to 1.7 times that of coal, a simple calculation will show that, in one of our first-class torpedo-boats, if enough space be reserved for fresh water to make up for the steam used in atomizing, the amount of fuel oil that can be carried in the present bunker capacity will more than equal the evaporative effect of the total amount of coal now carried. This is important, because the steam atomizers involve very little complication, while the use of compressed air involves a good deal.

Another point in connection with the use of fuel oil, which should be carefully noticed, is that many persons conclude, because the fuel oil has a greater calorific value than coal, that a boiler worked with liquid fuel will necessarily have a greater power than one worked with coal. This inference is not only not justifiable, but is probably erroneous. The experiments thus far made with liquid fuel under high forcing have shown a rate of combustion equivalent to only about 55 pounds of coal per square foot of grate per hour, while there are reliable data of coal having been burned at the rate of more than 80 pounds per square foot of grate per hour. There are practical difficulties in the way of providing an adequate supply of air for burning the fuel oil in large quantities under a given boiler that make it seem probable that, where the very highest results must be obtained, coal will be used.

The cost and difficulty of obtaining fuel oil in all parts of the world have thus far prevented its general use, and, as far as can be seen now, seem likely to continue to have that effect. On the United States coast, representatives of the great oil companies give the assurance that fuel oil can be supplied in large quantities for less than three cents per gallon.

The United States Navy Department intends, on the recommendation of the Bureau of Steam Engineering, to fit one of the torpedo boats with oil fuel apparatus, and, if the bureau's anticipations of complete success are realized, all American torpedo vessels intended for operating on the American coast will probably be fitted for burning liquid fuel. — *Commodore George W. Melville, Engineer-in-Chief, U. S. N., in* CASSIER'S MAGAZINE.

Inspectors' Report.

JANUARY, 1899.

During this month our inspectors made 9,697 inspection trips, visited 19,474 boilers, inspected 6,034 both internally and externally, and subjected 526 to hydrostatic pressure. The whole number of defects reported reached 12,046, of which 1,148 were considered dangerous; 77 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	791	50
Cases of incrustation and scale,	2,233	65
Cases of internal grooving,	105	5
Cases of internal corrosion,	525	42
Cases of external corrosion,	560	53
Broken and loose braces and stays,	114	42
Settings defective,	264	19
Furnaces out of shape,	335	25
Fractured plates,	289	41
Burned plates,	251	40
Blistered plates,	97	7
Cases of defective riveting,	1,565	81
Defective heads,	63	13
Serious leakage around tube ends,	2,962	404
Serious leakage at seams,	394	47
Defective water-gauges,	186	51
Defective blow-offs,	162	54
Cases of deficiency of water,	25	13
Safety-valves overloaded,	84	39
Safety-valves defective in construction,	77	24
Pressure-gauges defective,	412	31
Boilers without pressure-gauges,	2	2
Unclassified defects,	550	0
Total,	12,046	1,148

ON October 13th, a ten-inch steam main burst in the boiler-room of the W. B. Conkey Company, on Dearborn street, Chicago. Engineer John Meldrum was scalded to death. Denis Swenie, M. Strook, and William Davis were also painfully scalded and bruised, but will recover.

Incorporated 1866.

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

Charter Perpetual.

Issues Policies of Insurance after a Careful Inspection of the Boilers,

COVERING ALL LOSS OR DAMAGE TO

BOILERS, BUILDINGS, AND MACHINERY,

AND DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES,

CAUSED BY

Steam Boiler Explosions.

Full information concerning the plan of the Company's operations can be obtained at the

COMPANY'S OFFICE, HARTFORD, CONN.,

Or at any Agency.

J. M. ALLEN, President.
W. B. FRANKLIN, Vice-Prest.
FRANCIS B. ALLEN, 2d Vice-Prest.
J. B. PIERCE, Secretary.
L. B. BRAINERD, Treasurer.
L. F. MIDDLEBROOK, Asst. Sec.
E. J. MURPHY, M. E., Consulting Engineer.

Board of Directors.

J. M. ALLEN, President.
FRANK W. CHENEY, Treas. Cheney Brothers Silk Manufacturing Co.
CHARLES M. BEACH, of Beach & Co.
DANIEL PHILLIPS, of Adams Express Co.
RICHARD W. H. JARVIS, Prest. Colt's Fire Arms Manufacturing Co.
LEVERETT BRAINARD, of The Case, Lockwood & Brainard Co.
GEN. WM. B. FRANKLIN, late U. S. Commissioner to the Paris Exposition.
HON. HENRY C. ROBINSON, Attorney-at-Law, Hartford, Conn.
HON. FRANCIS B. COOLEY, of the National Exchange Bank, Hartford, Conn.
GEORGE BURNHAM, Baldwin Locomotive Works, Philadelphia.
HON. NATHANIEL SHIPMAN, Judge United States Circuit Court.
C. C. KIMBALL, President Smyth Manufacturing Co., Hartford, Conn.
PHILIP CORBIN, of P. & F. Corbin, New Britain, Conn.
GEORGE A. FAIRFIELD, Prest. Hartford Machine Screw Company.

GENERAL AGENTS.	CHIEF INSPECTORS.		OFFICES.
THEO. H. BABCOCK,	R. K. McMURRAY,	NEW YORK CITY.	Office, 160 Broadway.
CORBIN & GOODRICH,	WM. J. FARRAN,	PHILADELPHIA, Pa.	" 432 Walnut St.
LAWFORD & McKIM,	R. E. MUNRO,	BALTIMORE, Md.	" Chamber Commerce.
		WASHINGTON, D. C.	" 511 Eleventh St., N.W
C. E. ROBERTS,	F. S. ALLEN,	BOSTON, MASS.	" 125 Milk St.
		PROVIDENCE, R. I.	" 29 Weybosset St.
H. M. LEMON,	JAMES L. FOORD,	CHICAGO, ILL.	" 169 Jackson St.
C. C. GARDINER,	A. B. ECOFF,	ST. LOUIS, MO.	" 319 North Fourth St.
S. R. BENJAMIN,	F. S. ALLEN,	HARTFORD, CONN.	" 650 Main Street.
W. G. LINEBURGH & SON,	J. H. RANDALL,	BRIDGEPORT, CONN.	" 1 Sanford Building
BURWELL & BRIGGS,	C. A. BURWELL,	CLEVELAND, OHIO.	" 208 Superior St.
JAMES W. ARROTT, LTD.,	BENJAMIN FORD,	PITTSBURGH, PA.	" 401 Wood St.
MANN & WILSON,	J. B. WARNER,	SAN FRANCISCO, CAL.	" 306 Sansome St.
THOS. F. DALY,	T. E. SHEARS,	DENVER, COL.	" Ernest-Cranmer Bldg
LOUIS V. CLARK & CO.,	B. F. JOHNSON,	BIRMINGHAM, ALA.	" 2021 First Ave.
W. S. HASTIE & SON,		CHARLESTON, S. C.	" 44 Broad St.
PETER F. PESCUD,	F. C. BITGOOD,	NEW ORLEANS, LA.	" 818 Gravier St.

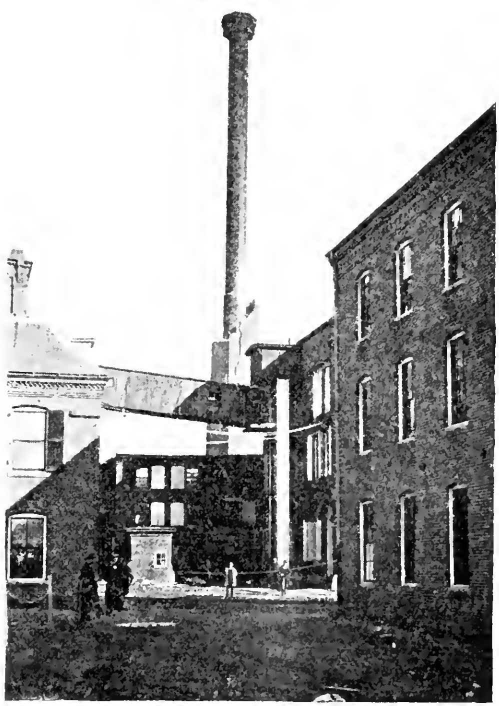
The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XX. HARTFORD, CONN., APRIL, 1899. No. 4.

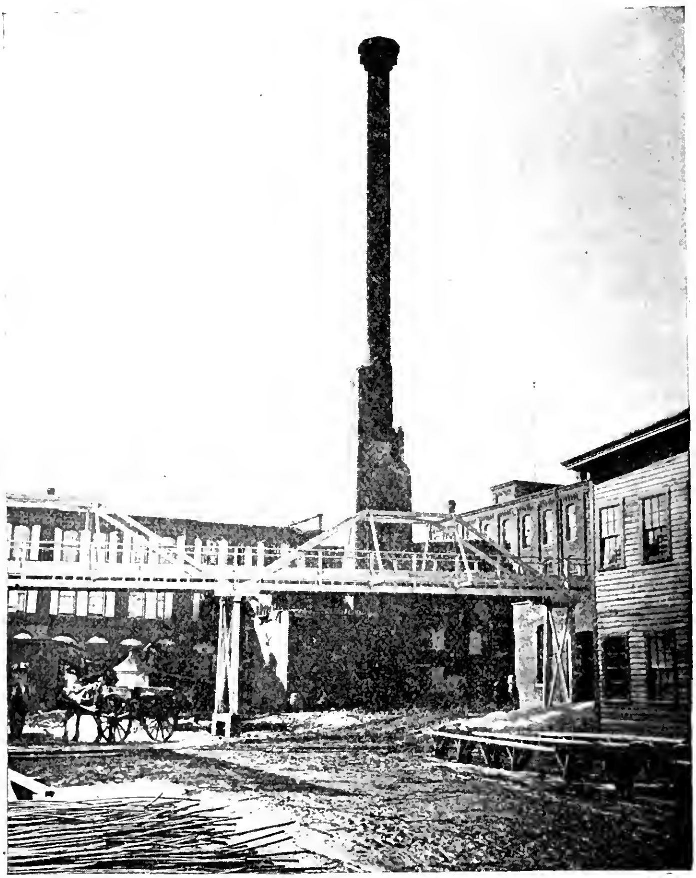
Lightning Strikes a Chimney.

On the evening of March 12th the town of Wakefield, Mass., was visited by a thunder-storm of unusual severity. To use the expression of a witness, the air "appeared to be full of electricity." The lightning was exceedingly frequent and vivid, and the thunder correspondingly heavy and impressive. The arc lights and incandescent lights were extinguished, and the trolley cars ceased to run, partly on account of the burning out of fuses, and partly through the intentional stoppage of the dynamos, as a precaution against possible damage to them. At 8.25 P.M. a bolt of lightning struck the chimney of the Wakefield Rattan Company, and stripped off its outer core for fully one hundred feet below the cap, leaving it in the curious condition shown in the accompanying photo-engravings.



Readers of The Locomotive hardly need to be told that chimneys of this sort are built in two concentric sections. The outer section, or shell, which is the only part of the chimney that is visible to an observer standing upon the ground, is intended to resist the wind pressure. Within this visible shell there is another practically distinct chimney, known as the "core" or "flue," through which the gases from the boilers pass. These two shells are entirely separate (except at the bottom), so that they can move independently without straining each other — the inner one expanding and contracting as it is exposed to varying conditions of temperature, while the outer one sways back and forth as the wind varies in intensity and direction. The air space between the two serves also to protect the outer shell from the heat to which the inner one is exposed. In the strange accident here illustrated, the lightning stripped off the outer shell of the chimney, while leaving the inner one practically uninjured except for a few feet at the top.

The chimney is about 153 feet high, and the inner core is about 48 inches in diameter, internally. The outer shell was octagonal in shape, and about 14 feet in diameter, externally, at the base. The shell fell in four different directions — towards the boiler house, away from it, and parallel to its length. One side struck the boiler house.



On the ground floor of the boiler house there were four boilers, and over these was the drying room, which was filled with wood in short lengths, destined to be used in the manufacture of chairs. The roof of the boiler house was of corrugated iron, supported by structural iron, and the floor of the drying room was constructed in the same manner. The wreckage that fell upon this building was partially deflected by the iron work of the roof, and by the contents of the drying room, so that a considerable fraction of it came down upon the boilers known as Nos. 1 and 2. The boilers themselves were not injured to any extent, but some damage was done to their fittings. Steam was taken from the boilers through four-foot risers, which communicated with the main steam pipe through angle valves. These angle stop-valves were broken on all the boilers. The pop safety-valve on boiler No. 1 was broken and ruined, and the top flange of the safety-valve on No. 2 was broken. The pop valves on Nos. 3 and 4 were uninjured. None of the steam nozzles were broken or strained at the riveting. A four-inch steel shaft which ran in front of the boilers and was supported from the roof, was thrown down and bent, breaking the stems of the valves to the water glasses in its fall, but not breaking the glasses themselves, nor disturbing either the water columns or the gauge

cocks. The fire alarm whistle of the town of Wakefield, which was located at the rattan factory, was destroyed, together with the mechanism used to operate it. The total damage is variously estimated at from $8,000 to $12,000.

Mr. John O'Neil, popularly known as "Steeple Jack," ascended the chimney by means of the iron rungs on the inside of the core, and removed the cast-iron cap, which was built in eight sections, flanged and bolted together. Portions of the outer shell were hanging to the under side of this cap, retained by the anchor bolts, some two feet long, by which the cap had been secured to the shell. A few feet of the core was also removed, and we understand that the core as it now stands is to be guyed until the outer shell can be rebuilt around it.

Fortunately there are no personal injuries to record, although the fireman had a narrow escape. He was attending to the fire of No. 3 boiler at the time, and although he was unhurt, he was thrown out into the yard through an open door directly in front of the boiler that he was looking after. The door through which he passed did not swing on hinges in the usual fashion, but slid up and down in ways, being balanced by a counterpoise. The falling debris broke the fastenings of the counterpoise, and let the door down after the man had passed through it, so that to haul the fires he had to go in through the engine-room. Boilers 1 and 2 were not in service at the time, but there were 60 pounds of steam on No. 3.

It is thought, by some who have viewed the ruins, that the destruction was not the direct effect of the electric shock, the alternative theory advanced by these persons being that the lightning merely set fire to an explosive mixture of air and coal gas, which had leaked through the core, from the inner flue into the space between the core and the outer shell. While this theory is undoubtedly possible, we do not see why it is necessary to resort to it to explain the observed effects.

It is worth noting that the present accident occurred on the eighteenth anniversary of the big fire by which the buildings of this same company were destroyed on March 12, 1881.

Boiler Explosions.

NOVEMBER, 1898.

(299.) — On October 8th an upright hoisting boiler exploded at a mine near Fort Jones, Cal., killing one man. The cause of the explosion is not stated.

(300.) — A boiler exploded, on October 25th, in a cotton gin on the Johnson place, four miles east of Leary, near Cuthbert, Ga., doing considerable damage to the place, and badly wounding a little son of Mr. R. M. Jordan, who was sitting in a doorway near by.

(301.) — A boiler exploded, on October 28th, near Lidgerwood, N. D. Lewis Smith was badly hurt, having both arms and one leg broken.

(302.) — Word has been received from Muncie, Ind., stating that on October 28th a boiler exploded at the Albany Tubing Works. A new and valuable furnace was destroyed. [This account and the three preceding ones were received too late for insertion in the regular October list.]

(303.) — A large boiler used for rendering lard at the slaughter-house of Graber Bros., near Massillon, Ohio, exploded on November 3d. The boiler held 500 gallons of melted tallow at the time of the accident. James Swisher and George Effinger were badly injured, and Effinger cannot recover. The building was badly shattered, and parts of the boiler were blown 300 feet. The property loss was large, but we have seen no estimate of its precise amount.

(304.) — A boiler exploded, on November 3d, near Brownfield, in Pope county, Ill. Engineer Frank Still was instantly killed, his body being torn to fragments. Charles Scott and Frank Still, Jr., were fatally injured, and another man named McAllister was also badly hurt.

(305.) — A cotton gin boiler exploded, on November 3d, on the plantation of Mrs. W. J. Killingsworth, of the Dunbarton section of Barnwell, S. C. Foreman Edward Rush and Engineer Charles Burton were killed. Rush's wife, who was standing near, had her hip broken, and several other persons sustained painful injuries.

(306.) — On November 4th a boiler exploded in the Cimming saw-mill, near Blackburn's Fork, in Jackson county, Tenn. The engineer and the fireman were killed instantly, and three other men were seriously injured.

(307.) — On November 4th a boiler exploded in a pumping station connected with Mr. Kent E. Keller's mill, about four miles south of Ava, Ill. Joseph Bowers, Peter Boucher, and Millard Thurman were injured.

(308.) — A new boiler exploded, on November 4th, in the Oil City Boiler Works at Oil City, Pa., while it was being tested. The explosion was exceedingly violent, and the part of the shop in which the boiler stood was badly wrecked. Charles McClosky's body was found about 100 feet from where he had been working, and when the wreckage had been cleared away, the body of Patrick Frawley was found beneath it. Andrew Gustafoson, Patrick Normile, Dennis McMahon, John Smith, John J. Gidders, and Patrick Londridgen were severely injured. It is very doubtful if Smith can recover, as he received a severe abdominal injury. The boiler passed up through the roof of the building, which is some forty feet high, and fell back again about 40 feet from its original position. The heavy rafters and trusses of the roof were broken off, and a portion of the roof fell with the boiler, covering several workmen in the débris. In reply to several correspondents who ask why such a violent explosion could occur at a *test*, we desire to say (on the authority of the *Oil City Derrick*), that the boiler "was being tested with steam," instead of by the safe and usual method of applying hydrostatic pressure. In view of this fact we consider it a trifle strange that at the inquest held by Coroner Snowden, "the jury rendered a verdict that the explosion resulted from causes unknown, and exonerating the company."

(309.) — On November 5th a threshing-machine boiler belonging to D. Wallace, exploded on the Thacker farm, near Hamilton, N. D. Engineer James Eggard was severely scalded and cut, and Alfred Steel was blown over a wheat stack, landing, headforemost but uninjured, in a pile of straw.

(310.) — A small boiler exploded, on November 6th, in Lewis Habor's restaurant, on Brighton street, Boston, Mass. The explosion wrecked the entire rear of the restaurant, but, fortunately, nobody was hurt.

(311.) — A boiler exploded, on November 8th, in Ephraim Evans's cotton gin, near Eastman, Ga. One person was killed.

(312.) — On November 10th the boiler of locomotive No. 678, on the Canadian-Pacific Railway, exploded one mile east of Shuswap, near Kamloops, B. C. Engineer James Little and Brakeman E. Reid were killed, and Fireman John George was badly scalded. The force of the explosion was so great that the engine was turned completely around. The top of the cab was blown upon a telegraph pole, and the tender and five cars were wrecked.

(313.) — The boiler of the steam heating apparatus in the Young Men's Christian Association building at New Haven, Conn., exploded on November 12th. We have not learned further particulars, except that somebody has worked up an ingenious and altogether useless and unnecessary theory of the explosion, which assumes that a poker fell down somehow, and opened the feed valve when the water was low and the boiler was overheated.

(314.) — On November 12th a boiler exploded in Whittinghill's flour mill at Hillham, Dubois County, Ind. Mr. Whittinghill, who was acting as fireman at the time, was instantly killed, and two other men were badly scalded.

(315.) — A boiler exploded, on November 12th, in the works of the Elk Tanning Company, at Curwensville, some twenty miles south of Dubois, Pa. William Brown, Herbert Sipes, and Bryan Charles were badly scalded, and it is doubtful if Brown can recover.

(316.) — A boiler exploded, on November 12th, in the gas works of the Richmond Water and Light Company, at Richmond, Ky. Night Watchman McCreary was injured, and the entire end of the building was demolished. One account that we have received states that "the large two-story brick structure looked like a cyclone had struck it."

(317.) — A slight boiler explosion occurred, on November 13th, on the steamer *XL*, at Carrabelle, near Jacksonville, Fla. George A. Ludwig was scalded so badly that he died within a few hours.

(318.) — On November 14th a boiler exploded in the electric light plant at Nelsonville, O. We have not learned further particulars, except that nobody was injured.

(319.) — On November 14th a boiler exploded in Howell & Abbott's cotton gin, at Warsaw, near Alpharetta, Ga. A man named Ellis was killed, and William Kellogg was badly scalded and had his thigh broken. The boiler passed through a dwelling house occupied by Arthur Maxwell, and fell several hundred feet from its original position.

(320.) — A boiler belonging to John Marshall exploded, on November 14th, at Coffin's Station, about three miles west of Tremont City, near Springfield, Ohio. David Zerkle, Jr., was instantly killed, and Benjamin Grube and David Zerkle, Sr., were badly injured. It is believed that Grube cannot live.

(321.) — On November 15th a boiler exploded in the hardwood plant of A. B Nickey, located at the junction of the Air Line and E. & T. H. railroads, near Princeton, Ind. Night-Watchman William Montgomery was fatally injured. The machinery in the plant was ruined, and the building was completely wrecked.

(322.) — The boiler of a threshing-machine outfit exploded, on November 16th, in Russia township, near Elyria, Ohio. William Springer was badly injured.

(323.) — On November 16th a boiler exploded at Cotton Hill, Fayette county, W. Va. The building in which the boiler stood was wrecked, and William Treadway, John Radford, and Elias Radford were blown to pieces.

(324.) — A boiler exploded on November 17th, at Maniton, Hopkins county, Ky. Two men, named Gentry and Durham, were badly injured, and it is doubtful if Durham can recover.

(325.) — The boiler of a New York Central freight engine burst, on November 18th, at Niagara Falls, N. Y. We have not learned of any personal injuries.

(326.) — On November 18th a boiler exploded in Rucker's mill, at Lono, near Malvern Junction, Ark. Two brothers named Ross were scalded so badly that their recovery is doubtful, and several other persons were injured to a lesser extent.

(327.) — The boiler of Erie freight engine No. 709 exploded, on November 20th, at Converse, on the Chicago & Erie railroad, near Galion, Ohio. Fireman David Little was instantly killed. Engineer Walter Shirtliff was badly injured, and Conductor Edward Quick and Brakeman Frank Smith were also injured, though less seriously. Two tramps that were stealing a ride on the train are also said to have been killed.

(328.) — On November 21st a boiler exploded on the Lintz oil lease, at Clarion, Pa. Nobody was injured.

(329.) — A slight boiler explosion occurred, on November 23d, in the Standard flour mill, at Minneapolis, Minn. Michael Churlik was scalded so badly that he died within a few hours.

(330.) — A small boiler exploded, on November 23d, at West Fork, near English, Ind. William Festler was fatally scalded.

(331.) — A boiler exploded, on November 23d, at Black Jack, St. Louis county, Mo. William and Hugo Jacobsmeyer were fatally injured.

(332.) — On November 23d the boiler of a freight engine exploded on the Cincinnati, Hamilton & Dayton railroad, near Jones Station, some five miles south of Hamilton, Ohio. Fireman Daniel Ronalson was instantly killed. Engineer Charles Boyer, Edward Martindale, and Henry Metz were seriously injured. The train was crossing a viaduct at the time of the explosion. The locomotive was thrown down to the ground below, a distance of some thirty feet. Twenty-three cars were derailed and piled upon top of one another, and the track was torn up for a distance of fifty yards. The locomotive was destroyed, and it is hard to conceive how any of those present escaped alive.

(333.) — On November 24th a boiler belonging to J. C. Houck exploded at Mooreland, near New Castle, Ind. Nobody was injured.

(334.) — On November 24th the crown-sheet of locomotive No. 578, of the Denver & Rio Grande railroad, gave way near Swallows, Col. Fireman J. E. Perkey and Brakeman Guy Livingston were killed, and Engineer W. C. Pennington was injured.

(335.) — A boiler explosion occurred, on November 25th, in the office of the *Weekly Republic*, at Weatherford, Texas. One of the employes, who was standing near by, was injured.

(336.) — On November 25th the boiler of locomotive No. 61, of the Dayton & Union railroad, exploded at Greenville, Ohio. The train was moving slowly, and the engineer and fireman jumped in time to save themselves from serious injury.

(337.) — A boiler exploded, on November 25th, in I. W. Session's mill, near Montevallo, Ala. James Sessions, the proprietor's son, was injured so badly that he died a few hours afterwards.

(338.) — The boiler of locomotive No. 67 of the F. C. & P. railroad exploded, on November 26th, at Waldo, Fla. Engineer Edward Green was instantly killed. Paul Whaley, who was standing near the locomotive, was somewhat injured by a flying fragments of the destroyed locomotive.

(339.) — On November 26th a boiler exploded in the Big Four pumping station, at Nokomis, Ill. Albert Lant and Engineer James Somers were injured. The building was wrecked, one side of it being blown entirely out, and the roof being also carried away.

(340.) — A boiler belonging to James C. Moore exploded, on November 26th, near Ypsilanti, Mich. Louis Moore was fearfully injured, but it is believed that he may recover.

(341.) — Two Northern Pacific locomotives collided, on November 27th, in a cut some twenty-one miles east of Missoula, Mont. The boiler of the west-bound locomotive exploded, killing Fireman P. J. Murray, and injuring Engineer F. M. House.

(342.) — On November 27th a boiler exploded on the river steamer, *T. C. Walker*, at Turner's Landing, some fifteen miles below Stockton, Cal. W. A. Blunt, Jeremiah Daly, Mr. and Mrs. Watson Henry, Ferdinand Ward, John Holdsberg, and John Tulan were killed. Louis Brizzolana, John Burns, James Corcoran, Coratti Dominici, G. Foppiano, John Figoni, Edward Paul Jones, Martin McCaffery, and George P. Smith were severely injured. Some fifteen other persons also received lesser injuries. The pilot house and all the forward works of the steamer were wrecked.

(343.) — Two boilers exploded, on or about November 30th, in Harned Bros.' spoke and handle factory, at Guthrie, Ky. Nobody was injured.

The Passing of Keely.

John Worrell Keely, the inventor of the impossible combination of spokes and wheels and pipes that was long notorious under the name of the "Keely motor," died in Philadelphia, on the 18th of last November, at the age of 71 years. We have never had the least idea that there was, or could be, any merit whatever in his "invention"; but, on the other hand, we have never been able to come to any definite conclusion concerning his real object in putting together such fearsome aggregates of iron and copper and other unoffending metals. The *American Machinist* says, in a recent issue, that the ways of Mr. Keely "were not the ways of an honest and truthful man, nor the ways of an inventor or discoverer of anything great; and that he was so long successful in his career is one of the marvels of the age. All his apparatus is well deserving of a place in some museum where it may stand as a warning to the over-credulous, whom, like the poor, we have always with us." This view of the case has much to justify it, and yet it somehow fails to be entirely satisfying. If Keely was a rogue, who knew well that he had nothing of value, it would be reasonable to expect him to float his company for a large amount, and then disappear. That is the prescribed *modus operandi* for such exploits. The genuine gold-brick artist does not spend a quarter of a century in a workshop. We think it is more or less probable that Keely believed (for a long time, at any rate, though perhaps not to the end) that he was on the track of something full of promise. His peculiar and extravagant verbiage, devoid of sense to the ordinary hearer, was doubtless due, to some extent, to his limited education. Most or all of his sesquipedalian words he had seen somewhere, and had appropriated to his own purposes, without knowing just what they meant. We think it doubtful if any man who *did* know their meaning, could string them together in the wondrous fashion in which they issued from him. We should say, in a general way, that Keely probably did not understand the difference between the exerting of a vast pressure against a fixed object, and the production of motive power, by causing such a force to *push* something continuously before it. We are more inclined to regard Keely as an uneducated man, not quite mentally sound, who thought, for a long time at any rate, that he was on the road to an important discovery; and who resorted to trickery when it became necessary to *show* results of some kind, in order to coax from the capitalists' pockets the dollars that he vainly hoped would enable him to achieve the same ends *without* trickery. It does not appear likely that he could apply himself so diligently to his one idea for a quarter of a century, without eventually satisfying his own mind that his longed-for goal was unattainable; and so towards the end he may have given up his hopes, and, weighed down by increasing years, he may have deliberately defrauded his remaining backers, at the last, in order to spend his declining years in comfort. We print, below, an extract from the April issue of *The Cosmopolitan*, which tells something of Keely and his ways. The original article from which this extract is taken is finely illustrated with half-tone pictures, and we commend it to the attention of persons who may be interested to know how Keely and his engines looked.

[Extract from THE COSMOPOLITAN.]

To understand Keely's history let us revert to the year 1872, when the Keely Motor Company was organized, and the enthusiasm over the "new force" brought into the fold men whose very names at that period stood for common sense and perspicacity. At the Fifth Avenue hotel, New York city, a meeting was held, presided over by Edward B. Collier, a lawyer, who in his particular line of patent attorney had from time to time come in contact with inventors struggling for a hearing. The meeting was composed of bankers, merchants, scientists, and practical engineers, and the result was satisfactory, from Keely's point of view. The project gained substantial assistance. Money was subscribed, and the following day there was placed in the hands of Keely a check for ten thousand dollars; and this, to do him justice, he immediately expended for machinery, or material necessary for the construction of his peculiar apparatus. In fact, whatever the vagaries of the man, however much his ideas may have been beyond the limit of common sense, that Keely spent the money which he obtained in experimental investigations cannot be denied, even by the most strenuous of his opponents, at that time or now. Small consolation this, to the many who fell victims to the smoothness of his speech or the incomprehensible language which he employed. At any rate, after being launched, the motor project soon found itself in deep water. Funds began to get low, and bankruptcy followed. Luckily, a friend now appeared on the scene. From one time to another, Keely's patroness, Mrs. Bloomfield Moore, who was left the executrix of her husband's will, advanced the "inventor" large sums out of the fortune accruing to her from her husband's estate. Now and then a halt was called, to be sure, but the persuasiveness of the "inventor" would make her rally to his assistance once more, and another lease of life would be accorded to the motor.

A great public exhibition was given in Philadelphia, but while enthusiasm ran riot among a certain clique, skeptics were plenty, too, and the persistency with which Keely would refuse to admit any one into his secret raised suspicion — which, nevertheless, did not prevent a famous Philadelphia physician from advancing his individual check for ten thousand dollars. This was in 1881. In 1890 the stockholders began to grumble, and something had to be done to save the cause. Keely had just declared that he was on the eve of success; that another step would bring him to the threshold of the mystery that until then had been a mystery even to him, as he admitted. Again his remarkable force of character saved the day. The work was continued and one machine followed another, only to be thrown aside for some new contrivance destined to assist in the revolutionizing of the existing order of things. One individual who visited Keely's place said that a pint of water poured into a cylinder seemed to work great wonders. The guage showed a pressure of more than fifty thousand pounds to the square inch. Great ropes were torn apart, iron bars were broken in two or twisted out of shape, and bullets were discharged through twelve-inch planks by a force which could not be determined. Keely also declared that with one cup of water he would be able to send a train of cars from Philadelphia to San Francisco, and that to propel a steamship from New York to Liverpool and return would require just about one gallon of the same very harmless and ordinary fluid.

It was almost worth the price of falling a victim to hear Keely theorize, expostulate where it became necessary, and survey his audience with one of those superior glances which were meant to show that he half pitied those who failed to understand his vocabulary.

After the death of Keely, the "motor" was removed to Boston, where it now reposes in the safe-keeping of one of Keely's friends. Mrs. Bloomfield Moore, who had supplied large sums of money for the furtherance of the project, died shortly after Keely himself, and her son, Mr. Clarence B. Moore, then resolved to expose the trickery which he was convinced lay at the bottom of the thing. Keely's house was rented, and investigations were begun. Leading Philadelphia scientists assisted in the work, and the first discovery came in the shape of an immense steel globe. Almost covered with dirt and rubbish, it was held down in the earth of the cellar by heavy beams. When relieved of its incumbrance, the sphere was lifted out of its resting-place, and subsequently was found to weigh more than three tons. On the top of the globe a threaded hole was discovered. Immediately near the sphere was found an iron pipe, which led for a distance of more than fifteen feet into the space under the front room. Here was discovered a pit lined with wood and covered by a trap-door. Fresh ashes gave evidence of a careful demolition of material not thought valuable enough for removal, and yet necessary to have out of the way. In these ashes, however, were found short sections of what at first was considered to be wire, but subsequently proved to be brass tubing. A large amount of glass tubing was likewise found in the debris. The fragments left behind gave striking evidence of the care exercised in removing the Keely motor machinery from its home. The next day, still greater results rewarded the searchers of the premises. The room in the rear was curiously raised above the others, and this was the apartment in which Keeley conducted all those experiments which had puzzled the world until his death. When the floor was torn up, the revelation was complete. Through the joists, in holes specially cut for the purpose, ran a short brass tube. Other tubes were discovered also, and the whole went to show that the motor had been connected, here, with the spherical contrivance in the cellar. In the presence of Prof. Arthur W. Goodspeed, professor of physics at the University of Pennsylvania; Prof. Carl Hering, one of the most eminent electrical engineers in the country; Prof. Lightner Witmer, professor of experimental psychology at the University of Pennsylvania, and Mr. Moore, who had the investigation in charge, the nature of what had been laid bare now came in for earnest consideration. It was determined beyond a doubt that the tubing, and the spherical reservoir found in the cellar, stood conclusively for the argument that compressed air might easily have accomplished all that had been demonstrated so mysteriously by Keely.

WE have received from the author a copy of François Sinigaglia's *Application de la surchauffe aux machines à vapeur* ("The Application of Superheating to Steam Engines"). It consists of a series of papers on the subject, which are reprinted from the *Revue de Mécanique*, and is a valuable contribution to the literature of superheated steam.

The Locomotive.

HARTFORD, APRIL 15, 1899.

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

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

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

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

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

THE circulation of THE LOCOMOTIVE has increased so greatly, that we have been obliged to introduce radical changes in our mailing department. In revising our lists for this purpose, it is probable that more or less mistakes have been made, and we shall consider it a favor if our readers will notify us of any errors that they may detect in the addresses, as we desire to have them all as correct as possible.

WE acknowledge, with much pleasure, the receipt of the *Report*, for 1898, of the chief of the Massachusetts district police, which contains, among other information, the reports of the various state boiler inspectors for the year. Massachusetts has a law requiring engineers and firemen to be licensed. It appears from the present report that 5,655 applicants for such licenses have been examined, with the result that licenses were issued in 3,571 cases, and refused in 2,084 cases. Two licenses were also revoked — a surprisingly small number, when the total number that were granted is considered.

"Magazine Science."

All science may be divided into two broad classes; namely, into science that *is* so, and science that *isn't* so. The first of these divisions is what we expect to find in the standard treatises that are written by eminent men, and in the articles that appear in high-class scientific periodicals. It is true that we are sometimes disappointed in this expectation, for occasionally we find some of the science that *isn't* so, even where we should expect it least. The kind that isn't so is far easier to write; and as the other kind can be produced only by great labor, it is not strange to find our most trusted authorities occasionally going astray, and giving us a few paragraphs of foolishness now and then.

Beautiful examples of the kind of science that *isn't* so can be found in the newspapers, and in a good many of the so-called "popular" books. Such books are written, for the most part, by men who have an idea that that mythical individual, "the average man," cannot understand the real facts of nature, and they appear to think it necessary to tone down those facts and smooth them off and fix them up and elucidate them by "popularized" illustrations that are more or less inaccurate, until their books, when they are completed, contain much of the second kind of science; that is, much of the science that *isn't* so. All of which is reprehensible in the extreme. It is also altogether unnecessary, as is evident from the few really first-class popular books that have been produced — Tyndall's "Heat Considered as a Mode of Motion," for example.

To the two classes of science into which most writings can be divided, and which are mentioned above, an intermediate division, or *sub class*, may be conveniently added, so as to include the science that is *almost so*, but *not quite*. For science of this sort we propose the name "Magazine Science," since it is in our leading magazines that such science is nowadays most prominently put forth. Magazine science, as thus defined, may degenerate at times into the kind of science that is *not* so, but it seldom rises so as to be clearly in the class that *is* so.

It isn't long since *Harper's Magazine* published a roseate article on the Jacques carbon battery, in which the vast possibilities that were said to be before that battery were suggested in the most hopeful terms. This battery attracted a great deal of attention from the general public, and with the apparent endorsement of a magazine as favorably known as *Harper's*, it would have been easy (we should think) for an unscrupulous man to have organized a company that would have taken many good dollars from men who could not afford to lose them. We do not mean to imply that Dr. Jacques had any such idea in his head; but we *do* mean that a magazine that is well known and widely read and trusted takes a great responsibility when it publishes an article that leads thousands and thousands of readers to believe that a great and probably profitable invention or discovery has been made, when it really has not been made. We discussed the Jacques carbon battery in the issues of THE LOCOMOTIVE for August and September, 1896; and the correctness of our view of the matter has been substantiated by the fact that the carbon battery has now fallen, to all appearances, into innocuous desuetude.

A recent and widely-discussed example of "magazine science" occurs in *McClure's Magazine* for March, of this year, where Mr. Ray Stannard Baker writes of "Liquid Air." The article contains much that is of deep interest, and some things that are not so. With one or two exceptions, the portions that treat of the *experimental* data are apparently correct, while the portions that deal with theoretical principles are sadly in error. This is probably due to the fact that neither the writer of the article nor the experimenter (Mr. Charles E. Tripler) are very well informed on the subject of thermodynamics.

This article on liquid air has already received much rough treatment from the technical journals and the newspapers, and we have no desire to add to the condemnation that has been heaped upon it. We have received a good many inquiries about it however, and our readers appear to expect us to go on record in the matter upon one side or the other, and so we shall give our views as briefly as possible.

The part of the article which has provoked hostile criticism is that in which Mr. Tripler speaks of running an engine with three gallons of liquid air, and using the power so developed to drive a compressor which produces ten gallons without being supplied with any mechanical energy save that obtained from the three gallons used in the engine. Many of the critics of the article appear to scent a perpetual motion scheme here, in spite of Mr. Tripler's earnest disclaimer. Mr. Tripler says that the heat *of the surrounding atmosphere* is boiling the liquid air in his engine and producing power, just as the heat of coal boils water and drives off steam, which develops power in the steam engine. He says that he is merely converting the natural heat of our atmosphere into mechanical energy, instead of following the usual plan and obtaining the heat to be so transformed by means of the combustion of coal. This explanation is a peculiarly seductive one, because, to the general reader who has not made a study of the theory of heat, it appears to be rational and by no means impossible, nor even improbable.

There is an obstacle in the way of such a project, however,—an obstacle known as the "second law of thermodynamics."

The transformation of heat into mechanical energy is governed by two general laws. The *first* of these laws states that whenever such a transformation does take place, whether in a steam engine or a gas engine or a liquid air engine or a heat motor of any other kind, a perfectly definite amount of heat disappears for every foot-pound of mechanical energy that is produced. This law is quite well known, and there is nothing in the article in *McClure's* which contradicts it in the smallest particular.

The *second* law governing the transformation of heat-energy is by no means as easy to state. It may be presented in several different forms, whose equivalence is not at all obvious. In the simplest of these forms, the second law consists in the statement that heat always tends to pass from a hotter body to a colder one, and that it cannot be made to pass in the reverse direction (that is, from a colder body to a hotter one) without the expenditure of energy. (When so stated, the law may be compared, for the sake of clearness, with the fact that water always tends to pass from a higher level to a lower one, and that it cannot be made to flow in the opposite direction without the expenditure of energy, by a pump or otherwise.) Although the "second law," when presented in this form, may appear absurdly simple, yet its consequences are by no means easy to follow, and many of them are so hidden that much patient study is required to trace them out. Without going into the matter more deeply, we shall state that one of the many important consequences of this "second law" is, that it is impossible, by means of any reversible mechanical device or combination of devices, in which a working body is subjected to a cyclical change of temperature, to derive continuous mechanical effect from air or any other substance, by cooling it below the temperature of the coldest of the surrounding objects. We have stated this consequence in a rather ponderous way, because when we are criticising another fellow we always want to be quite exact in our own statements. The untechnical reader need not trouble to cipher out just what the foregoing statement means, provided he is willing to accept our assurance that Mr. Tripler's apparatus is the equivalent of the kind of apparatus there described, and that the thing he is trying to do is the very thing that is there declared to be impossible. He subjects a given mass of air to the following operations: Firstly, he cools it and compresses it, until it liquifies. Secondly, he allows the air thus liquified to evaporate and expand in an engine. Thirdly, in the course of this process he claims to have gained a certain amount of mechanical energy, and he states that the mechanical energy so gained is obtained by the absorption of heat from the surrounding atmosphere, and the transformation of the heat so absorbed into work. That is, he claims that the mechanical energy that he gains is obtained by cooling a certain portion of the ambient air *below the temperature of the rest of the ambient air;* which is precisely what the second law of thermodynamics says cannot be done by such means as he employs.

In reply to these considerations it may be urged that all human knowledge is liable to additions and corrections, and it may be claimed that Mr. Tripler has discovered that the second law of thermodynamics is unsound, and that he has shown how it can be violated. Our rejoinder to this argument would be as follows:

(1) The second law of thermodynamics has been subjected to the most searching tests, by many physicists and mathematicians of undeniable ability, and yet it has withstood all these tests perfectly. It has predicted many previously unknown facts which have afterwards been verified by direct observation, and it has never, heretofore, been found to be at variance with experience in the smallest particular.

2. We believe that Mr. Tripler is not thoroughly informed on the subject of thermodynamics, for the following reasons: (*a*) He speaks of the "absolute zero" as "Dewar's," whereas the fact is that Dewar has had nothing to do either with the theory of the absolute zero, or with the experimental determination of its position. The theory is due to Lord Kelvin, and the experimental determination of the position of the point is due to Kelvin and Joule. (*b*) He says that "we don't yet know just how cold the absolute cold really is . . . but Professor Dewar thinks it is about 461 degrees below zero, Fahrenheit." Now this is literally correct, and yet it is hardly what a man would say, if he were aware that our uncertainty about the position of the absolute zero can hardly amount to a third of a degree. The language is that of a man whose knowledge of the theory comes from some popular lecture or article, rather than from a sound knowledge of what the absolute zero is, and how and by whom its position was determined. (*c*) On the last page of the article in question it is implied (presumably with Mr. Tripler's sanction) that the efficiency of a reversible cyclical heat engine may depend upon the nature of the working body, it being particularly intimated that air is superior, as a working body, to water and steam. Now this is one of those plausible-looking things that further study shows is not so: and Carnot taught us, in the early part of the present century, that the efficiency of the engine does not depend in the least degree upon the nature of the working body, being the same whether that body is air or steam or ether or bisulphide of carbon, or anything else. (*d*) Except in the more advanced treatises, writers of books on heat engines and thermodynamics have seldom treated the "second law" carefully enough and fully and clearly enough to give the reader a good understanding of it. This is unfortunate, and it doubtless explains why so many otherwise capable inventors repeatedly try to do things that are opposed to this law. The "second law" ought to be popularized as the first one has been, so that such intelligent and capable men as Mr. Tripler might have an opportunity to inform themselves about it, without having to study higher mathematics and perhaps some foreign language also, to do so. A book is wanted on this subject, and if somebody doesn't write it pretty soon, we may be forced to write it ourselves!

Now if it be admitted (1) that the "second law" of thermodynamics has been sorely tried and yet never before found wanting, and (2) that Mr. Tripler is probably not well informed concerning this "second law," then the probability that he has demonstrated the falsity of this law becomes very small, and the alternative probability, namely, the probability that his reputed production of ten gallons of liquid air from three is to be explained in some other way, becomes correspondingly greater.

It will be observed that we have adhered, in this discussion, strictly to the technical and scientific aspects of the problem, and that we have scorned to make use of the suggestion raised by our esteemed contemporary, the *American Machinist*, which says that "Mr. Dickerson, Mr. Tripler's most trusted assistant, was compelled to acknowledge, at a recent meeting of the Franklin Institute, that the statement [about producing ten gallons of liquid air from three] was untrue." We trust that our forbearance in not raising this point will be appreciated by all concerned.

Another recent example of "magazine science" will be found in *The Century* for April of this year, under the heading, "Absolute Zero." The author of this article tries, at the outset, to give his readers an idea of the kinetic theory of gases — a theory about which he appears to have some very hazy ideas. He compares the molecules of a gas with a lot of little balls, in the following language: "Picture to your mind a room in which there are small balls all alike, each ball endowed with bitter hatred of all other balls of its own kind, and an intense desire to get as far from them as possible.

The balls will assume positions equidistant from one another in every direction, and the outer ones will press against the walls of the room with all the force they may possess in their effort to get away from their kind. If more balls are forced into this room, all the balls must readjust their positions and come nearer to one another. The result of forcing them nearer together will be to produce a greater tendency to go farther apart, and greater pressure against the walls of the room. The balls represent molecules of gas — for example, oxygen. The gas presses against the walls of its retaining vesse: *because of the repulsion between the molecules.*"

As the article here under examination has not attracted the same attention as the one in *McClure's*, and as it does not hold out the same extraordinary possibilities in the way of producing power and otherwise revolutionizing things, we shall not need to discuss it at any great length. We cannot allow our author, however, to speak of molecules as "becoming accustomed to one another," or as being "endowed with bitter hatred," or as having "intense desires" to do things, without a passing expression of our contempt for all such puerile phrases. A magazine of the standing of *The Century* should not admit such wishy-washy language to its pages. Its readers are not children, and any man who would take any interest in the "absolute zero" whatever, would be able to understand good straight English.

Passing now to the question of *accuracy*, we find that the passage quoted above contains a serious error of fact. "The gas presses against the walls of its retaining vessel," says our author, "*because of the repulsion between the molecules.*" Now one of the most elementary teachings of the molecular theory is, that this is not the case at all. In fact, the molecules of bodies never do repel one another, so far as we are aware, except possibly in the case of hydrogen. The evidence of such repulsion even in hydrogen is very weak indeed, and in all other bodies that have been investigated the molecules *attract* one another. The pressure that gases exert against the vessels containing them is due to the collisions of the flying molecules with the walls of those vessels. The intermolecular forces, instead of *causing* that pressure, actually tend to *diminish* it to a slight extent. A writer who would fall into an error as elementary and as gross as the one here signalized, has no business to write articles on these matters for the "instruction" of the public. We are not surprised, after noting this blunder almost at the outset, to find other meaningless or erroneous phrases later on. For example, on page 884 the article refers to the diminution of the electrical resistance of pure metals at low temperatures, and goes on to make the meaningless suggestion that "perhaps electrical waves traverse external space without loss of energy." If he means that a vacuum will allow of the passage of an electric *current* without resistance, he is writing arrant nonsense. If he means that perhaps waves of electrical *displacement* can traverse external space without resistance, he is only putting forth as his own crude guess a proposition that has been established ever since Maxwell's electromagnetic theory of light was first accepted by physicists. Besides, what has temperature to do with space, anyhow? How can a vacuum be hot or cold?

The illustrations used in *The Century* article were made from photographs taken in Mr. Tripler's laboratory; and in the closing paragraph of the article we find that its author is more or less tinctured with Triplerism. He just nibbles at it a little bit, but is too wary to commit himself to it fully, as *McClure's* writer did. The paragraph in question is as follows: "Eager minds are striving to invent grander uses for the greater forces which the recent results place at our disposal, and some think they can foresee the day when the power stored in these abysses of cold will enable man to do that which is now looked upon as impossible, or at least chimerical."

"Magazine Science" is a wondrous thing.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XX. HARTFORD, CONN., MAY, 1899. No. 5.

On Heating Water by Steam.

In the course of the past year and a half we have published several articles, in THE LOCOMOTIVE, concerning the heating of water by steam, both by the direct injection of steam and by the use of closed coils. Since these articles were published, we have received numerous letters in which the rules given, and the calculations given to illustrate them, are declared to be at variance with the results that are attainable in practice. Hence it has become desirable to publish still another article on the same subject, point-

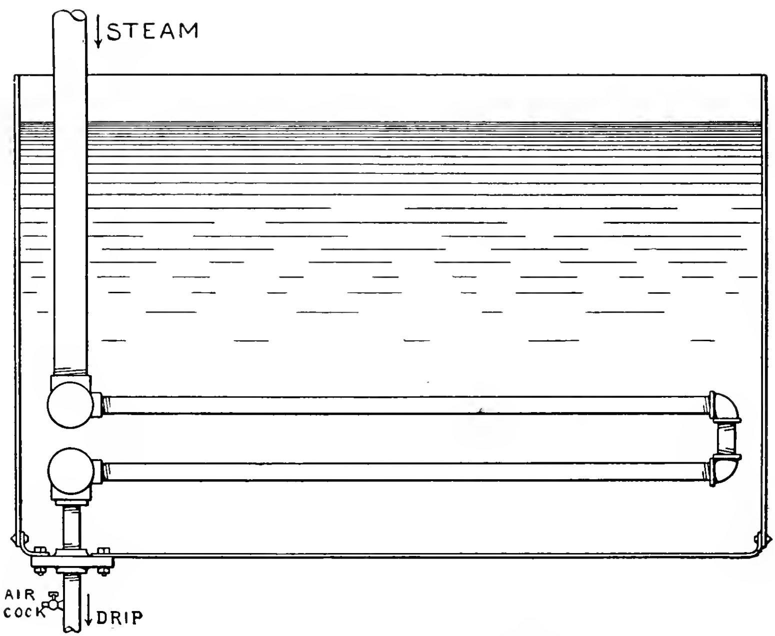


FIG. 1.—SIDE VIEW OF COIL WITH MANIFOLDS.

ing out some of the reasons why the results that are theoretically possible are not always attained in practice. The rules that we have given are, in our judgment, substantially correct; and when the results that they promise are not realized, it is safe to say that there is some fault in the size or arrangement of the piping. In quite a number of the letters that have come in, it has not been possible to point out the exact nature of the trouble, because our correspondents have frequently omitted to give full enough data concerning the arrangement and mode of operation of their heating apparatus.

Generally speaking, however, we are inclined to the opinion that the main difficulty has been, in most cases, that the steam supply was deficient in quantity.

In The Locomotive for October, 1897, we told how to calculate the weight of steam that would be required to heat a given tankful of water through a given range of temperature and in our issue for February, 1898, we gave a rule for finding the approximate *time* required to heat a given tankful of water through a given range of temperature, with a given pipe-coil, supplied with steam at a given pressure. In applying this rule to practice, it is assumed, of course, that the steam supply is sufficient to furnish the coil in the tank with steam as fast as the coil can condense it; and when the results given by the rule are not realized in practice, the trouble usually is, that this all-important condition is not fulfilled. A pipe-coil submerged in a tank of cold water will condense a quantity of steam that appears to the inexperienced to be out of all proportion to the amount of condensing surface of the pipe. Failures in heating in this manner are sometimes due to deficient boiler power, and sometimes to the use of too small a supply pipe, between the coil and the boiler.

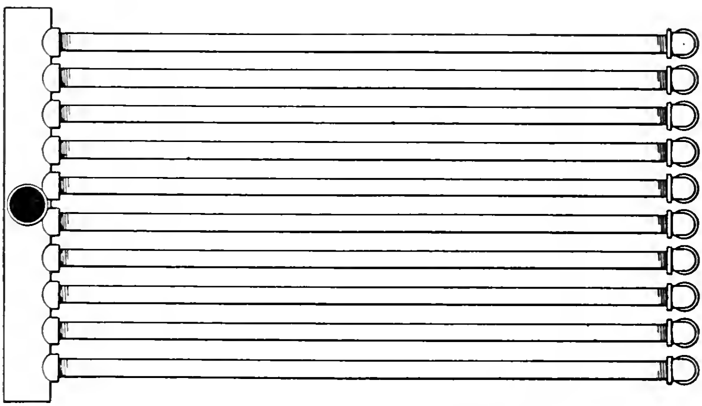


Fig. 2.—Plan View of Coil with Manifolds.

To make this plain, we may cite a case that recently came to our attention, where one of our readers, basing his work upon the data that we have published in previous issues, constructed an open tank in which, by the aid of a pipe coil, he proposed to heat 700 gallons of water from 45° to 180° in from 30 to 35 minutes, using steam at five pounds pressure. The condensing coil was constructed of 2-inch tubing, and had the requisite surface for doing the work. The supply pipe, from the boiler to the coil, however, was *only one inch in diameter*; and right here was where the trouble lay. A little calculation will make this plain. The tank in question contained 700 gallons of water, as we have said; and if we allow 8 1-3 pounds as the weight of one gallon, the total weight of water present was 700 × 8 1-3 = 5,833 pounds. To heat this mass of water from 45° to 180° we have to raise it through a temperature of 180° — 45° = 135°; and hence the total number of heat units required will be 5,833 × 135 = 787,455. Now one pound of steam at 5 pounds pressure by the gauge will give out about 955 heat units, in condensing into water without fall of temperature. Omitting from our calculation such heat as may be radiated from the sides of the tank and the surface of the water within it, we see that in order to heat the proposed quantity of water from 45° to 180° we shall have to condense

787,455 ÷ 955 = 824 pounds of steam.

That is, we shall have to evaporate 824 pounds of water in the boiler, and condense the resulting steam in the tank-coil. To accomplish this work in 30 minutes, we shall have to condense it at the rate of $824 \div 30 = 27.5$ pounds per minute. The supply pipe, which connects the coil to the boiler, must therefore be of such a size as to allow of the free passage of 27.5 pounds of steam per minute, at a pressure of 5 pounds per square inch.

In the issue of THE LOCOMOTIVE for February, 1899, we called attention to the fact that there must always be *some* loss in pressure in a pipe conveying steam, because otherwise there would be nothing to make the steam flow at all. Many engineers appear to think that in heating water with steam coils, it is only necessary to keep the coil filled with steam, without any special regard to the *pressure* in the coil. This belief is probably based upon the well-known fact that the latent heat of liquefaction of steam changes quite slowly with the pressure, so that a pound of steam gives out about the same amount of heat when condensing under a pressure of 15 pounds as it does when condensing under ordinary atmospheric pressure. Such a view of the case is erroneous, however, for it is highly important, where rapid heating is desired, to keep the pressure in the coil as high as possible,— not on account of any difference in the latent heat of liquefaction (which *falls off* slightly as the pressure rises), but on account of the *gain in temperature* of the coil, and the consequent gain in the rapidity of heat-transmission from the coil to the water.

Returning to the special case that we are considering, let us suppose that the boiler pressure is 6 pounds per square inch. We cannot hope to realize the full 6 pounds in the coil, but we ought to realize at least the five pounds that we have assumed to be available, in the statement of our data, above. Let us see how much steam we can expect our friend's one-inch supply pipe to deliver to his coil, under these circumstances. By reference to the table on page 18 of THE LOCOMOTIVE for February, 1899, we see that a one-inch pipe, 100 feet long, with a boiler pressure of 6 pounds and a drop in pressure of one pound, may be expected to deliver 1.02 pounds of steam per minute, in the place of the 27.5 pounds that the solution of his problem requires! We do not know just how long his supply pipe was, but if we take its length at 50 feet (including such corrections as may be necessary to make allowance for inlet, elbows, and a valve), we find, by the process explained in our issue for February last, that even if the pressure in the coil were no greater than that of the atmosphere, the one-inch pipe that he used would probably supply only about 3.53 pounds of steam per minute, which is only about one-eighth of the weight of steam, at five pounds, that is required to do the work. By examining the first table in the February issue of THE LOCOMOTIVE, it will be seen that a supply pipe nearly $3\frac{1}{2}$ inches in diameter would be required to furnish the steam for this coil, provided a drop in pressure of 1 pound is allowed between the coil and the boiler; the supply pipe, when corrections have been applied for inlet, elbows, and one globe valve, being supposed to be 100 feet long. If the length of this pipe, when corrected for the said items, is only 50 feet, then a 3-inch supply pipe should be sufficient.

If the condensing surface of the coil is considerable, it is better to arrange the coil as suggested in the accompanying illustrations, rather than to make it all in one length. If it is all in one length, there is danger of the condensation being so rapid that the first portion of the coil will not transmit steam fast enough to keep the pressure up to the desired point in the more remote parts. The result is, in such a case, that the efficiency of the coil is greatly reduced; and many failures to realize the expected results from such coils are due to this cause.

The illustrations presented herewith call for but little explanation. The general idea that they are intended to convey is, that when a considerable amount of condensing surface is required in the coil, it is better to run the pipe in separate loops, between two generous-sized manifolds, rather than to arrange it all in one length. Fig. 1 shows a side view of a tank fitted up in this way, and Fig. 2 is a plan view of the piping when arranged in this manner. By disposing the pipe as here suggested, it is easy to keep every part of the coil filled with steam at full pressure; and this is the all-important thing to do, if an efficient coil is desired, which will give the results that we have declared to be possible, in previous articles on the subject of heating water by steam.

Boiler Explosions.

December, 1898.

(344.) — On December 1st a boiler exploded in the Colorado Co-operative Company's mill, on the mesa east of Ship Creek, and about sixty-five miles from Montrose, Col. C. C. Dunn and Miner Dunn were instantly killed, and Engineer Edward Whitney was injured so badly that he died within a short time. The mill was completely destroyed, and the dead employes were buried in the wreckage.

(345.) — On December 1st a boiler belonging to the Eagle Coal Company exploded at Barren Forks, Ky., on the Cincinnati Southern Railroad. The boiler was near the tip house, on the top of a hill. The explosion wrecked the tip house, and the boiler itself was hurled 300 feet into a valley below, where it crashed into a grocery store. Two men were slightly injured, and there were numerous remarkable escapes from death.

(346.) — A small coil boiler, used for hoisting, exploded, on December 2d, in the Newell Coal and Lumber Company's yard, at Providence, R. I. Engineer Carl Lindstrom was painfully burned.

(347.) — On December 3d a boiler exploded in the Hardy mill, at Limebank, near Ottawa, Can. We have not learned further particulars.

(348.) — On December 3d a boiler exploded in J. W. Briggs' pickery, at Cottage, near Eldora, Iowa.

(349.) — A boiler explosion occurred on the Mallory Line steamer *Alamo*, on December 3d, as the steamer was about to leave her pier in New York. The second assistant engineer and five firemen were killed.

(350.) — A boiler exploded, on December 5th, in John E. Smith's grist mill, about 4½ miles from Springfield, Ky. The explosion was violent enough to be felt for miles around, and a gentleman who viewed the site of the mill after the explosion stated that about the only things left to mark the spot were two millstones. Fortunately, the men who had been at work in the mill were at dinner at the time of the explosion, and nobody was injured. If the accident had occurred at any other time of day, it is hard to see how any of the employes could have escaped instant death.

(351.) — A disastrous boiler explosion occurred at Martinstown, Putnam County, Mo., on December 5th. Sherman Husted and D. L. Husted were injured so badly that it is believed they may die. Frederick Husted, Grey Cowan, and Joseph Mullenix were also slightly injured.

(352.) — On December 5th a boiler exploded in James Brown's sawmill at Walnut Log, on Reelfoot Lake, near Union City, Tenn. Engineer West Cook was instantly killed, and the mill was blown to atoms. The other employes happened to be outside of the mill at the time.

(353.) — A slight boiler explosion occurred, on December 6th, in the rear of the American restaurant, on Adams and State streets, Chicago, Ill. Albert Zamzo was fatally scalded, and Engineer A. E. Noble and Fireman Ives Stout were badly injured

(354.) — On December 6th a boiler exploded at the Grassy Shaft (coal mine), Olyphant, Pa. Fortunately, nobody was injured.

(355.) — A boiler exploded, on Dec. 7th, in the electric light plant at Moscow, Idaho. We have not learned particulars.

(356.) — On December 8th a boiler exploded on the tugboat *America*, at New York, as the result of a collision with another vessel. Captain Feltner and Engineer Jackson Yonkers were seriously injured, and several others of the crew were slightly hurt. The pilot-house and smokestack were blown away, and the *America* was taken in tow by the tug *Palmyra*. She was so badly damaged, however, that she sank before she could be towed to a dock.

(357.) — A heating boiler exploded, on December 9th, in the residence of Mr. George A. Rogers of Freeport, Ill. Nobody was injured, but the heating plant was wrecked.

(358.) — A boiler exploded, on or about December 9th, in the electric light plant at Sulphur Springs, Texas.

(359.) — A heating boiler exploded, on December 10th, in the Commercial Club, at Albuquerque, N. M.

(360.) — The boiler of the locomotive drawing special stock train, No. 23, on the Southern Pacific Railroad, exploded, on December 12th, about four miles west of Luling, Texas, near the bridge over the San Marcos river. The locomotive was wrecked. Fireman Elmore Dudley was thrown over the tender and against the front car, and Brakeman John Sullivan was also badly bruised. Both men were very seriously injured, but it is believed that they will recover.

(361.) — On December 12th a boiler, used for running the *Recorder* presses, exploded at Potsdam, N. Y. Nobody was hurt.

(362.) — On December 13th a boiler exploded in E. T. Canfield's sorghum mills, at Pittsville, four miles west of Wauseon, Ohio. Nathan R. Thomas and C. A. Emmons were killed outright. William Markley was seriously injured, and A. G. Canfield, O. L. Guyman, Andrew Base, Lewis A. Miller, and Charles A. Wenger were also injured, though to a lesser extent. The building in which the boiler stood was completely wrecked, and the shock of the explosion was felt five miles away.

(363.) — A boiler exploded, on December 13th, in a flouring mill at Manson, Iowa.

(364.) — On December 14th, a boiler exploded in P. B. Osborn's mill, near Webster City, Ia. The plant was considerably damaged.

(365.) — On December 14th a boiler exploded at the South Penn Oil Co's. No. 1 Frazier well, on Laurel Creek, near Tally Ho, which is some seven miles from Parkersburg, W. Va. Contractor J. L. Simpson was badly injured, but there is some hope of his recovery. The boiler house was wrecked.

(366.) — John Shultz, an oil well pumper, employed by Mr. C. B. Whitehead, was killed, on December 14th, by the explosion of a boiler on Mr. Whitehead's lease, on Bolivar Run, north of Bradford, Pa.

(367.) — On December 14th a heating boiler exploded in the basement of the Imperial Hotel, at Petersburg, Va. The boiler room and the first floor of the hotel were considerably damaged. As the explosion occurred in the early morning, there were few persons about, and no injuries resulted.

(368.) — A boiler exploded, on December 15th, in C. T. Hunter's sawmill, near Gurley, some seven miles northwest of Marlin, Texas. John Welch was killed, and the mill was badly damaged.

(369.) — A boiler bursted, on December 15th, in the water works at New Dorp, Staten Island, N. Y. We have not learned definite particulars, but the boiler appears to have been undergoing some sort of a test.

(370.) — A heating boiler exploded, on December 16th, in Riley Jay's barber shop, on South Washington street, Marion, Ind. Several persons were near, but all escaped without injury.

(371.) — A heating boiler exploded, on December 16th, in the Park House, at Morristown, N. J.

(372.) — On December 17th, a heating boiler exploded in the Union House, at Montpelier, Vt. The local paper says: "Luckily for the hotel, the explosion was a horizontal one; if it had happened to be vertical, the blessed sunlight would now be shining through the roof, and probably through the souls of several of the boarders." We can judge somewhat of the unprecedented violence of the explosion, and the thunderous racket that it made, from the added statement, that "the explosion is said to have been loud enough to awaken the man who looks after the heater!"

(373.) — A boiler exploded on December 17th, in a mill operated by James Hamilton, at Bright, near Woodstock, Ont. The building was somewhat damaged, but nobody was injured.

(374.) — On December 17th, a locomotive boiler exploded on the Evansville & Terre Haute Railroad, at King's Station, in Gibson County, Ind. Fireman Frank Spindler was killed, and the locomotive was blown into a thousand pieces.

(375.) — A boiler belonging to Harvey W. Rowland, exploded on December 17th, some two miles southwest of Pulaski, near Sharon, Pa. Edward Clark was thrown some distance, and fatally injured. Charles Clark, Harvey Rowland, and James Book were also seriously injured, and the mill in which the boiler stood was almost totally wrecked.

(376.) — A boiler exploded, on December 19th, in a steam laundry at Placerville (Idaho). Charles Lyons, the proprietor, was badly scalded, but it is thought that he may recover.

(377.) — The great department store of the Havens & Geddes Company, at Terre Haute, Ind., was destroyed by fire on December 19th. During the fire three boilers exploded in the wholesale department, blowing down the walls of this part of the building, and thereby smothering the flames to a sufficient extent to enable the fire department to save the new Tilbeck hotel from the certain destruction that appeared to await it. According to the *Terre Haute Express*, twelve persons received injuries as the direct result of the explosion of the boilers, and Claude Herbert was buried and instantly killed by the débris that was blown down upon him.

(378.) On December 22d a locomotive boiler exploded at Britts, Ark. Three men were killed and one was injured.

(379.) — The crown sheet failed, on December 27th, on yard engine No. 50 of the Ohio Southern railroad, at Springfield, O. Engineer Herman Schellinger and Fireman Thomas Walsh were blown out of the cab and seriously injured. Schellinger will die. Conductor Charles Snow and Brakemen Layer and Brickman were also injured.

Boiler Explosions during 1898.

We present, in the accompanying table, a summary of the boiler explosions that occurred in the United States during 1898, 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 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 1898. 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 1898 was 383, against 369 in 1897, 346 in 1896, and 355 in 1895. In three instances during the past year two boilers have exploded simultaneously, and in one instance three boilers have so exploded. 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 1898 was 324, against 398 in 1897, 382 in 1896, and 374 in 1895; and the number of persons injured (but not killed) in 1898 was 577, against 528 in 1897, 529 in 1896, and 519 in 1895.

It will be seen from these figures that during the past year there was, on an average, over one boiler explosion a day. The figures in the table show that the average of the deaths and injuries during 1898, when compared with the number of explosions, was as follows: The number of persons killed per explosion was 0.84; the number of persons injured (but not killed), per explosion, was 1.51; and the total number of killed *and* injured, per explosion, was 2.35.

The year 1898 was not marked by any of those fearful boiler explosions which horrify the whole country from time to time, although there were several that approached that class. The worst explosion of the year was that at the Niagara Starch Manufacturing Company's works, at Buffalo, N. Y., on July 14th. Seven persons were killed by this explosion and thirty others were injured. The entire plant was destroyed, and the property loss was about $150,000. A closely similar explosion, so far as the number of killed and injured is concerned, occurred on November 27th on the steamer *T. C. Walker*, owned by the California Navigation and Improvement Company, while the steamer was on her regular trip from San Francisco to Stockton, Cal. The explosion occurred just after leaving Turner's Landing, near Black Slough, about 14 or 15 miles from Stockton. Eight persons were killed, and twenty-three were more or less injured. It happened that one of the Hartford company's inspectors was aboard the *Walker* at the time, on his way to Stockton, and a few technical particulars that he secured may be of interest. There were four horizontal tubular boilers on the *Walker*, each of which was 48″ in diameter and 18 ft. long. The plates were from 0.34″ to 0.37″ thick, and composed of steel of 60,000 pounds tensile strength. Each boiler had 56 tubes, 3″ in diameter and 18 ft. long, and the four boilers were connected by a cross mud drum and a cross steam drum. The accident consisted in the explosion of the steam drum, which was 36″ in diameter and 14 ft. long, constructed of steel 0.37″ thick, of a tensile strength

SUMMARY OF BOILER EXPLOSIONS FOR 1898.

MONTH.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January, ...	26	32	52	84
February, ...	26	15	36	51
March, ...	25	18	25	43
April, ...	26	22	27	49
May, ...	22	17	21	38
June, ...	26	25	50	75
July, ...	36	27	68	95
August, ...	27	23	43	66
September, ...	49	34	83	117
October, ...	40	43	58	101
November, ...	42	45	70	115
December, ...	38	23	44	67
Totals, ...	383	324	577	901

of 65,000 pounds, and an average ductility of 54.5 per cent. The bursted drum was constructed with $\frac{3}{4}$-inch rivets, driven in drilled holes that were $\frac{13}{16}$″ in diameter. The longitudinal joint was double-riveted, with the rivets pitched 3″ from center to center. The girth joints were constructed with similar rivets, pitched 2″ from center to center, and single-riveted. The fracture in the steam drum followed the line of the rivets in the horizontal joint, substantially as shown in THE LOCOMOTIVE for November, 1893, page 161. None of the rivets sheared in the horizontal joint, but four of them were found to be sheared in the girth joints. The boilers were only five years old, and the United States inspectors had tested them to 255 pounds hydrostatic pressure, and allowed them a working pressure of 170 pounds. We do not know the pressure at the moment of explosion, and it is doubtful if anybody now living knows what it was ; but we have no reason to suppose that it was greater than the load allowed by the United States inspectors in May, 1898.

The Locomotive.

HARTFORD, MAY 15, 1899.

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

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

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

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

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

The American Society's "1899 Code" for Boiler Trials.

At the meeting of the American Society of Mechanical Engineers, held at Washington on the 10th instant, the committee which was appointed for this purpose at the Detroit meeting in 1895 presented its full report "On the Revision of the Society Code of 1885, Relative to a Standard Method of Conducting Steam Boiler Trials." The report, together with the remarks upon it as published in the advance copy of the paper furnished to THE LOCOMOTIVE, fills more than 100 pages. We therefore cannot publish it in full, but we consider it to be of such importance that we present below the general recommendations of the committee, which are accompanied in the original paper by numerous appendices, giving very fully and satisfactorily the methods by which the committee suggests that these various recommendations be carried out in practice.

RULES FOR CONDUCTING BOILER TRIALS.

(Code of 1899, A. S. M. E.)

I. *Determine at the outset* the specific object of the proposed trial, whether it be to ascertain the capacity of the boiler, its efficiency as a steam generator, its efficiency and its defects under usual working conditions, the economy of some particular kind of fuel, or the effect of changes of design, proportion, or operation; and prepare for the trial accordingly.

II. *Examine the boiler*, both outside and inside; ascertain the dimensions of grates, heating surfaces, and all important parts; and make a full record describing the same, and illustrating special features by sketches. The area of heating surface is to be computed from the surfaces of shells, tubes, furnaces, and fire-boxes in contact with the fire or hot gases. The outside diameter of water-tubes and the inside diameter of fire-tubes are to be used in the computation. All surfaces below the mean water level which have water on one side and products of combustion on the other are to be considered as water-heating surface, and all surfaces above the mean water level which have steam on one side and products of combustion on the other are to be considered as superheating surface.

III. *Notice the general condition* of the boiler and its equipment, and record such facts in relation thereto as bear upon the objects in view. If the object of the trial is to ascertain the maximum economy or capacity of the boiler as a steam generator, the boiler and all its appurtenances should be put in first-class condition. Clean the heating surface inside and outside, remove clinkers from the grates and from the sides of the furnace. Remove all dust, soot, and ashes from the chambers, smoke connections, and flues. Close air leaks in the masonry and around poorly fitted cleaning doors. See that the damper will open wide and close tight. Test for air leaks by firing a few shovels of smoky fuel and immediately closing the damper, observing the escape of smoke through the crevices, or by passing the flame of a candle over cracks in the brickwork.

IV. *Determine the character of the coal* to be used. For tests of the efficiency or capacity of the boiler for comparison with other boilers the coal should, if possible, be of some kind which is commercially regarded as a standard. For New England and that portion of the country east of the Allegheny Mountains, good anthracite egg coal, containing not over 10 per cent. of ash, and semi-bituminous Clearfield (Pa.), Cumberland (Md.), and Pocahontas (Va.), coals are thus regarded. West of the Allegheny Mountains, Pocahontas (Va.), and New River (W. Va.) semi-bituminous, and Youghiogheny or Pittsburg bituminous coals are recognized as standards. (These coals are selected because they are about the only coals which contain the essentials of excellence of quality, adaptability to various kinds of furnaces, grates, boilers, and methods of firing, and wide distribution and general accessibility in the markets.) There is no special grade of coal mined in the Western states which is widely recognized as of superior quality, or considered as a standard coal for boiler testing. Big Muddy lump, an Illinois coal mined in Jackson county, Ill., is suggested as being of sufficiently high grade to answer the requirements in districts where it is more conveniently obtainable than the other coals mentioned above. For tests made to determine the performance of a boiler with a particular kind of coal, such as may be specified in a contract for the sale of a boiler, the coal used should not be higher in ash and in moisture than that specified, since increase in ash and moisture above a stated amount is apt to cause a falling off of both capacity and economy in greater proportion than the proportion of such increase.

V. *Establish the correctness of all apparatus* used in the test for weighing and measuring. These are:

1. Scales for weighing coal, ashes, and water.

2. Tanks or water meters for measuring water. Water meters, as a rule, should only be used as a check on other measurements. For accurate work, the water should be weighed or measured in a tank.

3. Thermometers and pyrometers for taking temperatures of air, steam, feed-water, waste gases, etc.

4. Pressure gauges, draught gauges, etc.

The kind and location of the various pieces of testing apparatus must be left to the judgment of the person conducting the test; always keeping in mind the main object, which is to obtain full and accurate data.

VI. *See that the boiler is thoroughly heated*, before the trial, to its usual working temperature. If the boiler is new and of a form provided with a brick setting, it should be in regular use at least a week before the trial, so as to dry and heat the walls. If it has been laid off and become cold, it should be worked before the trial until the walls are well heated.

VII. *The boiler and connections* should be proved to be free from leaks before beginning a test, and all water connections, including blow and extra feed pipes, should be disconnected, stopped with blank flanges, or bled through special openings beyond the valves, except the particular pipe through which water is to be fed to the boiler during the trial. During the test the blow-off and feed pipes should remain exposed to view. If an injector is used, it should receive steam directly though a felted pipe from the boiler being tested. (In feeding a boiler undergoing test with an injector taking steam from another boiler, or the main steam pipe from several boilers, the evaporative results may be modified by a difference in the quality of the steam from such source compared with that supplied by the boiler being tested, and in some cases the connection to the injector may act as a drip for the main steam pipe. If it is known that the steam from the main pipe is of the same quality as that furnished by the boiler undergoing the test, the steam may be taken from such main pipe.) If the water is metered after it passes the injector, its temperature should be taken at the point where it leaves the injector. If the quantity is determined before it goes to the injector, the temperature should be determined on the suction side of the injector; and if no change of temperature occurs other than that due to the injector, the temperature thus determined is properly that of the feed-water. When the temperature changes between the injector and the boiler, as by the use of a heater, or by radiation, the temperature at which the water enters and leaves the injector, and that at which it enters the boiler should all be taken. The final temperature, corrected for the heat received from the injector, will be the true feed-water temperature. Thus if the injector receives water at 50 degrees and delivers it at 120 degrees into a heater which raises it to 210 degrees, the corrected temperature is $210 - (120 - 50) = 140$ degrees. See that the steam main is so arranged that water of condensation cannot run back into the boiler.

VIII. *Duration of the Test.*— For tests made to ascertain either the maximum economy or the maximum capacity of a boiler, irrespective of the particular class of service for which it is regularly used, the duration should be at least 10 hours of continuous running. If the rate of combustion exceeds 25 pounds of coal per square foot of grate surface per hour, it may be stopped when a total of 250 pounds of coal has been burned per square foot of grate. In cases where the service requires continuous running for the whole 24 hours of the day, with shifts of firemen a number of times during that period, it is well to continue the test for at least 24 hours. When it is desired to ascertain the performance under the working conditions of practical running, whether the boiler be regularly in use 24 hours a day or only a certain number of hours out of each 24. the fires being banked the balance of the time, the duration should not be less than 24 hours.

IX. *Starting and Stopping a Test.*— The conditions of the boiler and furnace in all respects should be, as nearly as possible, the same at the end as at the beginning of the test. The steam pressure should be the same; the water level the same; the fire upon the grates should be the same in quantity and condition; and the walls, flues, etc., should be of the same temperature. Two methods of obtaining the desired equality of conditions of the fire may be used, viz.: those which were called, in the Code of 1885, "the standard method" and "the alternate method," the latter being employed where it is inconvenient to make use of the standard method. (The committee concludes that it is best to retain the designations "standard" and "alternate," since they have become widely known and established in the minds of engineers and in the reprints of the Code of 1885. Many engineers prefer the "alternate" to the "standard" method on account of its being less liable to error due to cooling of the boiler at the beginning and end of a test).

X. *Standard Method of Starting and Stopping a Test.*— Steam being raised to the working pressure, remove rapidly all the fire from the grate, close the damper, clean the ash pit, and as quickly as possible start a new fire with weighed wood and coal, noting the time and the water level while the water is in a quiescent state, just before lighting the fire. (The gauge-glass should not be blown out within an hour before the water level is taken at the beginning and end of a test; otherwise an error in the reading of the water level may be caused by a change in the temperature and density of the water in the pipe leading from the bottom of the glass into the boiler). At the end of the test remove the whole fire, which has been burned low, clean the grates and ash pit, and note the water level when the water is in a quiescent state, and record the time of hauling the fire. The water level should be as nearly as possible the same as at the beginning of the test. If it is not the same, a correction should be made by computation, and not by operating the pump after the test is completed.

XI. *Alternate Method of Starting and Stopping a Test.*— The boiler being thoroughly heated by a preliminary run, the fires are to be burned low and well cleaned. Note the amount of coal left on the grate as nearly as it can be estimated; note the pressure of steam and the water level. Note the time and record it as the starting time. Fresh coal which has been weighed should now be fired. The ash pits should be thoroughly cleaned at once after starting. Before the end of the test the fires should be burned low, just as before the start, and the fires cleaned in such a manner as to leave a bed of coal on the grates of the same depth, and in the same condition, as at the start. When this stage is reached, note the time and record it as the stopping time. The water level and steam pressures should previously be brought as nearly as possible to the same point as at the start. If the water level is not the same as at the start, a correction should be made by computation, and not by operating the pump after the test is completed.

XII. *Uniformity of Conditions.*— In all trials made to ascertain maximum economy or capacity, the conditions should be maintained uniformly constant. Arrangements should be made to dispose of the steam so that the rate of evaporation may be kept the same from beginning to end. This may be accomplished in a single boiler by carrying the steam through a waste steam pipe, the discharge from which can be regulated as desired. In a battery of boilers, in which only one is tested, the draft can be regulated on the remaining boilers, leaving the test boiler to work under a constant rate of production. Uniformity of conditions should prevail as to the pressure of steam, the height of water, the rate of evaporation, the thickness of fire, the times of firing and quantity of coal fired at one time, and as to the intervals between the times of cleaning the fires. The method of firing to be carried on in such tests should be dictated by the expert or person in responsible charge of the test, and the method adopted should be adhered to by the fireman throughout the test.

XIII. *Keeping the Records.*— Take note of every event connected with the progress of the trial, however unimportant it may appear. Record the time of every occurrence and the time of taking every weight and every observation. The coal should be weighed and delivered to the fireman in equal proportions, each sufficient for not more than one hour's run, and a fresh portion should not be delivered until the previous one has all been fired. The time required to consume each portion should be noted, the time being recorded at the instant of firing the last of each portion. It is desirable that at the same time the amount of water fed into the boiler should be accurately noted and recorded, including the height of the water in the boiler, and the average pressure of steam and temperature of feed during the time. By thus recording the amount of water evaporated by successive portions of coal, the test may be divided into several periods if desired, and the degree of uniformity of combustion, evaporation, and economy analyzed for each period. In addition to these records of the coal and the feed water, half hourly observations should be made of the temperature of the feed water, of the flue gases, of the external air in the boiler-room, of the temperature of the furnace when a furnace pyrometer is used, also of the pressure of steam, and of the readings of the instruments for determining the moisture in the steam. A log should be kept on properly prepared blanks containing columns for record of the various observations. When the "standard method" of starting and stopping a test is used, the hourly rate of combustion and of evaporation and the horse power should be computed from the records taken during the time when the fires are in active condition. This time is somewhat less than the actual time which elapses between the beginning and end of the run. The loss of time due to kindling the fire at the beginning and burning it out at the end makes this course necessary.

XIV. *Quality of Steam.*— The percentage of moisture in the steam should be determined by the use of either a throttling or a separating steam calorimeter. The sampling nozzle should be placed in the vertical steam pipe rising from the boiler. It should be made of $\frac{1}{2}$-inch pipe, and should extend across the diameter of the steam pipe to within half an inch of the opposite side, being closed at the end and perforated with not less than twenty $\frac{1}{8}$-inch holes equally distributed along and around its cylindrical surface, but none of these holes should be nearer than $\frac{1}{2}$ inch to the inner side of the steam pipe. The calorimeter and the pipe leading to it should be well covered with felting. Whenever the indications of the throttling or separating calorimeter show that the percentage of moisture is irregular, or occasionally in excess of three per cent., the results should be checked by a steam separator placed in the steam pipe as close to the boiler as convenient, with a calorimeter in the steam pipe just beyond the outlet from the separator. The drip from the separator should be caught and weighed, and the percentage of moisture computed therefrom added to that shown by the calorimeter. Superheating should be determined by means of a thermometer, placed in a mercury well inserted in the steam pipe. The degree of superheating should be taken as the difference between the reading of the thermometer for superheated steam and the readings of the same thermometer for saturated steam at the same pressure as determined by a special experiment, and not by reference to steam tables.

XV. *Sampling the Coal and Determining its Moisture.*— As each barrow load or fresh portion of coal is taken from the coal pile, a representative shovelful is selected from it and placed in a barrel or box in a cool place and kept until the end of the trial. The samples are then mixed and broken into pieces not exceeding one inch in diameter, and reduced by the process of repeated quartering and crushing until a final sample weighing about five pounds is obtained, and the size of the larger pieces is such that they will pass through a sieve with $\frac{1}{4}$-inch meshes. From this sample two one-quart, air-tight glass preserving jars, or other air-tight vessels which will prevent the escape of moisture from the sample, are to be promptly filled, and these samples are to be kept for subsequent determinations of moisture and of heating value and for chemical analyses. During the process of quartering, when the sample has been reduced to about one hundred pounds, a quarter to a half of it may be taken for an approximate determination of moisture. This may be made by placing it in a shallow iron pan, not over three inches deep, carefully weighing it, and setting the pan in the hottest place that can be found on the brickwork of the boiler setting or flues, keeping it there for at least twelve hours, and then weighing it. The determination of moisture thus made is believed to be approximately accurate for anthracite and semi-bituminous coals, and also for Pittsburg or Youghiogheny coal; but it cannot be relied upon for coals mined west of Pittsburg, or for other coals containing inherent moisture. For these latter coals it is important that a more accurate method be adopted. The method recommended by the committee for all accurate tests, whatever the character of the coal, is described as follows: Take one of the samples contained in the glass jars, and subject it to a thorough air-drying by spreading it in a thin layer and exposing it for several hours to the atmosphere of a warm room, weighing before and after, thereby determining the quantity of surface moisture it contains. Then crush the whole of it by running it through an ordinary coffee mill, adjusted so as to produce somewhat coarse grains (less than $\frac{1}{16}$ inch), thoroughly mix the crushed sample, select from it a portion of from 10 to 50 grams, weigh it in a balance which will easily show a variation as small as 1 part in 1,000, and dry it in an air or sand bath at a temperature between 240 and 280 degrees Fahr. for one hour. Weigh it and record the loss, then heat and weigh it again repeatedly, at intervals of an hour or less, until the minimum weight has been reached and the weight begins to increase by oxidation of a portion of the coal. The difference between the original and the minimum weight is taken as the moisture in the air-dried coal. This moisture test should preferably be made on duplicate samples, and the results should agree within 0.3 to 0.4 of one per cent., the mean of the two determinations being taken as the correct result. The sum of the percentage of moisture thus found and the percentage of surface moisture previously determined is the total moisture.

XVI. *Treatment of Ashes and Refuse.* — The ashes and refuse are to be weighed in a dry state. If it is found desirable to show the principal characteristics of the ash, a sample should be subjected to a proximate analysis, and the actual amount of incombustible material determined. For elaborate trials a complete analysis of the ash and refuse should be made.

XVII. *Calorific Tests and Analysis of Coal.* — The quality of the fuel should be determined either by heat test or by analysis, or by both. The rational method of determining the total heat of combustion is to burn the sample of coal in an atmosphere of oxygen gas, the coal to be sampled as directed in Article XV of this code. The chemical analysis of the coal should be made only by an expert chemist. The total heat of combustion computed from the results of the ultimate analysis may be obtained by the use of Dulong's formula (with constants modified by recent determinations), viz.: $14,600\ C + 62,000\left(H - \frac{O}{8}\right) + 4,000\ S$, in which C, H, O, and S refer to the proportions of carbon, hydrogen, oxygen, and sulphur, respectively, as determined by the ultimate analysis. It is desirable that a proximate analysis should be made, thereby determining the relative proportions of volatile matter and fixed carbon. These proportions furnish an indication of the leading characteristics of the fuel, and serve to fix the class to which it belongs. As an additional indication of the characteristics of the fuel, the specific gravity should be determined.

XVIII. *Analysis of Flue Gases.* — The analysis of the flue gases is an especially valuable method of determining the relative value of different methods of firing, or of different kinds of furnaces. In making these analyses, great care should be taken to procure average samples, since the composition is apt to vary at different points of the flue. The composition is also apt to vary from minute to minute, and for this reason the drawings of gas should last a considerable period of time. Where complete determinations are desired, the analyses should be entrusted to an expert chemist.

XIX. *Smoke Observations.*— It is desirable to have a uniform system of determining and recording the quantity of smoke produced where bituminous coal is used. The system commonly employed is to express the degree of smokiness by means of percentages dependent upon the judgment of the observer. The committee does not place much value upon a percentage method, because it depends so largely upon the personal element; but if this method is used, it is desirable that, so far as possible, a definition be given in explicit terms as to the basis and method employed in arriving at the percentage. The actual measurement of a sample of soot and smoke by some form of meter is to be preferred.

XX. *Miscellaneous.* — In tests for purposes of scientific research, in which the determination of all the variables entering into the test is desired, certain observations should be made which are, in general, unnecessary for ordinary tests. These are the measurement of the air supply, the determination of its contained moisture, the determination of the amount of heat lost by radiation, of the amount of infiltration of air through the setting, and (by condensation of all the steam made by the boiler) of the total heat imparted to the water. As these determinations are rarely undertaken, it is not deemed advisable to give directions for making them.

XXI. *Calculations of Efficiency.* — Two methods of defining and calculating the efficiency of a boiler are recommended. They are :

$$1.\quad \text{Efficiency of the boiler} = \frac{\text{Heat absorbed per lb. combustible}}{\text{Heating value of 1 lb. combustible}}$$

$$2.\quad \text{Efficiency of the boiler and grate} = \frac{\text{Heat absorbed per lb. coal}}{\text{Heating value of 1 lb. coal}}$$

The first of these is sometimes called the efficiency based on combustible, and the second the efficiency based on coal. The first is recommended as a standard of comparison for all tests, and this is the one which is understood to be referred to when the word efficiency alone is used without qualification. The second, however, should be included in a report of a test, together with the first, whenever the object of the test is to determine the efficiency of the boiler and furnace together with the grate (or mechanical stoker), or to compare different furnaces, grates, fuels, or methods of firing. The heat absorbed per pound of combustible (or per pound of coal) is to be calculated by multiplying the equivalent evaporation from and at 212 degrees per pound of combustible (or coal) by 965.7.

XXII. *The Heat Balance.* — An approximate "heat balance," or statement of the distribution of the heating value of the coal among the several items of heat utilized and heat lost, may be included in the report of a test when analyses of the fuel and of the chimney gases have been made. [A blank form for stating this "heat balance" is given in the Report. Extensive blank forms are also given for presenting the entire data and results of the trial; but for these we must refer the reader to the original paper, which will be published in full in Volume XX of the *Transactions* of the American Society of Mechanical Engineers.]

Our esteemed English contemporary, *The Practical Engineer*, is troubled by the successes of American manufacturers in foreign markets; and as an illustration of the way we manage to fill "hurry" orders, it prints the following item: "In view of the continuous increase in the estimates of the traffic for the White Pass and Yukon Railway, it was decided, in December, that two more locomotives should be obtained for that line at once. These engines were to be built to special specifications, drawn up by the [railway] company's own engineer, representing the latest developments in narrow-gauge, hill-climbing locomotives, and each engine (including its tender) was to weigh over sixty tons. The contract for these engines was let to the Baldwin Locomotive Works at Philadelphia on the 19th day of last December, and thirty days were allowed for completion and delivery. This was a short time to allow, but the engines were built, and, after an exhaustive series of tests, were delivered at the works to the railway company's representative on January 14th, five days within the time allowed by the contract. Considering that the specifications were so special, it must be allowed by everyone that this was very quick work indeed. The engines are now running on the line, and are giving every satisfaction."

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XX. HARTFORD, CONN., JUNE, 1899. No. 6.

Boiler Explosion in a Brewery.

We present, herewith, three photo-engravings, showing the results of a recent boiler explosion at the plant of the Standard Brewing Company, Rochester, N. Y. The boiler that exploded was one of a battery of two which stood in a brick boiler-house at the rear of the brewery. The explosion wrecked the boiler-house entirely, so that the only vestige of its walls that remained was a section about three feet square at one corner,

Fig. 1.—General View of the Ruins.

where a brick foundation for a pump had afforded it some protection. The rest of the building was scattered in every conceivable direction, and bricks and fragments of iron were picked up fully 1,000 feet away. Engineer Thomas Costello was instantly killed, and his body was buried in the wreckage. The boiler that exploded was of steel, 16 feet long and 60 inches in diameter. It was built of two big sheets, one of which formed the top half, while the bottom half was formed of the other. The two sheets were secured together by double-riveted joints running the entire length of the boiler, and situated on either side of the shell, about opposite the middle line of the boiler. The line of rupture followed the rivet holes in the upper sheet of the boiler, and extended from head to head. None of the rivets in this joint were sheared. At the head seams the rivets appeared to have drawn through the plate, and, very likely, they remained in the heads. The heads, with most of the tubes still secured to them, were thrown over the bank of the river into the water, and at the time of our informant's visit to the plant they were too inaccessible to permit of careful examination. The main shell plates were flattened out.

The details of the joint that failed were as follows: It was double-riveted, the rivets

FIG. 2.— GENERAL VIEW OF THE RUINS.

being pitched $2\frac{3}{4}$ from center to center, and the rivet holes were $\frac{13}{16}$ in diameter. The plates were of steel, their thickness varying from 0.339''. to 0.350''. Taking the thickness of the plate at 0.339'', and the tensile strength of the steel at 60,000 pounds per square inch, and the shearing strength of the rivets at 38,000 pounds per square inch, we find that a section of the joint $2\frac{3}{4}$ long had the following strengths in its various parts: Strength of the solid plate = 55,935 pounds; strength of net section of plate through rivet holes = 39,409 pounds; shearing strength of rivets = 39,405 pounds. The close equality between the rivet strength and the strength of the net section of the plate is phenomenal, and it shows that the joint was very well designed. The efficiency of the joint as indicated by these figures, is $39{,}405 \div 55{,}932 = 0.704$, or 70.4 per cent.

The ultimate pressure that the shell might be expected to withstand without bursting is found by multiplying the tensile strength of the plate by the thickness of the plate, and, again, by the efficiency of the joint, expressed decimally, and then dividing the product so found by half the diameter of the boiler; all dimensions being taken in inches. Thus we have

$$\text{Bursting pressure} = \frac{60{,}000 \times .339 \times .704}{30} = 477 \text{ pounds per square inch.}$$

Allowing a factor of safety of 5, the calculated safe working pressure on the boiler, so far as the strength of the shell is concerned, would be $477 \div 5 = 95.4$ pounds per square inch. (We do not need to examine the strength of the bracing and other parts, because the event proved that these were stronger than the fore-and-aft joint.)

As this boiler was not insured with the Hartford Steam Boiler Inspection and Insurance Company, we are not in possession of all the facts in the case; but we understand that the inspector who passed upon the boiler precisely two months before the explosion, allowed a working pressure of 90 pounds per square inch, and that the safety-valve was set at 80 pounds. These figures, according to the calculations given above, appear to be reasonable and proper; and yet the boiler exploded, killing one man and destroying property to an extent that is variously estimated at from $18,000 to $25,000.

Fig. 3.—General View of the Ruins.

The main conclusion that suggests itself from these premises is, that the safest and best thing to do is to insure your boiler, whether you feel sure it is safe or not. The man who inspected this boiler may see, *now*, why it exploded; so might we, too, if we had a proper opportunity to examine it and inform ourselves. But the point is, that the boiler figured up all right, and a presumably competent man looked it all over and found no serious trouble; and yet, in precisely two months, the place was in ruins.

If we were to hazard a pure guess as to the cause of the trouble in the present case, it would be, that the joint that gave way had been damaged by exposure to the heat of the furnace. This will be understood by referring to Figs. 4 and 5, which show endwise views of two boilers that are alike in all respects, except that in Fig. 4 the shell is composed of two big single sheets, riveted together from end to end of the boiler, just as in the case of the boiler whose explosion we have described above: while in Fig. 5, the boiler is built of several courses of plates, in the usual way. In Fig. 5 each ring or course of the boiler is formed of a single plate, which is rolled into the circular shape and riveted to itself at the ends. The joint so formed is made to come well up towards the top of the boiler, a little to the left of the top on one course, and a corresponding distance to the right on the next course. It will be seen, that by building the boiler in this way, it is easy to keep the "fore-and-aft" joints well up away from the fire. In the single sheet construction, however, this cannot be accomplished so easily. If the top and bottom plates are equal in size in such a boiler, the joints will come opposite the

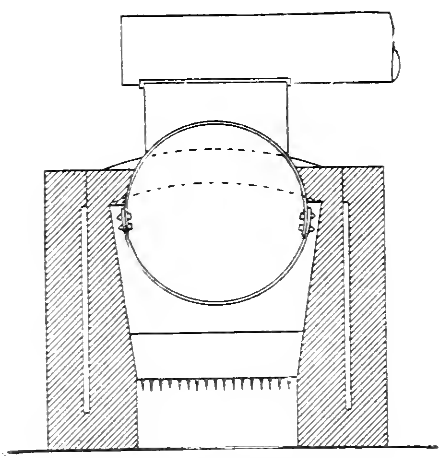


FIG. 4.—"SINGLE SHEET" BOILER.

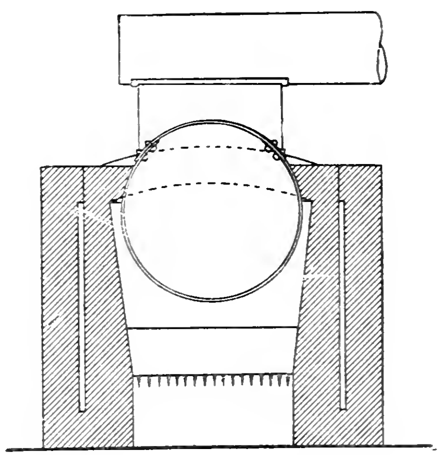


FIG. 5.—THREE RING BOILER.

center of the boiler, on either side: and unless the furnace closes in against the boiler at a lower point than usual, we shall have the condition of things suggested in Fig. 4, where the fore-and-aft joints come within the furnace, and are liable to injury from the heat. When single-sheet boilers are used, care should be taken that their fore-and-aft joints are *not* exposed to heat in this way. The desired protection may be had either by carrying the setting in against the boiler *below* the middle of the boiler, or by making the upper sheet narrower than the lower one, so that the joints may fall above the center line of the boiler. Of these two remedies, the first cuts off a certain amount of heating surface, and the second either introduces difficulties in the arrangement of the supporting lugs, or else calls for a bottom sheet of enormous size. Boiler-makers are therefore apt to let the joints come wherever they will: and it may be that the particular two-sheeted boiler whose explosion is here described had had its joints weakened by exposure to the fire, as indicated in Fig. 4. In THE LOCOMOTIVE for March, 1895, we touched upon this matter of single-sheet boilers, and pointed out the importance of keeping the fore and-aft joints well up out of the way of the furnace gases.

Inspectors' Report.

FEBRUARY, 1899.

During this month our inspectors made 8,018 inspection trips, visited 16,314 boilers, inspected 4,952 both internally and externally, and subjected 540 to hydrostatic pressure. The whole number of defects reported reached 9,780, of which 929 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.	605	52
Cases of incrustation and scale.	1,737	56
Cases of internal grooving.	65	3
Cases of internal corrosion.	366	19
Cases of external corrosion.	368	32
Broken and loose braces and stays.	101	7
Settings defective.	209	31
Furnaces out of shape.	280	21
Fractured plates,	247	42
Burned plates.	216	36
Blistered plates,	130	8
Cases of defective riveting.	1,504	45
Defective heads.	70	9
Serious leakage around tube ends.	2,420	364
Serious leakage at seams,	320	22
Defective water-gauges,	226	49
Defective blow-offs.	143	40
Cases of deficiency of water,	17	4
Safety-valves overloaded.	75	27
Safety-valves defective in construction.	75	11
Pressure-gauges defective.	339	34
Boilers without pressure-gauges.	17	17
Unclassified defects.	250	0
Total,	9,780	929

Boiler Explosions.

JANUARY, 1899.

(1.) — On or about January 1st, the residence of Mr. I. J. Friedlander, of Cincinnati, Ohio, was considerably damaged by the explosion of a heating boiler. Nobody was injured, but the property loss was about $2,000.

(2.) — The heating boiler in Mr. Flavel Gaylord's residence, at Amherst, Mass., exploded on or about January 1st. The boiler was destroyed, and a considerable amount of damage was done to the house.

(3.) — A boiler exploded, on January 2d, in William Fitch's wagon factory, at Mill Village, near Meadville, Pa. A brother of the proprietor was injured.

(4.) — A boiler exploded, on January 2d, in R. D. Schwartz's grist mill, at Olympia, Kans. The proprietor and his fireman, Frank Johnson, were injured. The boiler was thrown 200 feet, and the mill was totally wrecked.

(5.) — A heating boiler exploded, on January 2d, in the cellar of the Providence Wall Paper House, at Providence, R. I. John Johnson, James Crompton, and Mrs. Tripp were slightly injured.

(6.) — On January 2d the boiler of freight locomotive No. 911, exploded on the East Penn railroad, about a mile and a half east of Bowers' Station, near Lebanon, Pa. Engineer William Weaver was instantly killed, and Conductor Joshua Robinson was fatally injured. Brakeman Adam Epp was also seriously injured, but it is believed that he will recover.

(7.) — A boiler exploded, on January 3d, at the Hoffman mine, Frostburg, Md. A large part of the roof of the power house was blown away, but the employes fortunately escaped injury.

(8.) — Two boilers exploded, on January 4th, in the Venedy Mill, at Venedy, Washington county, Mo. The explosion occurred after the fires had been banked for the night, and nobody was injured. The mill, however, was almost totally wrecked. A number of houses in the vicinity were also damaged.

(9.) — On January 4th a boiler exploded in a saw-mill some thirty miles from New Roe, Ky. One man, named Barthel, was killed outright, and his brother was fatally injured.

(10.) — A locomotive boiler exploded, on January 4th, at the Pennsylvania Colliery, Shamokin, Pa. Engineer Charles Collins and Conductor Joseph Lucas were buried under the wreckage, and severely scalded. It was discovered that the boiler was leaking, and Superintendent Visick ordered the fire drawn ; but the explosion occurred before this could be done. The locomotive was destroyed.

(11.) — On January 4th the auxiliary heating boiler exploded in the Fire Department's engine house, at Climax, Minn. The inside of the building was wrecked, and William Larson was seriously wounded. He will probably lose one hand. Paul Blomm, Peter Eie, and John Lochen were also injured, though less seriously.

(12.) — William Newton, a resident of Orchard Park, near Lockport, N. Y., was killed, on January 4th, by a compound accident. A boiler exploded first, and the resulting shock caused the explosion of some nitro-glycerine, by which Mr. Newton was killed.

(13.) — On January 7th a boiler exploded at the J. D. Guthrie coal bank, Oskaloosa, Iowa. David Grier, Mrs. Samuel West, and Mrs. Kate Bricker were badly scalded, and Mrs. West was otherwise hurt. The engine house was completely demolished, and bricks and timber were scattered about over a radius of 200 feet. The yard in the vicinity of the destroyed building was filled with drivers and teams at the time, and it is remarkable that no one was killed.

(14.) — A boiler exploded, on January 7th, at the Davidson & Wansey salt block, Marine City, Mich. The front of the works was blown out, and William Wansey, a son of one of the owners, who was working in the office, was badly scalded.

(15.) — A boiler exploded, on January 10th, in Frederick Hall's mill, at South Warrensburgh, near Troy, N. Y. Gilbert Manning was struck by falling wreckage, and painfully injured. The mill was destroyed.

(16.) — On January 11th the head blew out of the steam or mud drum of one of the boilers in the Peoria Provision Company's plant, at Peoria, Ill. Fortunately there were no personal injuries. The damage to property was about $1,000.

(17.) — A boiler exploded, on January 13th, in the Thorpe-Kyle Works, at Akron, Ohio. The building was damaged, but nobody was injured.

(18.) — A boiler exploded, on January 13th, on North Juniper street, Philadelphia, Pa. The damage was small, and nobody was hurt.

(19.) — On January 16th a boiler exploded in Capt. J. H. Johnson's cotton gin, at Davenport, Red River county, Texas. The engineer was slightly injured.

(20.) — On January 17th a boiler exploded in Willy Bros'. flouring mill, at Appleton, Wis. Engineer W. H. Kramer was instantly killed, and A. Sorenson, Charles Kispert, Albert Erdmann and Otto Kargus were seriously injured. The mill was destroyed, and the property loss is said to be about $30,000. This is the third boiler explosion that has occurred in this same mill within five years. The first occurred on January 13th, 1894, when Night Engineer Joseph Barta was killed. The property loss on that occasion was about $5,000. The boiler house was destroyed, and half of it was blown to a distance of 500 feet. The second of the explosions occurred on December 15th, 1894, when Engineer John Steinel and a laborer named Joseph Kreuzer were instantly killed, two other persons were injured, and a property loss of about $12,000 was inflicted.

(21.) — On January 17th a boiler exploded in Lorillard's tobacco factory, at Jersey City, N. J. Several persons are said to have been injured.

(22.) — A boiler exploded, on January 17th, in C. W. Callaghan's restaurant, on South Calvert street, Baltimore, Md. No serious damage was done.

(23.) — A heating boiler exploded, on January 17th, in the residence of Thomas McNeill, of Collingswood, near Camden, N. J., doing considerable damage to the furniture and carpets.

(24.) — On January 18th a boiler exploded in Frederick Sohler's elevator, at St. Jacob, near Highland, Ill. We have learned no further particulars.

(25.) — Two boilers exploded, on January 20th, in the plant of the Swineford Arsenic Lithia Water Company, at Osceola, in Chesterfield county, near Richmond, Va. Some damage was done to the boiler house, but nobody was hurt.

(26.) — On January 20th a boiler exploded at the Knickerbocker Ice Co's. ice house, at Toronto, Ont. Andrew Evoy was fatally injured, and he died within an hour or so. Frank Cairo and Richard McGerigan were also very badly hurt. The boiler house was totally wrecked.

(27.) — On January 21st a boiler exploded in Gold & Stevens' flouring mill, at Hamden Junction, near McArthur, Ohio. Engineer Edward Smith was badly scalded.

(28.) — The Thompson mill, at Tatumville, near Little Rock, Ark., was completely wrecked by a boiler explosion on January 21st. Thomas Hush was seriously injured.

(29.) — A slight boiler explosion occurred, on January 21st, in D. K. Oakley's planing mill at Dunmore, near Scranton, Pa. The damage was not great, and nobody was injured.

(30.) — On January 21st two boilers exploded in the Union Coal Company's Pennsylvania colliery, at Shamokin, Pa. The boiler house was wrecked, and four men, who were given a moment's warning by escaping steam, made their exit from the boiler house barely in time to save their lives. The property loss was probably about $2,000.

(31.) — A boiler exploded, on January 23d, at the Tie-Hoist works near Charleston, W. Va. Engineer John Harmon was hurt.

(32.) — The pumping station of the C., H. V. & T. railroad, at Nelsonville, Ohio, was burned on January 24th, and during the course of the fire the boiler exploded contributing its share to the general destruction of the place.

(33.) — A locomotive boiler exploded, on January 24th, at Richmond, Ind., as the result of a collision. The locomotive was almost destroyed.

(34.) — On January 24th a boiler exploded in F. R. Noble's saw-mill, about six miles east of Fayette, La. T. J. Erwin was instantly killed, and several other employés were slightly injured. The plant and its machinery were totally wrecked.

(35.) — On January 26th a boiler exploded in H. M. Loud's Sons & Co's. shingle mill, at Munising, Mich. Daniel McFarlan, the night watchman, was instantly killed.

(36.) — A boiler exploded, on January 27th, in E. J. Flippo's saw-mill, some three miles from Hanover Courthouse, Va. John Robinson, C. C. Covington, and Frank Allen were killed, and Washington Taylor was fatally injured. Milton Page and James Gatewood were also injured. The mill sheds and machinery of all kinds were wrecked.

(37.) — A boiler exploded, on January 27th, in C. P. Fox's flouring mills at Daretown, near Bridgeton, N. J. Three workmen were badly scalded, and the plant was damaged to the extent of about $1,000.

(38.) — The boiler of freight engine No. 271, on the Norfolk & Western railroad, exploded, on January 28th, some two miles east of West Appomattox, Va. Engineer Oliver and Fireman Joseph W. Cox were injured so badly that they died within a day or two. The front brakeman was also seriously injured, though it is believed that he will recover. The locomotive was completely wrecked.

(39.) — On January 30th a boiler exploded in the Shreveport Cotton Oil Co's. plant, in Bossier Parish, about a mile from Shreveport, La. John List, William Hawkins, Allen Hall, and John Johnson were killed, and Charles Flowers was injured. The boiler house was destroyed.

(40.) — The big Burr block, at Mt. Vernon, Ohio, was completely wrecked by a boiler explosion on January 30th. Mrs. Solomon Montis, who was sleeping on the third floor of the building, was perhaps fatally burned, and her son, "Jed" Montis, was badly, if not fatally, injured. Several persons in the neighboring streets were also slightly injured by falling debris.

(41.) — Merle Varney, a daughter of Charles Varney, of Manistee, Mich., was instantly killed, on January 30th, by the explosion of a heating boiler in the basement of her father's residence. Mrs. Varney was also seriously injured. The whole west side of the house fell down, pinning Mrs. Varney beneath it, and carrying Merle down with the debris into the basement. The dwelling was totally destroyed, and the furniture was also ruined.

(42.) — A hot water boiler exploded, on January 30th, in the basement of the Alta and Ortiz flats, at Kansas City, Mo. Nobody was injured, and the damage was not serious.

(43.) — On January 31st, a heating boiler exploded in the basement of the county jail, at Wooster, Ohio. Nobody was injured.

(44.) — A portable boiler, used to operate a pile driver on the Denby farm, near Norfolk, Va., exploded on January 31st.

(45.) — On January 31st a boiler exploded in the Spears saw-mill, at Ouachita City, near Monroe, La. Considerable damage was done, but nobody was injured.

(46.) — On January 31st a boiler exploded at the Kennebec mines, some seven miles southeast of Oskaloosa, Iowa. William Spowart, Frederick Drennan, David Love, and John Gillispie were struck by flying debris, but were not seriously injured. The boiler house was wrecked.

As we have already said in these pages, the little book entitled *The Metric System of Weights and Measures*, which was published by this company, has met with a very favorable reception, and has had a ready sale. Some few of our correspondents, however, have erroneously assumed that it is for gratuitous distribution; and for the sake of saving unnecessary correspondence on this point, we have thought it well to print the present note. We did not publish the book with the idea of making money out of it, but merely because we felt that there was a need for such a thing. The production of a book full of tables is an expensive matter, and the price that we have set upon this book is based merely upon the actual sum expended by us in defraying the cost of composition, electrotype plates, press work, and binding. We have contributed, without one cent of expense to the public, the very considerable amount of labor involved in the accurate calculation and proof-reading of the 150 pages of tables that the book contains; and in order to make good our actual cash outlay in meeting the printer's bill for the mechanical work of printing and binding, we have set the price, as previously noted, at $1.25 for the ordinary edition, and $1.50 for the edition printed upon bond paper.

The character of the book, and the way in which it has been universally received by those who have seen it, are sufficiently indicated by the mass of unsolicited and uniformly commendatory testimonials we have received. Mr. C. H. McCullough, Jr., general superintendent of the Illinois Steel Company, says "It is a very meaty volume, one that will be very useful." Professor Robert H. Thurston says, "It is an excellent thing, in admirable form." Judge Thomas Updegraff, who was a prominent member of the committee on coinage, weights, and measures in the last Congress, says, "Constant reference to its tables is almost a necessity; the book is admirable in its contents and structure; *it is a little jewel.*"

A BIG boiler exploded, on January 6th, while it was being tested in Hewitt's ship-building yards at Barking, seven miles from London, England. The chief engineer and eight other men were killed. About forty persons were also injured, some of them fatally; and several men and boys are missing. The factory, which covered several acres, was practically razed, and all the shops and dwellings in its immediate vicinity were wrecked. The body of one of the victims was found 300 yards away, and one of the sheets of the boiler came down through a building a quarter of a mile distant. The entire ship-building yard was wrecked; and although our accounts do not say so, we presume that after the "test" was over, the experts concluded that the boiler was not safe

The Locomotive.

HARTFORD, JUNE 15, 1899.

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

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

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

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

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

The Temperature and Pressure of Saturated Steam.

One of the most fundamental and best known facts in steam engineering is, that saturated steam has a certain definite temperature for each and every definite pressure; and in all books on steam we find tables of corresponding temperatures and pressures, by the use of which we are enabled to find out what the temperature of the steam is when we know what the pressure is, and *vice versa*. For accurate work these tables are all right; but when (as is usually the case) we do not need to know either the temperature or the pressure with any very great precision, a diagram which presents the facts directly to the eye is much more convenient. Such a diagram is presented herewith. On the left-hand side of each vertical line we have marked the pressures, and on the right hand side of the same lines we have marked the corresponding temperatures. The pressures are all *gauge* pressures, that is, they represent the direct gauge reading or pressure *above* that of the atmosphere. The temperatures are on the Fahrenheit scale. The diagram is based upon Professor Cecil H. Peabody's steam tables, and we have assumed that the average atmospheric pressure is 14.70 pounds per square inch.

A few examples will make the use of the diagram clear. (1) What is the temperature of saturated steam, when its pressure, above the atmosphere, is 75 pounds per square inch? *Ans.* We find 75 pounds on the left-hand side of the second vertical line, and looking on the other side of the line we see that the corresponding temperature is just a fraction of a degree less than 320° Fahr. (2) What is the temperature of saturated steam when its pressure, above the atmosphere, is 197 pounds per square inch? *Ans.* We find 197 pounds on the left-hand side of the last vertical line. It is not marked in figures, but 195 is so marked, and 197 is two divisions higher than 195. Looking opposite to 197 we see that the corresponding temperature is about half way between 386° and 387°. Hence we conclude that the temperature of saturated steam at the given pressure is about 386½°. (3) When the temperature of saturated steam is 227°, what is its pressure? *Ans.* We find 227° on the right-hand side of the first line, two divisions above 225°; and looking opposite to it we see that the gauge pressure corresponding to this temperature is almost exactly 5 pounds. (4) When the temperature of saturated steam is 363°, what is its pressure? *Ans.* We find 363° on the right-hand side of the third vertical line, three divisions above 360°; and looking on the other side of the vertical line we see that the corresponding gauge pressure is about 144½ pounds to the square inch.

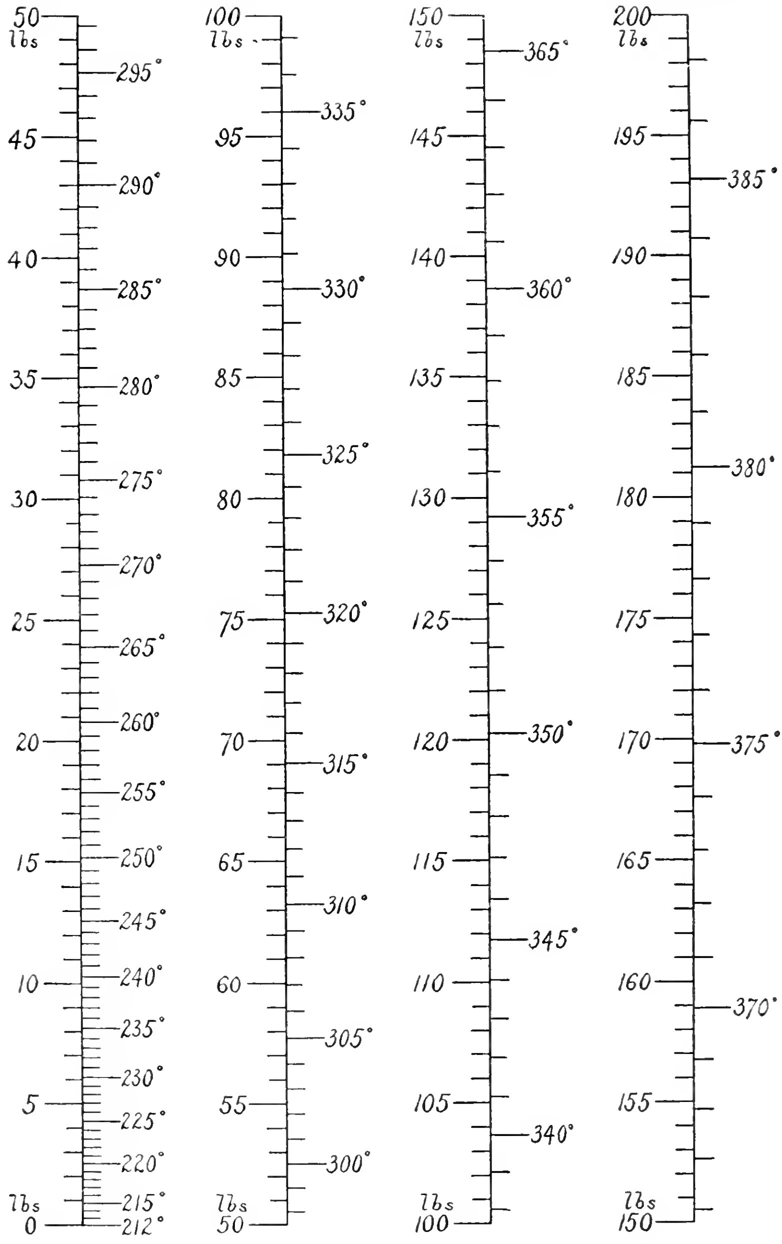


Diagram of the Temperature and Pressure of Saturated Steam.

(Pressures are in pounds per square inch, as read by the gauge;—*i. e.*, above the atmosphere. Temperatures are on the Fahrenheit scale.)

With these explanations and examples, the use of the diagram ought to be readily understood: and we think that after a little practice with it, our readers will prefer it to the tables that are commonly employed for the same purpose.

The Metric System of Weights and Measures.

We are so accustomed to pride ourselves upon our *fin-de-siècle* receptiveness, and upon the readiness with which we eliminate the useless and the superstitious from the true, that it is only when we come to analyze some of our most cherished customs that we find how potent a factor is conservatism in determining our tendencies, and how all-pervading is the power of habit, even when opposed to simplicity and usefulness. A striking example of this kind is to be found in the system of weights and measures in use and in course of education in this country and in all English-speaking countries at the present time. It must be patent to every one who calmly and dispassionately reviews our current tables of weights and measures that they are heterogeneous, ambiguous, incoherent, and burdensome to the memory. It is most rarely that any man or woman in the community, excepting professed teachers of the subject, has the various tables of weights, lengths, volumes, and areas so completely within the grasp of memory as to be able to reproduce them without the aid of a book. Many persons who pass for being well educated, live and die in the belief that the pound avoirdupois is the same as the pound Troy, or that the United States gallon is the same as the British gallon, or that a bushel has but one voluminal value. It is terrible to think of the waste of labor in teaching so barbarous a system, of the ambiguity in using it, and the labor in performing computations with it. The advantage of the metric system of weights and measures over the ordinary heterogeneous English systems of weights and measures is as manifold and as marked as is the advantage of the dollar and cent or decimal system of coinage over the old English penny, shilling, crown, sovereign, and guinea. No better evidence of the force of habit could be adduced than that which conserves so ridiculously complex and unwieldy a system in such extensive use.

The opponents of the metric system argue that a change to the metric system would involve nothing less than chaos and panic in mechanical construction, seeing how many thousands of tools and patterns are in use based upon the measure of the English foot or inch. This, however, is not an argument against the change, but only against a sudden change. Nothing, indeed, could be more disastrous or injurious than a sudden change to the metric system. It would be immensely costly, and, bad as the present system is, its continued use is preferable to such a penalty for rash reform. There is, however, no necessity for such extravagance. Tools do not last forever, and all things change. It would only be necessary to ordain by legislation that all government contracts, after the lapse of a certain time, say one or two years, should be based solely upon the metric system, and the change would probably come about so smoothly and gradually under the influence of this stimulus, that in the course of ten or twenty years the present tangle would probably be forgotten.

The tangle is, perhaps, more twisted and contorted in the business of dynamo design than in any other, for the reason that the electrical and magnetic units of the "centimeter-gramme-second" system are very simple and easy to remember. We have no such ridiculous ratios in the "centimeter-gramme-second" system, as, for example, 437.5 grains in an ounce avoirdupois, or 231 cubic inches in the United States gallon. Nevertheless, in order to deal with dynamos as actually constructed in the shops, it is the almost universal practice to employ hybrid units connecting the "centimeter-gramme-second" measures with the English measures in a manner which, while quite clear and definite to those who are accustomed to it, requires extra labor to learn and extra labor to compute; nor is there apparently any hope of simplification so long as the old tangle persists.

There are signs, however, of rebellion against the iron glove of arithmetical bondage, and a spirit of awakening is at hand. For years efforts have been made in Congress to introduce legislation looking towards a gradual introduction of the metric system. At the present time, we have arrived thus far, that the metric system may be legally used in the country, and that the standard of length recognized by the government is the distance between certain marks upon a bar of metal preserved in Paris, which is the Standard International Meter. A commentary upon the condition of affairs is found in the fact that government engineers and geodetical surveyors compute all their observations in the metric systems, and finally reduce the result to feet and miles for the benefit of the vernacular; that every modern scientific book or publication of any prominence or standing employs the metric system; chemistry, physics, and all the exact science have assumed the garb of metric expression, and if physiology and materia medica are still behind the van in this respect, it is solely because they are yet but inexact sciences. In all good modern schools the metric system is taught, thus paving the way for the transition that must sooner or later come about, when the sense of the ridiculous upon this question has been sufficiently awakened in the community at large.

It is doubtful if any set of tables of weights and measures could be designedly prepared, so as to be more elaborately confused than those which we possess as our heritage from the time-honored creations of barbarous and uncivilized usages. There was a time, not so many centuries ago, when all arithmetical computations in the then civilized world were performed in Roman numerals. Imagine the difficulty of multiplying the numbers; say, MDCCCXCIX and LXVIII. It is hard to imagine, at the present time, how the process was conducted, or how much time it occupied. It remained for the Arabs to introduce the metric system of numerals, and to enable 1899 to be multiplied by 68 in the way we ordinarily execute the process. Yet this radical improvement which revolutionized the numerics of that day is scarcely more beneficent to the engineer than would be the change from the common to the metric system of measures; and we are informed by historians that the change from the arithmetic of the Roman numerals to the arithmetic of the Arabic numerals was only brought about in the face of vehement opposition on the part of numerous teachers and scribes; partly because the new system rendered the use of the abacus or counting machine unnecessary, and people were accustomed to carrying about the abacus in order to execute the computations of the multiplication table.

The introduction of the metric system would be of especial use to the electrical fraternity because it would enable the fundamental physical relations of things to be more readily grasped, since the labor which now has to be expended by the student in arranging and co-ordinating his ideas of magnitude, so arduous a task in the elementary stage of the work, would be entirely removed from his path. Any school boy from the continent of Europe has less work to grasp the fundamental principles of engineering than his compeer in an English-speaking country, by reason of the fact that he has the magnitudes all presented to him in a simple coherent form. Although it may be granted that all mental labor is in some manner remunerative, the labor which would be saved to the student by an adoption of the metric system could be utilized in some manner bringing him more immediate and valuable return. — *Electrical World.*

A Remarkable Boiler Accident.

The following account appears in the *Shipping Gazette*, for March 15th, of a boiler accident of a remarkable, though not quite unprecedented, nature, which has just been made public through the medium of the Board of Trade instructions to examiners of engineers. It was unhappily attended by loss of life, and may well be put on record as a warning to marine engineers of what is an insidious and perhaps not generally recognized danger.

The British steamer *Ellerslie*, of 2,761 tons gross, was at Smyrna last October. The boilers having been blown down, the third engineer, E. Marshall, proceeded to open up, assisted by a Greek fireman. The boilers were two in number, double-ended, and apparently of the ordinary return-tube type. The manhole door, which was being removed at the time of the accident, was 16¼ in. by 12¼ in., and was in the end plate at the after end of the boiler. According to the testimony of the Greek fireman, Spinoli, one dog or cross bar had been taken off the door and the other nut started, when Marshall sent him to prepare to take off the door of the manhole of the other boiler. The fireman had only just left when he heard a loud report, and, going back, he found the manhole door open, but could see nothing of the third engineer, nor of the manhole door. The chief engineer, who was on deck at the time, then joined in the search for Marshall. He says the boiler was so hot that he could not keep his hand in it, and on trying to put his head through the manhole, found it impossible to do so on account of the heat. He at first thought that the third engineer had allowed the door to drop into the boiler, and in attempting to get it out had gone inside and had been overcome by the heat. He then tried to look in with lamps, but could see nothing until he got the forward bottom doors off, when he discovered blood on the sides of the furnace.

The boiler was then allowed to cool down for about four hours, after which it was possible to get inside. The dead body of the third engineer was then found lying on two of the longitudinal stays close to the forward end plate and opposite the manhole. The skull was fractured, and there were evidences of scalding. It would thus appear that the man was drawn into the boiler and carried from end to end, a distance of 16 feet, and was thrown against the opposite end plates with sufficient force to fracture his skull. Moreover, the arms and shoulders looked as if they were seriously injured, and the clothing was torn in places. The body was discovered on a level with the place where it was drawn in, evidently having slid along the longitudinal stays. The manhole door was found resting on the tubes at the same end, and almost immediately below the body, it also having been carried nearly the length of the boiler, but being small enough, it fell between the stays.

A spanner was also found on the top of the combustion chamber, which, of course, was in the middle length of the boiler, as the latter was double-ended. The only explanation of this remarkable accident appears to be the one given by the Board of Trade circular. When the boilers were blown down neither the safety-valves nor cocks were opened, although the chief engineer gave instructions that they should be. The boiler was evidently blown down at a fairly high pressure, and when the steam condensed there would be a loss of pressure inside, so that the tension there would be considerably less than the atmospheric pressure outside. Marshall was working on a platform level with the door. When the latter was removed the rush of air carried him in, dashing him to the other end of the boiler in the manner described. It is supposed that the deceased was almost in a lying position as he worked, and, it is conjectured, was holding the door by one of the studs, or by a piece of rope which was attached to them. Probably when the door was loosened it would be driven inwards suddenly by the atmospheric pressure, and the man trying to hold it back would be drawn into the opening, which his body would nearly fill.

In such a case, which is extremely probable, it is easy to understand the great force with which he would be projected to the opposite end of the boiler. He is said to have been a small man, five feet five inches high, and weighing ten stone. The weight of the door was eighty-five pounds. The area of the manhole was 156 square inches, and it is assumed that with a temperature of about 180 degrees in the boiler there might exist an external pressure of seven pounds to the square inch, which, if suddenly applied, would exert a force of 1,092 pounds. The formation of a partial vacuum inside a boiler is not an uncommon occurrence, and it is a precaution always taken by a careful engineer upon blowing down his boilers to open the gauge cocks in order to prevent the formation of a vacuum. Otherwise the boiler may fill itself again from the sea if the blow-off cock be left open, and in this way most undesirable strains may be set up owing to unequal contraction through sudden cooling. In the old days of box boilers and very low steam pressures, the possibility of damage through atmospheric pressure due to cooling was never forgotten by the engineer; and there is an ancient humorous tale that used to be told in bygone days of a bygone engineer who mended his boiler with a funnybag and a brick, the point of the tale turning on the patch disappearing inside the boiler one day, just as poor Marshall did at Smyrna last October.

A well authenticated instance is quoted, however, of a very similar nature. In this case the junior engineer pumped the water out of the boiler without admitting air. Assisted by a Chinese fireman, he proceeded to take off the lower manhole door, which was a few inches above the stokehole floor. The Chinaman squatted down, after the manner of his race, and was left to remove the nuts and dogs. When he started the door he was instantly drawn in towards the boiler, his stomach closing the aperture, the door meanwhile being projected to the back end of the boiler with a loud report. The unfortunate fireman was thus held captive until the engineer, attracted by his cries, opened the gauge cocks and thus destroyed the vacuum. The man suffered great pain at the time, and complained of internal injuries, but as he was at work again in a few days, it was concluded that they were not of a permanent nature.

The Board of Trade have done well to call the special attention of examiners of engineers to this exceptional case. We are so accustomed to consider boilers as vessels for withstanding internal pressure only, that a young engineer may easily forget that there may be a partial vacuum inside. It is just one of those accidents which occur so seldom as to be likely to be forgotten, but the consequences of which may be extremely serious.— *Practical Engineer* (England).

The Canton Compress plant, at Canton, Miss., was wrecked by an explosion on January 30th. The fireman fired up his boilers on the morning of that day, with the purpose of compressing some 300 bales of cotton in the afternoon. After getting up steam he turned it into the compress cylinder, and in a few seconds the cylinder exploded, blowing the whole press and the building surrounding it to atoms, and causing a property loss of about $25,000. Fortunately no one of the press gangs had gone to work. In half an hour there would have been fifteen men around the press, and it is hard to see how more than a small fraction of them could have escaped immediate death. The damaged plant was one of the finest in the state.

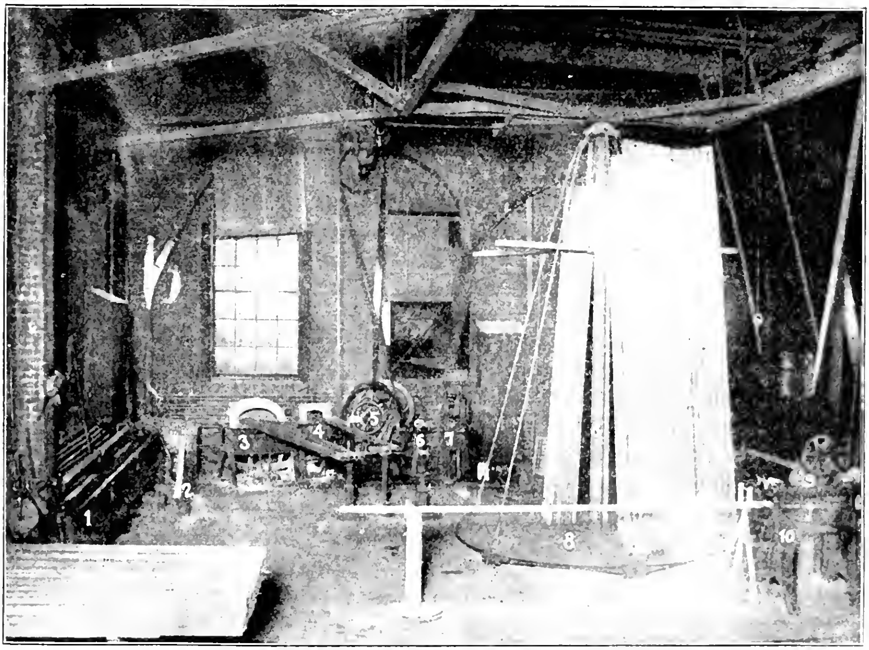
The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XX. HARTFORD, CONN., JULY, 1899. No. 7.

The Flue-Welding Plant of the C., B. & Q. Railway.

There is a widely-spread belief among engineers that flues and tubes cannot be satisfactorily lengthened by welding. This belief is probably due to the fact that such welding is not commonly attempted in connection with stationary boilers. The flues of locomotive boilers are often repaired and lengthened in this manner, however, and there is no reason why a good job of tube-welding cannot be done, provided the proper appli-



THE WELDING PLANT IN THE WEST BURLINGTON SHOPS.

ces are available, and a skilled workman can be had to operate them. As evidence of this fact we present the accompanying illustration of the flue-welding plant in the West Burlington shops of the Chicago, Burlington & Quincy Railway. For the engraving, and for the description which follows, we are indebted to the *Railway Master Mechanic*, which, in turn, acknowledges its own indebtedness to Mr. J. F. Deems, master mechanic at the shops in question.

For convenience of reference the various tools in the engraving have been numbered. Number 1 is an apparatus for testing the flues with 300 pounds water pressure after they are welded. Number 2 is the straightening device. Numbers 3 and 4 are the furnaces for heating the flues. In No. 3 are placed five or six flues and as many safe ends, the blast in this furnace being just sufficient to bring the flues up to a nice white heat, but not strong enough to burn them, even if they are left in the furnace indefinitely. The flues are transferred from this furnace to the small fire, No. 4, one at a time as occasion arises, to heat them to the proper welding heat. No. 5, adjoining the last mentioned furnace, is the Hartz welding machine. No. 6 is simply a stake with a taper point and a scraper on it, upon which the end of the flue is expanded, and on which also the scale is scraped from the weld. No. 7 is a pneumatic swager. This tool is a parallel stroke hammer, which strikes about 240 blows per minute, and which is so constructed that the hammer advances a given amount with each blow, the amount of advance being capable of adjustment to less than 1-100 inch per blow. It is also so arranged that this advance will continue only to a point at which the flue is swaged to the proper size and then cease — the hammer continuing to strike, but advancing no further. This hammer has been found to do very perfect work, and it is believed that the flues swaged by it work much better and give much less trouble from cracking when being set in the flue sheet than those swaged on a mandrel or Hartz machine. No. 8 is a revolving rack, which will carry six full sets of flues of 250 flues per set. No. 9 is an Otto cleaner. No. 10 is a pneumatic-hydraulic cutting-off machine. Right in front of No. 6, the scraper, there is to be placed a pneumatic machine for scarfing safe ends. When this is completed and placed in position, one heating of the flue and safe end will be sufficient for scarfing both of them, welding and swaging the flue, and completing the job in every particular.

In operation the flues are brought into the shop on a rubble car, made especially for the purpose, and are passed through the cutting-off machine. This is a pneumatic-hydraulic affair that does its work very neatly. The flues are driven against the cutter by a constant water pressure of 30 pounds applied at the lower part of the cylinder, as shown. When the flue is cut off the rollers carrying the flue are driven down by admitting air on top of the piston at 120 pounds pressure. This drives the water back into the pipe so that there is no waste of water whatever, and no wetting of the floor or surroundings. It has been found that this works much better than to use air in applying the pressure while the flue is being cut off, on account of the elasticity of the air and the irregular thickness of old flues. After leaving this cutting-off machine the flues are passed to the cleaner, and are then placed in the revolving rack at the side most convenient to this tool. At the proper time the rack is turned around to suit the convenience of the man at the fire, the safe ends are scarfed, and the flues are scarfed, welded, and swaged, and again placed back in the rack. Later on the helper takes the flues from the rack, tests and straightens them, and places them on the rubble car ready to go to the erecting shops. It should be explained that one man does all this work at the fire without the aid of a helper. He has nothing whatever to do with the cutting-off, cleaning, testing, or straightening of the flues. On this plant one man will scarf safe ends, scarf the flue, and weld and swage about sixty per hour — this including all handling of the work, no helper being used at all.

A boiler exploded, on January 6th, in Hewit's ship-building yards, at Barking, near London, England. The superintendent, engineer, and eight other men were killed, and about forty persons were injured, some of them fatally so. The whole ship-building works were wrecked. A woman was found dead 300 yards from the site of the boiler.

Inspectors' Report.

March, 1899.

During this month our inspectors made 9,982 inspection trips, visited 19,550 boilers, inspected 6,279 both internally and externally, and subjected 635 to hydrostatic pressure. The whole number of defects reported reached 12,874, of which 1,094 were considered dangerous; 63 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment.	941	52
Cases of incrustation and scale,	2,171	67
Cases of internal grooving,	107	4
Cases of internal corrosion,	556	29
Cases of external corrosion,	503	38
Broken and loose braces and stays,	124	56
Settings defective,	312	34
Furnaces out of shape,	334	18
Fractured plates,	236	41
Burned plates,	271	31
Blistered plates,	136	8
Cases of defective riveting,	2,985	64
Defective heads,	87	12
Serious leakage around tube ends,	2,724	433
Serious leakage at seams,	311	21
Defective water-gauges,	243	39
Defective blow-offs,	167	48
Cases of deficiency of water,	17	7
Safety-valves overloaded,	65	29
Safety-valves defective in construction,	74	19
Pressure-gauges defective,	366	29
Boilers without pressure-gauges,	15	15
Unclassified defects,	129	0
Total,	12,874	1,094

Boiler Explosions.

February, 1899.

(47.) — A boiler owned by Mr. C. Edgar Sprout exploded, on February 1st, near Renovo, Pa. Joseph E. Smith was struck on the head by a falling timber and rendered unconscious. It was thought at first that he would recover, but, after lingering in his unconscious condition for over three weeks, he died on February 24th. One other man was also injured in the explosion.

(48.) — Locomotive No. 1,327, on the Susquehanna division of the Erie Railroad, exploded its boiler, on February 1st, at Cameron, near Hornellsville, N. Y. Engineer Francis C. Solomon and Fireman F. N. Chamberlain were blown fifty feet and were badly bruised and scalded. Chamberlain died from his injuries, some twenty-four hours later. At last accounts it was thought probable that Solomon would recover. Melvin McCormick, who was on the engine tank, was struck on the head by the fire door, and was also seriously scalded.

49. — A boiler exploded, on February 1st, in the American Drilling Tool Company's shops, at St. Mary's, near Parkersburg, W. Va. Engineer Jacob Judy was scalded so badly that he will probably die.

50. — A boiler exploded, on February 2d, in a greenhouse in the rear of St. Patrick's Cathedral, at Harrisburg, Pa.

51. — The boiler at Fitzkee & Co's creamery, at Rawlinsville, near Lancaster, Pa., exploded on February 2d, doing considerable damage to the machinery. Engineer Thomas Wirk was blinded and burned by escaping steam. His injuries are serious.

52. — On February 2d, a boiler exploded in Coffey & Co's saw-mill, near St. John's Church, in Cline's township, near King's Mountain, N. C. The boiler and engine were demolished, and some of the fragments were thrown half a mile. Seven men were about the mill at the time, but none of them was injured.

53. — A boiler exploded, on February 4th, in the flouring mill at Markland, near Vevay, Ind. The property loss was $1,600. Nobody was injured.

54. — The crown sheet of one of the boilers of the Tennessee river steamboat *Lucile Borden* gave way, on February 4th, as the *Borden* was passing Wright's Ferry, some fourteen miles below Knoxville, Tenn. Samuel Archer was killed, and Green Blair and Frank Stowers were painfully injured.

55. — On February 6th a boiler exploded in Rose's mill, at Salesville, near Cambridge, Ohio. Cliff Stillion, Frank Stillion, Forrest Carpenter, Albert Emerson, Albert Rose, and Jonathan Rose were badly injured. Carpenter and Emerson are not expected to recover, and two of the others will lose their eyesight.

56. — On February 7th a boiler exploded in the Columbia Brewing Company's plant at Columbus, Neb. Thomas Hannon and Louis Luetsinger were badly injured, and the engine-room and cooper shop were wrecked.

57. — A boiler exploded, about February 7th, in S. Whitehead's stave factory, at Burns, near Nashville, Tenn. Nobody was injured, but considerable damage was done.

58. — A heating boiler exploded, on February 8th, in Martin's store, at Lincoln, Ill. No serious damage was done, and nobody was hurt.

59. — On February 10th, a boiler exploded in B. A. Ascherman's grist mill, at Dewey, Ill. William Ascherman was badly scalded, and Wesley Cross was scalded less seriously.

60. — A heating boiler exploded, on February 10th, at Philadelphia, Pa., in the Girls' Playhouse, built by the Culture Extension League, on Dickinson Square. The interior of the house was wrecked, but nobody was injured, although an engineer and a sub-teacher had somewhat narrow escapes.

61. — A heating boiler exploded, on February 11th, in the basement of Dr. Ira L. Fetterhoff's residence at Baltimore, Md. The damage was small, and nobody was injured.

62. — Dean Lloyd, the little son of Robert C. Lloyd, was badly burned, on February 14th, by a boiler explosion at Mt. Sterling, Ky.

63. — The boiler of locomotive No. 249, of the Norfolk and Western railroad, exploded, on February 14th, at Ceredo, near Huntington, W. Va. Engineer Everett

Fields was instantly killed, and Fireman Frederick Morris was fatally injured. Brakeman Edward Hensley was also injured seriously, though he will recover.

(64.) — A boiler exploded, on February 14th, in C. T. Stiers' slaughter-house, at North Nashville, Tenn. The boiler passed up through the roof of the building. Nobody was injured.

(65.) — On February 14th a boiler exploded in the Dock Road flouring mills, near Geneva, Ohio. Fortunately, nobody was hurt, and the damage was small.

(66.) — A boiler exploded, on February 15th, in the great ice storage plant at Buckeye Lake, near Newark, Ohio. Engineer W. C. Miller was fatally scalded, and three other employes were also hurt.

(67.) — A boiler exploded, on February 15th, in the Brunette sash and door factory, at Sapperton, near New Westminster, B. C. The factory was nearly wrecked, and John Ross was seriously injured.

(68.) — On February 17th a boiler exploded in the basement of a brick building on South Eleventh street and Kent avenue, Brooklyn, N. Y. The immediate damage from the explosion is not known; but a fire followed, and the total damage done is estimated at $165,000. The accident occurred very early in the morning, and nobody was injured.

(69.) — On February 17th a boiler exploded on Jennings Bros.' oil lease, on College Hill, at Scio, near Steubenville, Ohio. One man was injured.

(70.) — A boiler exploded, on February 18th, in R. O. Konkle's mill at Beamsville, near Hamilton, Ont. John Konkle, a son of the proprietor, was seriously injured, and the mill was totally wrecked. The boiler was carried four or five hundred yar[illegible]

(71.) — The Kroll Furniture Works, at Allentown, Pa., was wrecke[illegible] explosion on February 18th. Eugene Allender was killed, and Charles S[illegible] Leibensperger, Charles Swartz, and Henry C. Boehm were injured.

(72.) — On February 18th a boiler exploded in the works of the Central [illegible] Cleaning Company, at Soho, near Pittsburgh, Pa. Horace Baer was instantly ki[illegible] and John A. Moore was injured so badly that it is believed that he will die. The buil[illegible]ing was badly wrecked.

(73.) — A boiler tube burst, on February 21st, in the Edison Electric Light plant at Des Moines, Iowa. John Pine was painfully scalded.

(74.) — A heating boiler exploded, on February 23d, in the residence of Charles Terry, at Atchison, Kan. The damage was small.

(75.) — On February 27th a boiler exploded in the shipping department of J. B. Jones & Bros., scrap dealers, at Allegheny, Pa. The building was wrecked, and the fifty-foot stack fell into the street. Nobody was injured.

In the early part of November, 1895, a boiler exploded in the building then occupied by the *Evening Journal*, of Detroit, Mich. We gave an illustrated account of this explosion in our issue for April, 1896. A small safe which stood in one part of the wrecked building could not be found, at the time, and it was finally given up as lost forever. A short time ago, however, it was unexpectedly discovered, after an absence of three years and a half, in the unused basement of a neighboring building. It was found to contain bonds and mining stock to the value of $25,000.

The Locomotive.

HARTFORD, JULY 15, 1899.

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.

It gives the undersigned great pleasure to announce that Trinity College, of Hartford, Connecticut, has bestowed the honorary degree of Master of Arts upon Jeremiah Mervin Allen, President of the Hartford Steam Boiler Inspection and Insurance Company. The event has an especial significance, because it is known that Trinity College is uncommonly conservative in its bestowal of such honors. The award, in the present case, is so eminently appropriate that no reasons for it need be sought, beyond those that are manifest to President Allen's friends and business associates; and yet it may be of interest to those friends and associates to know the precise grounds which Trinity's trustees selected as a basis for their action. One of the trustees was therefore questioned upon this point, and his answer was as follows: "You may state that the degree was awarded for three general reasons. First, in recognition of Mr. Allen's broad scientific
(56.) — second, in recognition of his unusual ability in applying scientific princi-
plant at Colical affairs; and third, on account of the generous way in which he has
and the erí his rare knowledge and ability, for the benefit of the community, and of
(5- w-men in general."

Burr

A. D. RISTEEN.

Steam Engineering in Darktown.

One day last November one of our inspectors visited a small town in Northern Alabama, to make the usual inspection of a battery of boilers located there. The visit being completed, and all things being found in the usual good condition, the inspector said farewell, and left the mill. As he was strolling back to the railway station, having a lay-over of several hours (as often happens in a southern town), he noticed a smokestack in the distance. Now, an inspector cannot rest easy until he feels acquainted with all the boilers in his territory, and with the owners thereof also; and, as this particular stack was a stranger to this particular inspector, the return course to the station was swept out into a great loop, to enable him to explore the surrounding territory, and make his discovery more definite.

As soon as he came within easy range, he observed, as the primary and most obvious external fact, that the building had seen better days; although it is doubtful if the boards had ever felt the protecting touch of even a single coat of paint. The joint was running full blast, and some time was spent in watching the interesting operation of ginning five cent cotton; though the machinery, so far as could be seen, betrayed no knowledge of whether the cotton was of the five cent or the twenty-five cent kind. The last bale having been run off, there was a lull in the proceedings, of which the inspector took advantage by introducing himself to the owner and operator, who happened to be consolidated into one single individual.

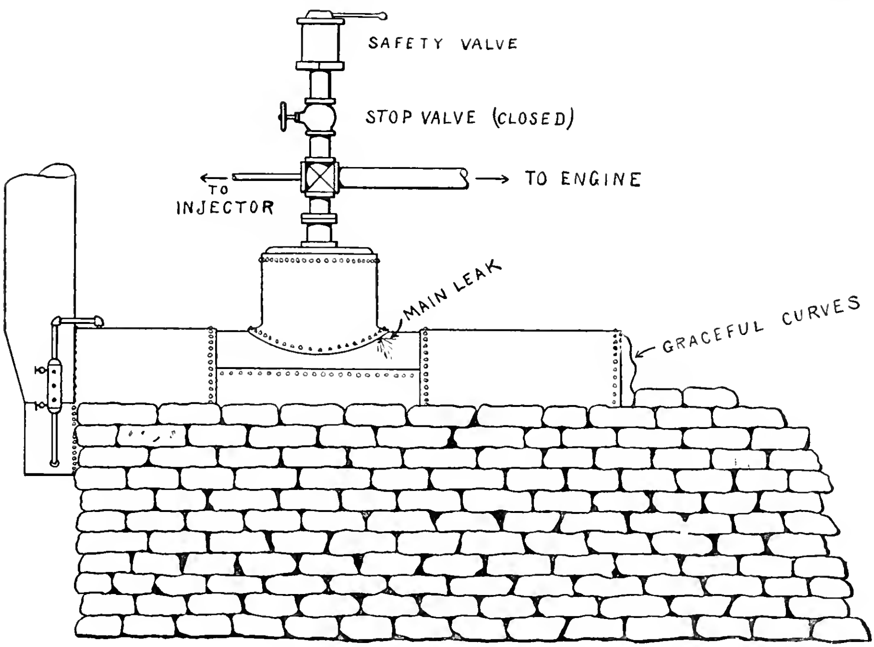
"Captain," said the inspector, "do you have your boiler inspected regularly?"

"Certainly," replied the captain; "what do I have an engineer for?"

"Oh, I didn't mean by him," continued the visitor; "I don't doubt but that he's a very good fellow, you know," he added, half apologetically, "but he may not be posted on all the ills to which boilers are subject. I meant to ask if you have it regularly inspected by somebody specially trained to that kind of work."

"My friend," was the withering reply, "my man has been running this same boiler for an even twenty years. He's held her down so far; and at that rate I guess we don't need any of your advice."

The inspector, to whom this argument was familiar and threadbare, then waxed



A Darktown Boiler Setting.

eloquent on the varied kinds of defects that boilers can have, after which he suggested a visit to the boiler-room, reasonably confident that he would there find something so manifestly out of gear that it would serve as a sound basis for further argument.

This being agreed to, the pair proceeded to the boiler-room, where they were joined by a third individual, whom, for courtesy, we will call the engineer. The inspector stood off and took a general broadside view of the boiler and its setting. (The accompanying cut was made from a sketch prepared by the inspector just after leaving the place, and gives a very good idea of what he saw.) The first thing that was noted was a stop-valve under the safety-valve. Upon further examination, it was found that this valve had been closed so long that no one could recollect when it was ever open; and after some vigorous labor the inspector concluded that the valve and its seat had grown together. Numerous leaks were noted around the dome and seams, one of which, at the flange of the dome, is indicated in the sketch by an arrow, partly because it was the largest one, but chiefly for another reason that will appear in a moment, if the patient reader will stick to the task of reading this sketch to the end. The back arch had been allowed to fall out at some time or other, and the upper part of the back head had become overheated to such an extent that it now shows some very graceful curves between the brace rivets. The rivets themselves leaked at first, but this tendency was discouraged by the liberal introduction of bran into the boiler.

After leaving the top of the boiler, the inspector looked at the water column, and found, to his surprise, that the openings for the gauge cocks were filled by hard plugs. The water glass had evidently been out of service for many a day, its former ends being now represented by a couple of excellent plugs of pine. This state of things naturally led to the question, "How do you know where your water level is?" But the engineer, being a man of practical ideas, led the way to the side of the boiler, and pointing to the big leak under the dome, he said, "We keep the injector on till she blows water out of that hole, and then she will run for quite a bit."

As the leak was then blowing an extra good quality of dry steam, the inspector inferred that his train must be nearly due, and he bade all hands adieu and retired. The thought that his accident policy is lodged with a sound company, afterwards gave him a certain placid satisfaction. He states that when he last passed the town in question, the stack at this plant was still standing, and adds that "for all I know the engineer may now be hunting for his water level with the blow-off cock."

In conclusion, we wish to certify that the foregoing is a strictly true narrative, not falsified nor exaggerated in the smallest particular.

The Philosophy of Combustion, in Boiler Practice.

The chief difficulty in discussions of boiler efficiency and boiler economy has hitherto been that they have been almost too practical. The subject involves a great many factors, and experiments which determine nothing but the practical efficiency in a given case throw no light upon the causes that govern this efficiency, and do not show how this efficiency may be improved. We do not need more boiler tests as badly as we need some practical theory.

The object of the boiler is, to transform the chemical energy of the coal into the heat energy of steam. The coal consists chiefly of carbon and hydrogen, the remaining constituents being comparatively unimportant. The carbon and hydrogen develop heat when they are burned with the oxygen of the air, and the quantity of heat so developed depends upon the nature of the products of this combustion. The ideal case is that in which the carbon is all oxidized to carbonic acid gas, while the hydrogen is all oxidized to water vapor. When the combustion takes place in this manner, it is said to be "complete," and the amount of heat then produced is the greatest amount that it is possible to obtain from the particular coal that is used, In practice, however, certain portions of the coal do not burn at all, and other portions burn in such a manner that they form compounds which are still combustible. In either of these cases the coal has not given up all the heat that is theoretically obtainable from it; the balance being represented by the unburned coal in the ashes, and by the combustible but unburned gaseous products that escape up the flue. The loss of heat that is represented by these two elements is known as the "loss from imperfect combustion," and it constitutes the first (but not the most important) factor on which the efficiency of the boiler as a whole depends.

After we have changed as much as we can of the chemical energy of the coal into heat, the next step is, to transfer as much as we can of this heat through the metal walls of the boiler, and into the water or steam. It is obvious that the amount of heat thus transmitted to the water will depend upon the rate at which the heat flows through the metal of the boiler at different points, as the gases pass to the chimney, and also upon the length of time that the gases remain in contact with the different parts of the boiler. The rate at which the heat flows into the boiler at any given moment depends upon the temperature of the gas at that moment. The gases are hottest when they first strike the boiler, and so they give up their heat fastest at that moment. As they part with their heat, however, their own temperature falls, so that afterwards they part with their heat less rapidly; hence the rate of transmission of heat through the walls of the boiler is not constant.

The initial temperature of the furnace gases (and hence, also, the rate of transmission into the boiler) depends to a considerable extent upon the amount of air that has been used to develop the heat; so that if one pound of air has been used to develop 1,000 heat units, the temperature attained should be higher than it would be if two pounds of air had been used. Theoretically, a perfectly definite weight of air is required, in order to burn each pound of the coal. The principles of chemistry show that a smaller amount of air than this theoretical quantity cannot possibly give "perfect combustion." If a larger quantity is introduced, the coal combines with a certain proportion of it, and the remaining (or unused) part of the air passes up the chimney, substantially unchanged. To obtain the best economical results, we must be sure to introduce air enough to make the combustion as perfect as possible, and in order to do this we *must* introduce a certain excess of air, beyond what is theoretically needed, because the operations in a boiler-room cannot possibly be conducted with the precision that is attainable in the laboratory. It is important, however, for us to exercise care not to have the excess of air greater than is really necessary; because all such excess chills the furnace gases, and so reduces the efficiency of the boiler. An excess of air lowers the efficiency of the boiler in another way, too. For example, suppose we have burned a certain weight of coal under our boiler in one hour, with the air supply very nicely regulated. Then suppose we repeat the experiment so as to burn just the same amount of coal, the only difference being that the second time we try it we introduce so much air that the total furnace gases are twice as bulky as before. They must all pass out of the boiler within the hour, just as they did before; and hence each cubic foot of gas, in addition to being cooler than before, can only remain in contact with the boiler half as long. Hence the reduction in efficiency would be materially greater than the simple chilling of the gases would indicate; and the same general principle holds true when the excess of air is far less than that here taken for the sake of illustration.

The rate of flow of heat from the furnace into the boiler depends also upon the condition of the heating surface; for if the heating surface be covered by soot or scale, the rate of flow of heat will be less than it would be if the surface were clean. It should be noted, however, that efficient heating surface, or excess of air, do not have the same effect in every case. Thus if we have a heavy scale over all the heating surface, the transmission of heat through the part of the surface where the gas first strikes will be very much diminished, and, in consequence, the temperature of the gas will not fall, in the first instant, as much as it would if the heating surface had been clean. Then, when the gas strikes the next portion of the heating surface, the higher temperature of the gas will compensate, to a considerable extent, for the higher resistance of that part of the heating surface to the transmission of heat.

One singular possibility that suggests itself in connection with the regulation of the air supply must not be overlooked. If the air is largely in excess of the theoretical quantity required, the immediate effect will be, as we have pointed out, to hurry the furnace gases along, so that they will not remain in contact with the boiler as long as they should. It may so happen, under suitable conditions, that this effect counteracts the initial chilling effect of the air to such an extent that the gases may escape into the chimney at a *higher* temperature than they would have if the firing had been more perfectly conducted. This is a curious result, but its possibility has been shown experimentally, as well as theoretically.

It is obvious that the ill effects of excess of air, or inefficiency of heating surface, will come into play much less when the heating surface is ample than when it is small. For example, if ten or fifteen times the heating surface per pound of steam were provided, the transfer of heat through the portion of the heating surface that is first in contact with the gases will be diminished, just as before; but this will mean that the gases will pass on in a hotter condition, so that at parts of the heating surface that are reached later, the transfer will be more rapid than it would be if the conditions were normal; and with the excessive heating surface that we have here assumed, the total absorption of heat may not be very different from what it would have been if the air supply were correct, and the heating surface clean. In a similar way it may be shown, by theory and by experiment, that if the air supply per pound of coal be very small, and the heating surface be very efficient, then so much heat is taken out by the first portion of the heating surface that the total amount of heating surface becomes of comparatively small importance.

These considerations explain the widely divergent results sometimes obtained by boiler tests made to determine the efficiency at different rates of evaporation. If the air supply per pound of coal is small, forcing the boiler makes but little difference in the economy; indeed, if the fireman should happen to use less air per pound of fuel when the boiler is forced, the forced test may even show the best efficiency. In another test, however, the air supply per pound of coal may be greater, and then the amount of heating surface becomes very important; and if it is not abundant, forcing the boiler will reduce the efficiency to a low figure.

It is evident that a certain proportion of the energy of the fuel must necessarily pass up the stack with the furnace gases. In ordinary good practice the sensible heat so lost will probably be, on an average, about 20 per cent. of that developed in the furnace; though tests are on record in which the loss into the stack was only about half this figure. This loss constitutes the largest item in our waste account. The next item, in order of importance, is the one which is covered by the phrase, "imperfect combustion." If we omit from consideration the unburned coal which falls through the grate and is thrown away with the ashes, the loss from imperfect combustion will consist of two general parts, whose relative importance is not always clearly understood. Firstly, some of the carbon of the fuel will fail to be fully oxidized to carbonic acid, but will pass up the stack in the form of carbon monoxide, which is still combustible, and therefore still capable of giving up heat. Secondly, some of the carbon and hydrogen will fail to be oxidized at all, but will pass off up the stack, combined with each other in the form of hydrocarbon gases. We may describe these two sources of loss as "incomplete combustion to carbon monoxide," and "incomplete combustion to hydrocarbons," respectively; although, strictly speaking, the second form of loss is not a mode of combustion at all, but arises from the partial absence of combustion.

The most obvious way to inform ourselves concerning the details of the combustion that is taking place in the furnace is to analyze the coal and test it in a calorimeter, and then to analyze the flue gases. From these data we could determine what portion of these gases is still capable of giving up heat, and also how much heat we are losing in this manner. The difficulty of this method is purely experimental. The carbon monoxide can be determined fairly well, but the hydrocarbons are difficult to estimate, because they exist in very small quantities, and in many different forms. Their importance may be judged, however, from the fact that the presence of one-tenth of one per cent. of any one of a large class of them signifies a loss of three or four per cent. (or even more) of the original energy of the coal. There is no practical method of flue gas analysis that will determine the amounts of these hydrocarbons with this degree of accuracy; and hence the only feasible way to determine the loss by incomplete combustion is to determine the amount of heat originally in the coal, and then subtract from this all the other heat developed, and charge the difference to "incomplete combustion." An examination of 103 tests on different types of boilers indicates that the loss from "incomplete combustion to hydrocarbons" varies from one per cent. to twenty per cent., and that it probably averages about seven per cent.; while the loss from "incomplete combustion to carbon monoxide" varies from nothing to twenty per cent., and probably averages from one-half of one per cent. to one per cent.

After the heat has been transferred through the heating surface into the steam, the only further loss is the loss from *radiation*. This has often been reported as constituting from 5 to 15 per cent. of the total heat; but estimates of this magnitude are based upon erroneous deductions from the tests, since, as a matter of fact, the loss by radiation is probably not over one per cent., in well covered boilers. The heat put into the steam, less the heat lost by radiation from the boiler itself, gives the measure of the performance of the boiler. Any further loss is chargeable against the steam pipe or engine, and not against the boiler. The loss by radiation cannot be determined from the boiler test itself, and must be determined by a separate experiment, which is possible only in certain types of boilers, and even then is a matter of some difficulty. In general it is not determined separately, but the balances left after subtracting the heat in the steam and the heat in the gases from the heat originally in the coal, includes both the loss by radiation and the loss by imperfect combustion. In such case the boiler test itself gives no indication of how much of the heat loss should be ascribed to each of these causes separately, but a comparison of a large number of tests has shown that in the great majority of instances the radiation loss is but small, and that most of the heat that is unaccounted for is chargeable to "incomplete combustion to hydrocarbons." Thus an examination of the 103 tests above referred to indicates, as we have said, that the radiation loss from well-covered boilers probably averages about one per cent. The radiation depends only upon the temperature of the outside of the boiler, and upon the temperature of the surrounding air. The heat lost in this manner, if expressed in heat units per hour, should, therefore, remain constant when these temperatures remain constant, whether the boiler is standing idle, or being forced. It follows from this that when the boiler is doing easy duty, the radiation loss should form a *larger percentage* of the total heat developed than it would when the boiler is being forced. Now it was found, upon examining a large mass of experimental data, that the heat that was unaccounted for averaged about 9½ per cent., whatever the rate of working, instead of varying when the rate of work varied, as would have been the case if the loss had been chargeable mainly to radiation. Hence the conclusion that this loss of heat is due to other causes, and probably to incomplete combustion.

Still omitting from consideration the unburned fuel that works into the ash heap and is thrown away, the heat energy of the coal that is actually used may be assumed to be distributed in ordinary good practice, in about the following average manner :

Lost in "incomplete combustion to hydrocarbons,"	7	per cent.
Lost in "incomplete combustion to carbon monoxide,"	1	"
Lost in sensible heat in flue gases,	20	"
Lost in radiation,	1	"
Available in steam,	71	"
Total heat energy of fuel used,	100	"

This analysis indicates the method that should be used in judging the results of tests of boilers or their appliances. For instance, if the radiation loss on a boiler is one per cent., a device applied to diminish the radiation can only save one per cent. If the loss by incomplete combustion is only eight per cent., a device to give perfect combustion can only save eight per cent. at the best. In comparing two tests it is necessary, also, to know what the different factors were that made up the results in each case. For instance, let us suppose that a complete combustion device is applied to a boiler, and that a test shows that the efficiency of the boiler, which was formerly 70 per cent., is now 77 per cent. Our table shows that it is theoretically possible to realize as much improvement as this by improving the combustion; but, notwithstanding this fact, it is highly probable that the saving was not due to the device at all, but that on the second test the amount of sensible heat lost in the flue gases was diminished by seven per cent. through some slight and almost unnoticeable variation not connected with the device. Thus, although a consideration of the efficiency alone might have indicated a saving, a complete test, with full data, might show the device to be absolutely ineffective.

A careful scrutiny of a large number of carefully-conducted boiler tests shows that, whenever the conditions were such that the fire was very hot and the initial temperature of the gases very high, the loss by incomplete combustion was correspondingly low. When the fire was surrounded by hot brick walls, the combustion was excellent ; and when it was surrounded by the cold walls of the boiler itself, the combustion was much more imperfect. The results of individual tests were irregular and capricious, but the general tendency was strongly in the direction here indicated, and further evidence of this same sort will doubtless be furnished when other experiments have been made, with the necessary accuracy.

It appears, therefore, from the point of view of economy of coal, and leaving out questions of safety, ease of management, first cost, and so on, that it is desirable that a boiler should have a large furnace lined with fire brick, where the temperature of combustion will be as high as possible and the combustion itself correspondingly perfect. In this furnace a small grate should be provided, on which the coal should be burned at a very high rate of combustion, say 25 or 30 pounds per square foot per hour. It is not practical to go much beyond 25 or 30 pounds, because beyond this point the draft is likely to draw unburned coke, coal, and cinders up the chimney. Finally, after the coal is burned in such a furnace, the gases should be passed over a large heating surface. These are the general conditions that appear to be requisite for burning coal economically under a steam boiler.— Adapted from an article by R. S. HALE in *The Engineering Magazine*, entitled "The Efficiencies of Steam Boilers and Furnaces."

The Providence School Boilers.

In the issue of the Providence *Sunday Journal* of June 11, 1899, we find a letter from Professor S. H. Woodbridge, relating to the school boilers of Providence, R. I., together with certain remarks thereon by the editor of the *Journal*.

"On the 30th of last January," says the *Journal* by way of introduction, "Mr. Edward S. Jones of this city wrote to the committee appointed to investigate Providence schools, a letter in which he stated that, after examining the boiler plants of the Classical High School and the East Side High School, he believed that they were unsafe; that the boilers were of a type liable to explosion, and that the lives of hundreds of of children were thereby imperiled. As the subject thus called to the attention of the committee was not mentioned in the committee's recently published report, Mr. Jones sent a copy of his letter to the *Sunday Journal*, with a request for its publication. 'I feel,' he wrote, 'that if an accident should take place in either of the buildings named, I should be an accessory to a crime had I not made public the facts within my knowledge.' Before complying with a request that involved alarming so many citizens, the *Sunday Journal* had the matter submitted to Mr. S. H. Woodbridge of the Massachusetts Institute of Technology, an expert of the highest standing on the subject. Following is his report; and, as will be seen, it makes quite unnecessary the publication of Mr. Jones's original letter."

"MASSACHUSETTS INSTITUTE TECHNOLOGY,
"ROGERS LABORATORY OF PHYSICS,
"BOSTON, May 26, 1899.

"*To the Editor of the Sunday Journal:*

"Absence from the city has delayed until to-day the receipt of the copy of Mr. Jones's letter to the chairman of the school investigating committee of Providence, written under date of Jan. 30, 1899, and which was kindly sent me by Mr. Albert T. Mansfield, the superintendent of public buildings of your city.

"There is, and presumably will always be, a class of estimable individuals whose mental make-up afflicts them with a chronic propensity to magnify remote possibilities into threatening probabilities. They belong to the genus known as alarmists. Their abnormally imaginative minds keep their owners in a state of more or less continuous alarm because of the unavoidable possibility of dangers which encompass human life at every step. No one can get into a vehicle behind a horse without incurring risk of a runaway, a smashup, bruises, broken bones, and death; and with some the picture of these possibilities takes such vivid form as probabilities, that they ride in expressed or else evident torture whenever circumstances force them into a carriage.

"Open switches, spread rails, broken frogs, weakened embankments, unsafe bridges, sharp curves, deep cuts, accidental or malicious obstructions, defective trucks, broken flanges, track jumping, mis-set signals, collisions, and resulting manglings, burnings, death tortures, and all the host of evil possibilities attending railway travel, become to some such a horror of probabilities that their anxiety is relieved only when the train is quit and feet are once more planted on terra firma. Multitudes are restrained from crossing the sea because of the fear born of magnified possibilities of disaster from wind, waves, fog, fire, icebergs, collisions, shipwrecks, and foundering. The writer once had a youthful acquaintance who ventured on the city street with timidity from fear of snow slides, falling icicles, flower pots, shutters, signs, loose boards, roof slates, chimney bricks or pots. He was abnormally impressed with the thinness and weakness of the single bone shell which lies between the human brain and the thousand possibilities of a death blow. Statistics, however, show life to be safer on a railroad train behind a locomotive boiler carrying 200 pounds steam pressure, or at sea in close proximity to boilers carrying pressures varying from 180 to 250 pounds, than it is on the street or even in the home. [We think this statement pretty strong, though the professor's general idea is correct.]

"The judgment that brands your correspondent, or any man, as criminally blameworthy because he takes his family to ride, and even in the face of the Scripture warning that "a horse is a vain thing for safety," or which makes a state guilty of criminal negligence when it not only permits but encourages the use of horses, locomotives, or bicycles within its limits, is clearly lacking in intelligent discrimination. Exposures to dangers are perpetual and inevitable. They become criminal only when their possibility assumes the phase of needless probability.

"High pressure boilers, under schoolhouses filled with teachers and scholars, is, in this case, the alleged criminality held up to view. High pressure boilers are not high pressure steam. Boilers made capable of high pressure work and used for low pressure steam, are in themselves guarantees of safety. The particular boilers noted by your correspondent are made strong enough to carry many — probably from eight to ten — times the pressure their actual duty calls for. It is pertinent to this case to note the fact that two boilers of the type condemned by your correspondent, and which had been in probable negligent use for from 12 to 14 years in schoolhouses in a Massachusetts city, and were then condemned by the state guardians of safety to be either removed or else to be used at no higher pressure than five pounds for one, and ten pounds for the other, were removed under protest of the city authorities, and were, by their order, hydraulically tested by experts, one boiler giving way at over 300 pounds pressure, and the other at something over 400 pounds.

"It is urged that, however strong the boilers may be, through negligence or accident steam pressure may reach and pass the safety limit. The engineer may be stricken dead before his boilers. He may be ignorant, or he may be negligent of his duty. What protection is there, then, against danger? Simply the same kind of precaution which makes high pressure steam railway and steamship travel, with all their multitude of attendant risks, as safe or safer than walking on the streets, or even remaining at home. These precautions are four:

"*First*, Strong boilers, made in accordance with plans and specifications drawn and approved by the best and most favorably-known steam boiler inspection and insurance company in the country, and constructed and inspected under their direction, and guaranteed under $10,000 insurance for each group of boilers for perfectly safe work at 60 to 80 pounds steam pressure, and at that pressure simply because the figure was stipulated as a precaution by the designing engineer, though it was known that the boilers would actually be run at less than half that pressure. The boilers are examined four times a year by the inspectors of the company mentioned, and should any defect be found, it would be immediately reported and corrected.

"*Second*, The steam pressure, when it reaches a point but one-half that of the low limit for perfectly safe steam pressure named in the insurance policy, shuts off the chimney draught and dulls the fire.

"*Third*, Should the damper regulator fail to act, a safety-valve, not of the old style lever pattern, which a stupid or willful engineer could wedge down, and whose valve seat might corrode and stick, and which, when open, would allow only a slow escape of steam, but a modern pop safety-valve, with set springs which cannot be reached to be tampered with, whose valve and seat are made of non-corrosive material, and which, on opening, gives wide vent for the quick release of steam pressure; such a safety-valve attached to each boiler makes practically impossible a dangerous accumulation of steam pressure.

"*Fourth*, The only further opportunity for accident disastrous to the boiler lies in a failure to furnish the boiler with water. Over-hot fires are prevented by the automatic closing of the chimney damper. The dangerous accumulation of steam pressure is prevented by the safety-valve. If, however, water is not furnished the boiler, its tubes become bared and very possibly over-heated, weakened, and perhaps collapsed, the steam then escaping in large volumes, but with insufficient force to do more than make a frightful noise as it leaves the wrecked boiler. The possibility of even that harm is met by the use of a safety plug located in the hottest head of the boiler, the plug being made of a composition which melts at such low temperature that when the water level falls below and bares it, the melting of the plug opens the boiler and allows steam to freely escape.

"An experienced engineer was recently asked how, if he should wish to do so, he could accumulate a sufficient pressure to explode boilers made and equipped as are those mentioned by your correspondent. On thinking the matter over, he frankly stated that he could not conceive of any way by which a sufficient excess of steam pressure could be produced to rupture the boilers unless by resorting to deliberate and tricky methods for the purpose, such as plugging from the inside of the boiler the safety-valve nozzle and also the pipe controlling the damper regulator. If an engineer is viciously and feloniously disposed, no boiler can be made strong enough to stand between him and the accomplishment of his fiendish purpose.

"Your correspondent will recognize Massachusetts as a leading state in providing for the safety of the life and property of her citizens, and yet the laws upon her statute books in no way prohibit or discourage the use of boilers of the type and housing he condemns. They would certainly be prohibited in public buildings if their use were regarded as a menace to life and limb. All that is required by statute is that proper protection against danger be employed. If the 'seeming criminal stupidity,' which your correspondent imputes to those responsible for the presence of water-shell and fire-tube boilers in the school buildings named actually exists, it must be shared by the designing engineer, by the steam boiler experts who drew specifications and plans, and who examined and approved their construction and proposed use; and also by the Providence committee on public property or school buildings, which examined and approved the plans. Personally, I do not hesitate to stand by my work. The Hartford Steam Boiler Inspection and Insurance Company emphatically states that nothing could be safer than the arrangements provided. The situation has also been presented to another and competitive insurance company, largely interested in steam plants and also insuring steam boilers, and their opinion is in complete harmony with that given by the Hartford Company. I cannot assume to speak for the Providence committee which had the matter in charge some years ago.

"Your correspondent raises some interesting points. First, with reference to the alleged malconstruction of boilers made up with lap joints. In large boilers, and for high-pressure work, the butt joints and strengthening pieces are now accepted as preferable to lap-joint boilers. If, however, your correspondent has been correctly informed in regard to the damage habitually done lap-jointed boilers by any boiler makers in hammering such boilers to their cylindrical shape, such makers should be advertised to be avoided. Your correspondent also speaks of the practice common with manufacturing establishments of building boiler houses outside the main building. This practice is very properly insisted upon by insurance companies as a protection against fire; and also, and, perhaps, chiefly, in order that the power to be used in operating the fire pumps may not be within, and so be cut off by the burning building. It is not denied that some forms of boilers have a larger factor of safety than have others; nor that some boilers in the market have, in this respect, a larger factor of safety than those condemned by your correspondent. A well-made one-inch hemp rope, to be used for lowering a man through a fatal falling distance, has for that purpose a factor of safety of 50. The reputation of criminal stupidity for using such a rope, rather than a five-inch rope having a factor of safety of 1500, is that which any practical engineer might honorably covet. Factors of safety, if alone considered in providing the ways and means for human environment and enterprise, lead to and end in absurdity.

"S. H. WOODBRIDGE."

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XX. HARTFORD, CONN., AUGUST, 1899. No. 8.

Explosion of a Pulp Cooker.

A short time ago a pulp cooker exploded in a paper-mill in Maine, doing considerable damage to the mill, killing two men, and injuring a third very seriously. The cooker was to be used for steaming blocks of wood, preparatory to their reduction to pulp in a digester. Its general design is shown in the accompanying cuts. It was 28 feet long and 8 feet in diameter, and was built of $\frac{3}{4}$ inch steel plate. The shell con-

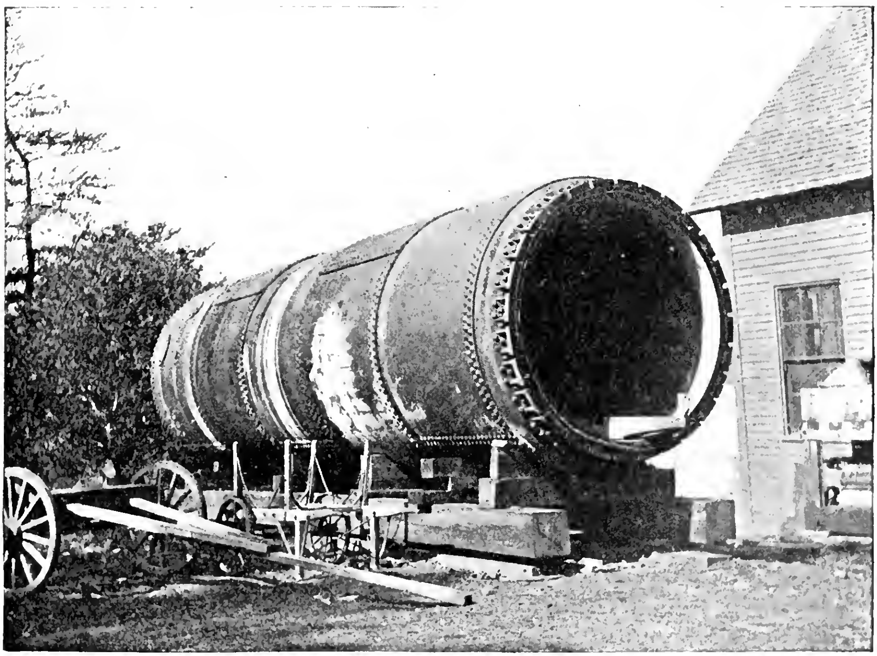


Fig. 1. — The Cooker after the Explosion.

sisted of five courses (as will be seen in Fig. 1), with two sheets to a course. All the joints, both longitudinal and circular, were double-riveted, with one-inch rivets, pitched $2\frac{1}{4}$ inches from center to center. The back head was made of $\frac{7}{8}$-inch steel, bumped and secured to the shell as shown in Fig. 2. The shell was lined with two courses of brick, as suggested in Fig. 2.

The front head consisted of a flat cast-iron plate, bolted to a frame of cast-iron by means of 28 one-inch bolts. The opening in the mouth-piece frame was 71 inches in diameter in the clear, and this may be taken as the diameter of the circle against which the steam pressure acted upon the head. The portion of the cover which fitted against the flange of the mouthpiece was $2\frac{1}{2}$ inches thick, with bosses making it 3 inches thick around the bolt-notches; but the part inside the flange was only $1\frac{7}{8}$ inches thick, although it was provided with ribs whose size and general proportions near the center of the cover are shown in Fig. 2. The accounts of this explosion that have reached us differ materially with regard to the number of these ribs. One account states that "there were twelve radial ribs on one side, alternating, like bicycle spokes, with twelve more ribs on the other side." Another account is accompanied by a sketch showing but *four* of these ribs on each side of the cover. A photograph of one of the fragments of the cover appears to indicate that the former description is correct, and hence in the outside view of the cover that is given in Fig. 3 we have assumed that there were twelve ribs on each side.

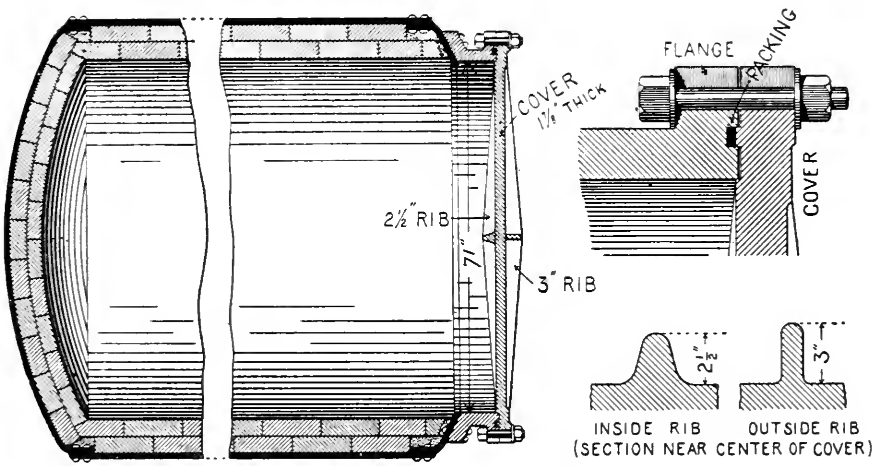


FIG. 2. — DETAILS OF COOKER.

We understand that the explosion occurred the first time the cooker was used. It was filled with blocks of wood some two feet long, from which pulp was to be made, and steam was turned on at about half-past six in the morning. We have been unable to learn much about the pressure to which the cooker was actually subjected, but we are credibly informed that it was proposed to run at about 60 pounds; and while the full sixty pounds very likely was not realized at the outset, it is probable that the actual pressure crept up towards this value as the charge became heated, so that we may assume that the pressure was as high as 60 pounds some time before eight o'clock. At any rate, the flat cast-iron head blew out at 8.30, "like a pane of window glass." The charge that the cooker contained shot out towards the north end of the mill, killing two men, destroying two "wet" machines, and doing much other damage: while the cooker itself traveled rather more than its own length in the opposite direction, knocking out a partition in its way, and landing upon a coal wagon that was backed into the fire-room.

Examination of the cooker showed that with the possible exception of the bolts that held the cover in place, no part of the apparatus was damaged except the cover itself, which was broken into fragments. We do not know the precise manner in which failure took place, but we understand that the initial fracture was probably on the inner surface of the cover, at the inside edge of the frame, where it was squared up in the lathe, and close to the starting point of the inside ribs. A photograph of one of the fragments of the cover shows that this particular fragment corresponds to the area shown shaded in Fig. 3. The rest of the cover was also broken, but we have no data to indicate the course of the remaining lines of fracture.

Engineers are by no means agreed concerning the proper method of calculating the strength of flat cast-iron covers such a the one here described. The rule given by Grashof, for a flat circular cast-iron plate secured at the edges like a boiler-head or cylinder cover, is as follows: Multiply the square of the thickness of the head by 15,000, and divide the product by the square of the diameter of the head. (The dimensions are to be taken in inches, and the result is the pressure, in pounds per square inch, that the head can safely bear.) If we apply this rule to the case in hand, we find that the safe working pressure for this particular cover was only 10.5 pounds per square inch, if no allowance is made for the strengthening action of the ribs. Undoubtedly, the ribs add to the resistance of the plate, but there does not appear to be the smallest probability that they would bring up the safe working pressure to any thing like 60 pounds per square inch. A proper hydrostatic test would undoubtedly have demonstrated the weakness of this head, and saved the loss of life and property that ensued from its failure.

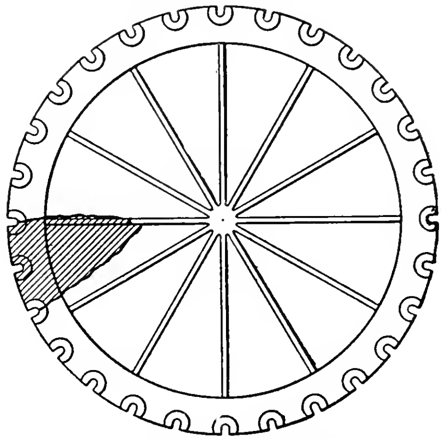


FIG. 3. — DIAGRAM OF COVER PLATE.

In conclusion, we desire to express our obligations to our sprightly contemporary, *Live Steam*, for a considerable portion of the data upon which this article is based.

Boiler Explosions.

MARCH, 1899.

(76.) — A boiler exploded, on March 2d, in the creamery at Waterville, near Waukesha, Wis. We have not learned further particulars.

(77.) — On March 3d a boiler bursted in the basement of the Central Hotel, at Pittsburgh, Pa. The accident consisted, it is said, in the rupture of the front plate on the right-hand side, about 12 inches below the fire line. It was undoubtedly caused by a heavy collection of scale and sediment at this point, which allowed the plate to become overheated. Nobody was injured.

(78.) — A tube failed, on March 3d, in a boiler in the Chester Manufacturing Company's No. 2 mill, on Penn street, Chester, Pa. No one was hurt.

(79.) — On March 3d a boiler exploded in C. D. Fountain's sawmill, about six miles from Dublin, Ga. The mill was completely wrecked; but there were no personal injuries received, because none of the hands were in the building at the time.

(80.) — On March 3d a boiler exploded in J. J. Kennedy's planing mill at Rib Lake, Wis. The smoke-stack and the walls of the building were wrecked, and Frank Frank was painfully injured.

(81. — A boiler exploded, on March 3d, in the electric light plant at Corunna, Mich. The damage was small, and we have not learned of any personal injuries.

(82.) — A boiler exploded, on March 3d, in the Howard Plate Glass Company's plant at Duquesne, Pa., completely wrecking the building. John Worricki, Paul Sneidzer, and John Martahigh were seriously injured, and it is doubtful if Worricki or Martahigh can recover.

(83.) — A boiler exploded, on March 3d, on Klingersmith, Moran & Co's oil lease, at Cygnet, near Bowling Green, Ohio. W. H. Wineman was seriously and perhaps fatally injured. The boiler-house was completely demolished, and the largest section of the boiler was thrown over 500 feet, passing through a 250-barrel oil tank in its course.

(84.) — On March 4th a boiler exploded in Frank Smaltzer's stone quarry, some two miles east of Myerstown, near Lebanon, Pa. Monroe Bollinger was instantly killed, and Irwin Firestine was fatally injured.

(85.) — On March 6th a locomotive boiler exploded at Millwood, Man., a flag station on the Manitoba & Northwestern railway. Engineer W. Hill and Fireman P. Dunlon were instantly killed. The locomotive and the first car were demolished.

(86.) — A boiler exploded, on March 6th, in Charles Bond's shingle mill, at Danielsville, Ga. David Scarborough and Calvin Freeman were instantly killed, and a brother of Freeman's was seriously injured.

(87.) — On March 6th a boiler exploded at Owensboro, Ky. Oliver Kelly was instantly killed, and Thomas W. Wisdom and Wilson Baxley were fatally injured. The boiler belonged to the Owensboro Canning Company.

(88.) — A boiler exploded, on March 7th, in the power-house of the electric railway system at East St. Louis, Ill. Engineer E. F. Sellers was severely scalded, and it is doubtful if he can recover. (We should say, from the account that has been received, that the explosion consisted in the failure of a dome, or a steam drum.)

(89.) — A boiler exploded, on March 7th, in the White Cloud steam laundry, at Ashland, Ky. Frank Owens was instantly killed. The laundry building was practically wrecked, and the boiler landed some 500 feet from its original position.

(90.) — On March 8th a boiler exploded at Hagerman, near Chipley, Fla. We have not learned further particulars, except that nobody was hurt.

(91.) — The boiler of locomotive No. 526 of the Denver & Rio Grande railroad, exploded on March 10th, at the Santa Fé crossing, Denver, Col. Engineer Ira Lowe, Fireman Wilbur Hoklas, and Brakeman Frank W. Painter were painfully injured. The front part of the locomotive was completely demolished, and a considerable length of track was torn up, the rails being spread and twisted, and some of the ties reduced to splinters.

(92.) — A boiler exploded, on March 11th, in Thomas Griffin's cotton gin, at Rienzi, near Whitney, Texas. No further information is at hand.

(93.) — A boiler exploded in the rolling-mill at Pullman, Ill., on March 13th. Details are lacking.

(94.) — On March 14th a boiler exploded in W. C. Cotton's sawmill, near La Grange, Ga. The fireman (whose name we have not learned) was fearfully injured, so that he died two days later. J. C. Norris and W. C. Cotton were also bruised to some extent.

(95.) — A boiler exploded, on March 14th, in Burkett Bros'. sawmill, one mile southeast of Sherman, near Grand Rapids, Mich. Nobody was injured, as the men were all away at supper at the time.

(96.) — On March 17th a boiler exploded in M. E. Leming's mills at Cape Girardeau, Mo. The place was wrecked. John Morgan and Ernest Willeford were killed, and George Roth, Jasper Phillips, and Fred Probst were injured.

(97.) — On March 17th a boiler exploded in Grant Daffron's sawmill, some two miles northeast of Cicero, near Noblesville, Ind. Alfred Bennett was instantly killed, and the building and most of the machinery were destroyed.

(98.) — On March 17th a boiler exploded in the artificial gas company's plant at North Dayton, Ohio. A man named Allbright was badly injured, but will recover.

(99.) — A boiler exploded, on March 17th, in John Minnie's mill, at Minnie Station, Bedford county, Pa. John Shess, David Snyder, and Peter Wink were killed, and John Snyder, Henry Siegal, and James Whitfield were fatally injured. Three other men also received lesser injuries.

(100.) — A boiler exploded, on March 17th, in David Clifton's shingle mill, at Cedar Creek, on the Cape Fear river, some twelve miles from Fayetteville, N. C. D. Clifton, O. H. Wheeler, R. Watson, and three men named Edwards were injured. Two or three of these men are believed to be fatally hurt. The mill was destroyed and the machinery wrecked.

(101.) — A heating boiler exploded, on March 21st, under the sidewalk in front of Blake's saloon, on Second avenue, Seattle, Wash. Several men who were passing at the time were blown into the air. D. W. Jacobs and Alfred Saltiel were killed, and Burns W. Beals, H Moss, Albert Swanson, and a 'longshoreman, whose name we have not learned, were injured. The 'longshoreman's injuries are believed to be fatal.

(102.) — On March 22d a boiler exploded in Samuel P. Greenwood & Bros.' sawmill, at Bruington Church, near Walkerton, Va. John Smith was killed, and Patrick Garnet was severely scalded. Samuel Greenwood, one of the owners of the place, also received minor injuries.

(103.) — A boiler explosion occurred, on March 24th, in Mosher's foundry, at Dallas, Texas. Nobody was injured, and the damage was small.

(104.) — A boiler exploded, on March 24th, in Cunningham & Greer's mill, near Dresden, Tenn. Lloyd Adams was killed, and Messrs. Cunningham and Greer were both injured.

(105.) — A boiler exploded, on March 25th, at the North Massillon mine, owned by the Ridgeway-Burton Company of North Massillon, Ohio. Fireman George Hodgson was badly scalded.

(106.) — Locomotive No. 862 of the Philadelphia & Reading railroad, was destroyed by the explosion of its boiler, on March 26th, at Mohrsville, some eight miles north of

Reading, Pa. Brakeman Oscar Leisey was instantly killed. Fireman Lyman Emerich was fearfully scalded, so that he died next day. Engineer George D. Zimmerman was also severely injured.

(107.) — On March 27th a boiler exploded on Jacob Plankerhorn's place at Muncy, near Williamsport, Pa. Richard Eckroyd, who was in charge of the boiler, was seriously injured, but will recover.

(108.) — On March 27th a boiler exploded in the Gordon sawmill, some eight miles southeast of Tiffin, Ohio. Joseph Williams and his son, Edward Williams, were painfully injured, and the mill was partially destroyed.

(109.) — A boiler exploded, on March 28th, in Jackson Bros.' mill, seven miles from Wetumpka, Ala. Bastin Jordan and Taylor Bickley were killed, and three other men were seriously injured. The mill was demolished.

(110.) — Four boilers exploded, on March 29th, in the Penwick distillery, at Cheswick, near Pittsburgh, Pa. Engineer Hugh Nulton was thrown a considerable distance, and was fearfully scalded and burned, so that he died a few hours later. James Henderson, an employe of the West Penn railroad, was also severely injured.

(111.) — A boiler exploded, on March 29th, on the Mississippi river steamer *Rowena Lee*, while she was nearly opposite Tyler, Mo., on her way from Cairo to Memphis. Two men were killed, and the boat, which was valued at $50,000, parted in the middle, and sank in seventeen feet of water.

(112.) — A slight boiler explosion occurred, on March 30th, in W. N. Jones' sawmill, near Fayetteville, Ark. Nobody was hurt and the damage was small.

(113.) — On March 31st a slight boiler explosion occurred in Cox & Co.'s machine shop, at Bridgeton, N. J. The accident, which was not serious, is said to have been due to corrosion.

(114.) — On March 31st a boiler exploded in Macbeth's sawmill, some seven miles from Kingsville, near Danville, Ky. James Carman was fatally injured, and Samuel Carman and Samuel Sweeney also received serious injuries.

Inspectors' Report.

April, 1899.

During this month our inspectors made 9,237 inspection trips, visited 18,280 boilers, inspected 7,646 both internally and externally, and subjected 793 to hydrostatic pressure. The whole number of defects reported reached 13,799, of which 969 were considered dangerous; 53 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,098	70
Cases of incrustation and scale,	2,524	77
Cases of internal grooving,	158	8
Cases of internal corrosion,	639	43
Cases of external corrosion,	553	57
Broken and loose braces and stays,	189	61
Settings defective,	350	26

Nature of Defects.	Whole Number.	Dangerous.
Furnaces out of shape,	420	18
Fractured plates,	289	37
Burned plates,	303	17
Blistered plates,	150	1
Cases of defective riveting,	3,064	64
Defective heads,	95	28
Serious leakage around tube ends,	2,439	249
Serious leakage at seams,	393	29
Defective water-gauges,	258	37
Defective blow-offs,	148	50
Cases of deficiency of water,	8	3
Safety-valves overloaded,	68	21
Safety-valves defective in construction,	82	27
Pressure-gauges defective,	414	37
Boilers without pressure-gauges,	8	8
Unclassified defects,	149	1
Total,	13,799	969

An Automatic Paper Mill. — "Joe" McCormick, of the International Pulp Company, tells a delicious story of paper-making in Connecticut, which shows that operating a mill is not such a serious matter as these big proprietors would have us believe. Strolling along the countryside in hay-making time, Mr. McCormick happened on a little paper mill which buzzed merrily in a shady dell, with everything clean and sweet around it. A look in the office showed no one there, and the visitor then wandered over the mill, hoping to find some one to whom he could talk business. The machine was humming along, and it seemed impossible that there should be no one in attendance. But even loud shouting failed to bring forth signs of life, and Mr. McCormick was about to leave when he spied some men in a hayfield, some distance away.

"I say," he called out to the nearest one when he got within hearing, "who runs this paper mill?" "I do," was the reply.

"Well, who's the owner?" "Why, I am, to be sure."

"Do you mean to say that the mill runs itself?"

"Cert. We start her up at six in the morning, and she runs till six in the evening. This mill's been weaned, stranger; she don't need a nurse. While I'm gettin' in hay she puts half a ton o' paper on the roll. Gee up, Bess!" — *Paper Trade Journal.*

"With the locomotive threatening to blow up at any moment, a train ran all the way from Wreck Lead to Lynbrook on the Long Island Railroad. It was a slow ride, but an exciting one. To stand beside a boiler that may at any moment be blown to pieces, needs nerve and devotion to duty. Both were shown by the engineer and fireman of the Long Island train. The train was from Long Beach. At Wreck Lead the locomotive refused to move. An investigation showed that the respirator which forces water into the boiler was not working. The train hands turned in with buckets, and saved the lives of all on board." So says the New York *World* of July 28th. There is something picturesque about the conception of a bucket brigade filling up the boiler when the "respirator" fails to work. We guess David Harum would say of the reporter that sprung this item, that it "ha'int rained wisdom an' knowledge in his part th' country fer quite a spell."

The Locomotive.

HARTFORD, AUGUST 15, 1899.

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.

Liquid Fuel.

In April of the present year we received a letter from Mr. James Holden, who appears to be connected with the Great Eastern Railway, with headquarters at Stratford, England. The letter dwelt upon the use of liquid fuel, and its substance was as follows: "In the English edition of *Cassier's Magazine* for the present month [April], there are, on pages 516 and 517, some notes on liquid fuel, in which reference is made to an article in THE LOCOMOTIVE, a journal which I understand is published by you. These notes state that 'even when the atomisers are in full operation they should be carefully watched, because they are liable, from time to time, to snap out,— that is, to go out suddenly, without warning.' It is also intimated that 'every now and then a fireman pays, with his life, the penalty for carelessness in re-starting the fire.' I enclose, for your information, a copy of a letter that I have to-day written to the editor of *Cassier's Magazine.*"

We do not see the English edition of *Cassier's Magazine*, so we don't know what it may have contained; but up to the present writing we have seen no mention of Mr. Holden's letter in the American edition. We therefore propose to give it due notice in the present place.

Mr. Holden's letter to *Cassier's* consists essentially of a repetition of the passage quoted above, followed by the following statement: "Liquid fuel has been in operation here for the last twelve years, and so far as our experience is concerned, these statements are absolutely incorrect. A man whose experience has been that stated, must be one who was acquainted only with the crudest and most elementary methods of using liquid fuel."

Perhaps we ought to admit what Mr. Holden tells us so cheerfully in the last sentence, for he knows what he knows, and we don't; and therein he has the advantage. Still, we trust he will not take umbrage if we are so bold as to offer a few words in our own defense. In the first place, THE LOCOMOTIVE has a circulation of 33,000 copies per issue, and is widely read by men who are likely to be put in charge of oil-burning devices, at any time that their employers may see fit to introduce liquid fuel. We therefore felt a certain moral obligation to tell the whole story, and to err, if we erred at all, upon the side of safety. We did not mean to say that a fireman who uses liquid fuel intelligently is in imminent danger of death. If we had believed that, we should have condemned the use of petroleum fuel unequivocally, instead of telling how it could be used with reasonable success. But, on the other hand, we had no idea of encouraging the belief that such fuel can be used with the same security as coal or cord wood. We don't know just what kind of fuel our English friend uses, but we suspect that it is petroleum *refuse*, from which the naphthas and other readily volatile constituents have been removed by distillation. If such is the case, his experience would naturally be somewhat different from our own, since a considerable fraction of the oil that is used as fuel in the United States is *crude* oil, which gives off inflammable vapors at almost any temperature. And so far as accidents are concerned, it is not sufficient to say that they *ought not* to happen, and it is not truthful to say that they *do not* happen. As an illustration of the possibilities of crude petroleum, we may say, that within half an hour's ride of the home office of the Hartford Steam Boiler Inspection and Insurance Company, there is a manufacturing plant in which this fuel was used for a considerable time, with what appeared to be a good form of burner, and with economical results that were satisfactory, so far as we are aware. On a number of occasions the flame "snapped out" without apparent cause. The attendants had been warned about the danger of relighting the oil without first shutting it off and ventilating the furnace, but it appears that this warning was not always heeded, for on two occasions a fireman was seriously burned, and on a third occasion one of the attendants was injured so badly that he died.

It is on account of experiences of this sort that we thought it wise to caution our readers as we did. We think that Mr. Holden, if he had seen our entire article instead of a mere brief extract from it, would probably have withheld his criticism. (The original article was in the issue of The Locomotive for December, 1898.)

The Circumference of a Circle.

All of the hand-books that tell us anything about a circle, tell us the circumference of a circle is found by multiplying the diameter by the decimal number 3.141592. Now we know that the circumference of a square is found by multiplying the side of the square by 4; and it is easy enough to understand that the circumference of a circle may be found by multiplying the diameter by *something*. The only point of difficulty about the case is, to see how we know that the particular long number that is given above is the thing to multiply by; and out of the multitude of engineers' books that have come to our notice, we do not recollect ever finding *one* in which any attempt is made to clear up this point, and explain how we know that the number 3.141592 is the right one to use.

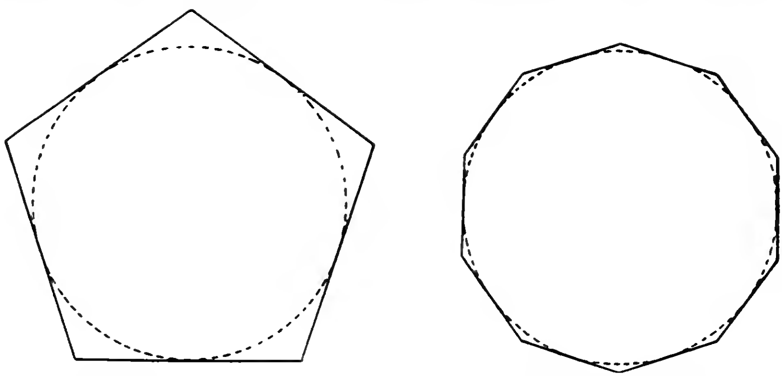
If we are going to understand this matter at all, we must make up our minds not to object to a little mathematical reasoning; for the problem in hand, being purely mathematical in its nature, must be solved by purely mathematical methods. We shall not go into it at all deeply, however, but shall content ourselves with showing how the circumference of the circle can be investigated by anyone who is good at figures, and has plenty of time and patience and paper and pencils.

As a starting point for our calculations, let us suppose that we have two circles of exactly the same size. Around the first one let us draw a regular figure with any number of sides we please, the sides being all equal to one another, and all just touching the circle, but not cutting it. A figure of this sort with *five* sides is shown, for the sake of illustration, in Fig. 1; but it should be understood that what we are about to say is in no wise restricted to this particular number of sides, but it is equally true, *what-*

ever the number of sides. Having drawn a figure of this sort, with some definite number of sides, around the first circle, let us now draw around the second circle a figure precisely similar in its nature, but with just twice as many sides as the first one. (If the first one had *five* sides, as in Fig. 1, the second one will have *ten* sides, as in Fig. 2.)

The figures that we have drawn around the circles are called "regular polygons." We may not know how to calculate the circumference of either of the two polygons that we have drawn; but it is not difficult to prove, by geometry, that a relation exists between these two circumferences, such that, if we could find out either one of them, we could calculate the other one. We shall not give the proof itself, but will merely state the relation between the two circumferences in the form of a rule, and for the sake of simplicity we will suppose that the circles are each one inch in diameter.

RULE. Having given the circumference of a certain regular polygon drawn around a one-inch circle, to find the circumference of another such polygon, *with twice as many sides*, and drawn around another one-inch circle, proceed as follows: (1st) Multiply the known circumference by itself, to the product add the square of the number of sides of



FIGS. 1 AND 2. — FIVE AND TEN-SIDED REGULAR POLYGONS.

the polygon, and take the square root of the sum. (2d) From the square root so found subtract the number of sides of the polygon. (3d) Multiply the remainder by twice the number of sides of the polygon, and divide the product by the polygon's circumference. The quotient so found will be the circumference of the polygon having *twice as many sides* as the first one, and drawn, like the first one, around a one-inch circle.

Without, as yet, going into any actual calculations, we can see how this rule will enable us to calculate the relation that the circumference of a circle bears to its diameter. For example, let us draw a large number of circles, each one inch in diameter, as suggested in Fig. 3. Around the first of these let us draw a square (or, in other words, a "four-sided regular polygon"). Around the second let us draw a regular polygon of *eight* sides, around the third a regular polygon of *sixteen* sides, and so on, as far as we please, doubling the number of sides each time. It is easy to see, without any calculation at all, that the circumference of the first polygon of this series (*i. e.* the square) is 4 inches. Knowing this fact, the rule just given enables us to calculate the circumference of the second polygon — that is, the eight-sided one. Then, when we know the circumference of the eight-sided one, a second application of the rule, with this as a starting point, enables us to calculate the circumference of the sixteen-sided one. Then, starting with the sixteen-sided one, a third application of the rule enables us to find the circumference of the thirty-two-sided one, and so on, as far as we please. Each of these successive applications of the rule brings us nearer to the circle that we desire to investigate; and by pushing the calculations far enough, we can approximate as closely as we please to the circumference of the circle.

The application of the rule is exceedingly laborious, and we shall not attempt to give the full calculation of the ratio of the circumference of the circle to its diameter, by this method. It may be worth while to give one example of the application of the rule, however, in order that the rule itself may be clearly understood. For this purpose we shall show how the circumference of the octagon (or eight-sided polygon) is computed from that of the square. The circumference of the square is 4, and the number of its sides is 4. Following the rule, we multiply the circumference by itself, and we have $4 \times 4 = 16$. Then the square of the number of sides happens to be 16 also; and adding these two together, as the rule requires, we have $16 + 16 = 32$. Next, we extract the square root of 32, and after considerable figuring we shall find that this square root, to eight places of decimals, is 5.65685425. The rule now requires us to subtract from this the number of sides of the polygon. This gives us

$$5.65685425 - 4 = 1.65685425.$$

We are next to multiply this by twice the number of sides of the square, and then to divide by the circumference of the square. If we do this, we shall find, as the final result, that the circumference of the octagon is 3.31370850″. A second application of the rule will then give us the circumference of the polygon with sixteen sides, and so

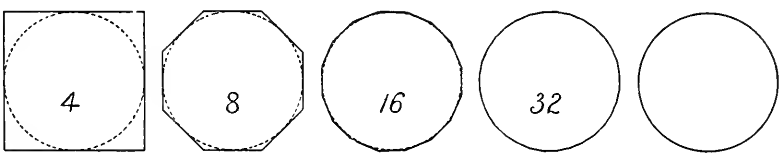


Fig. 3. — Showing the Approach of the Polygons to the Circle.

on; but to give the full calculation up to a point where the final polygon may be considered to be for all practical purposes identical with the circle, would require nearly as much space as there is in a whole issue of The Locomotive. To show how the process works, and how the figures gradually draw up to the accepted decimal that we quoted at the beginning of this article, we will give the circumferences of the first twelve regular polygons of the series, to six places of decimals (each polygon being supposed to be drawn around a one-inch circle).

Circumferences of Regular Polygons, Circumscribed about a Circle of Diameter = 1.

Number of Sides of Polygon.	Circumference of Polygon.	Number of Sides of Polygon.	Circumference of Polygon.
4	4.000 000	256	3.141 751
8	3.313 708	512	3.141 632
16	3.182 598	1,024	3 141 602
32	3.151 725	2,048	3.141 595
64	3.144 118	4,096	3.141 593
128	3.142 224	8,192	3.141 593

The final result to six places of decimals, it will be seen, is, that the circumference of a circle is equal to its diameter multiplied by 3.141593. The number given in the books, for this ratio, almost invariably ends, in the sixth place of decimals, with a "2" instead of a "3." This is wrong, however, for the true value of the number in question to ten places of decimals, is 3.1415926536; and if we throw away the last four decimals and keep only six of them, we ought to increase the sixth decimal by one unit, and call it a "3," since what we are throwing away is more than half of a unit in the sixth place.

A great many methods of calculating the circumference of a circle are known, and some of them are far easier of application than the one we have given here, although they require a considerable knowledge of mathematics for their clear comprehension. The circumference of a circle can be calculated in terms of the radius to within any proposed limit of accuracy; but it can never be expressed with absolute precision, because the ratio of the circumference to the diameter consists in a decimal that never ends, and never repeats itself. A great many enthusiasts have worked over this decimal, and it has been calculated (if we remember correctly) to seven hundred places, presumably in the hope that somewhere or other it might begin to repeat itself, and hence be capable of expression in finite form. The general problem of expressing the ratio of the circumference of a circle to its diameter with *absolute precision*, and yet without the use of a never-ending decimal, is commonly known as the problem of "squaring the circle." It has been recognized, for a long time, that it is probably impossible to "square the circle," and yet no absolute *proof* of this impossibility was given until 1882, when such a proof was first published by the German mathematician Lindemann.

The Sea Serpent Again.

According to a veracious contemporary, a lady sea serpent, properly equipped with a straw hat and a parasol, recently sailed up to the shore near a fashionable seaside hotel, and accosted the proprietor thereof in friendly terms. "Go away," cried he; "you're out of date; nobody wants to see you now. We've had a war, and a Klondike craze, and any number of other things to think of, and a sea serpent is a back number, and won't draw." But the serpent is proverbially wise, and the lady serpent here described was no exception. Moreover, she evidently read the papers, and knew very well the tendency of the modern drama. So she merely said, "I've got a brand new repertoire; I'm going to shed my skin, and you can advertise me in a disrobing act." We don't know whether she was engaged or not; but we're sorry to say that we think the chances were strongly in her favor.

The interest in the sea serpent has not abated "on the other side," however, and no disrobing specialty is there required to command attention, as will appear from a recent sea serpent story in the *Yorkshire Evening Post*, published at Leeds, England. The Scottish papers, it says, are still dealing with a sea serpent that was seen a short time ago near Campbelltown. One reporter had an interview with the skipper of the trawl that the monster pursued. "It was a wonderful adventure, if a somewhat narrow escape," began Sandy; "and an experience to be remembered. The monster suddenly loomed up astern, and followed in our wake for fully one hundred yards, coming so near as to almost touch our rudder. We were quite 'chummy' with him at first, but his attentions were becoming too close, and Buchanan, here, made to butt him with an oar. Then the savage in him showed itself. He snapped at the oar like a cock at a grosset, but my man was too smart for him. His length? Well, he was about twice the length of the *Puritan*, sir; that's about 60 feet; and he'd be from twelve to fifteen feet beam —

I mean, broad. What color? Gray, sir, very gray,— just like your trousers. But it's a lie to say, as the papers are saying, that he had 'an ugly big head and hideous jaws.' They were nothing special to speak of — that is, for his size." "But you got a fright, I presume," said the reporter, "when he made to swallow the oar, and kept so hard astern?" "Sure," replied Sandy; "and you'd have got a bit of a fright, too, if you had been there. I guess he could have put us where Jonah was. And the fins! You ought to have seen the fins. Big enough, they were. for a comfortable lug sail for a small-boat. I never saw such a fish — if it was a fish — in all my life; and I don't care if I shouldn't meet another." "Then, Mr. Galbraith, do you really think it was the sea serpent?" "Oh," said Sandy, with a knowing leer, "as to that I have my doubts; but I should say if it wasn't the sea-serpent it was a near relation. Anyhow, we all breathed a bit freer, I can tell you, when we lost his company." Mr. Galbraith's crew confirmed their skipper's narrative, and his father, who was present during the interview, and who is the oldest fisherman in Carradale, recalled an exciting adventure in his experience, when, a few years ago, a large porpoise, which was caught in the bag of the net, had a rope slipped around its tail, and then towed the skiff *Oimara* from off The Woods, on the Arran shore, to within a quarter of a mile of Carradale.

A correspondent of the London *Daily Graphic* also reports having seen a sea serpent on May 21st, while steaming close to Cape Falcon, on the African coast. At first it looked like a school of porpoises in a line, but, on a closer examination being made, it proved to be a sea serpent of some description. It was fully 130 feet in length, and moving with a slightly undulating motion in the same direction as the ship, only very much slower. "Unfortunately," says the narrator, "at the distance we passed it — about one mile,— we were unable to see the head, which, so far as could be made out, was on a level with the water."

A Hint to the Railroads.

There are some commonplace truths which only take on a practical value in men's minds when they receive some startling and easily understood illustration. Of such a kind is the theory of atmospheric resistance to moving bodies. People who are, or ought to be, greatly interested in the subject (foremost among whom are the railroad men of the country) are aware that air resistance is one of the impediments that keep down the speed of moving bodies; but we question if one in a hundred of them realizes this is not merely *one*, but probably at high speeds the *chief*, resistance. Engineers and architects are all familiar with the tables of wind pressure, from those of Smeaton to the later ones of Trautwine, Kent, and others; and roofs, bridges, and other frame structures are proportioned to meet pressures which range anywhere between 30 and 56 pounds to the square foot, according to the particular selection which is made from among the many tabulated guesses as to wind pressure which adorn the accepted technical pocket-books of the day. But while it is believed that a 60-mile wind will exert an 18-pound (Smeaton) or a 36-pound (Trautwine) pressure per square foot, it does not seem to occur to practical men that a 60-mile train (action and reaction being equal) will be subject to the same unit of pressure — or if it does occur to them, the fact is steadily ignored.

The daily papers have described in full the ride of a mile a minute recently made by a bicyclist behind the shelter of a locomotive and car. The facts are profoundly significant. Here is a man who, even if exerting himself to the utmost, could not ride a mile unpaced at the rate of thirty miles an hour, but can yet sweep along behind the shelter of a railroad train at a speed of sixty-four miles an hour, and have a reserve of strength to spare.

Let us look at the matter as a question of mechanics. A pressure of 33,000 pounds exerted through a distance of one foot in one minute equals one horse power — at least, so we are all agreed to believe. A pressure of one pound exerted through the same distance in the same time would equal $\frac{1}{33000}$ part of a horse power, and hence a pressure of one pound exerted through 5,280 feet, or one mile, in one minute would equal $\frac{5280}{33000}$, or 0.16 horse power. Let us suppose that a rider, when bent down into the racing position, represents about three square feet of front vertical surface, and that the wind pressure at 60 miles an hour is even less than that given by Smeaton's original formula, or say only 15 pounds per square foot, then $3 \times 15 \times 0.16 = 7.2$ horse power; that is to say, a bicyclist must exert over seven horse power to make a mile a minute against still air. Now, as a matter of fact, it is questionable if any but a few of the crack racing men can exert a full horse power, and they are capable of sustaining this effort only for about an eighth of a mile. Professor Denton, of the Stevens Institute of Technology, tested one or two powerful riders on the Webb floating dynamometer, and found that one "extremely powerful rider using his utmost effort" could only exert for a few seconds power at the rate of 19,780 foot-pounds of work per minute, while another in a hill-climbing test exerted 21,200 foot-pounds, or, say, two-thirds of a horse power,— but only for a fraction of a minute. The difference (supposing our assumed unit pressure for the atmosphere to be correct) between less than one horse power and over seven horse power represents a part of the work which was being done in the recent trial by the locomotive, which was opening out the atmosphere, as it were, to allow Murphy to ride through it in the body of still air within the shield.

Now applying these facts to a train composed of an engine, tender, and, say, half a dozen cars, moving at the rate of a mile a minute, we see at once that the accumulated atmospheric pressure on the front of the engine, the front of each car, the front of each set of trucks, and the various projections of ventilators, window recesses, and so on, must mount up in the aggregate to an enormous figure; and it is certainly a proof of the extraordinary conservatism of even such practical people as build and operate our railroads, that nothing whatever has been done to smooth down and close in our trains, so that the engine should do for the train that follows it what it did for the cyclist Murphy.

For the train to get all the benefit of the "pace" (to use a cycling term) afforded by the engine, the front car should be connected to the engine and each car to the one behind it by a continuous sheathing, similar in cross-section to the shield built for the recent bicycle trials. Sheathing should also extend from the sides of the cars to the rails, as in the wind shield; and this sheathing should be continuous from the pilot of the engine to the rear steps of the last car. The train would thus be vestibuled from the roof to the rails and from the pilot to the rear platform, and the result would be that the total front vertical area opposed to the atmosphere would be reduced prodigiously. As trains are now built, the air that is pushed aside by the engine closes in upon the first car, and upon the front of every car that follows it. Each truck also, and all of the brake gear and other external appliances, add to the total resistance, until we think there is little reason to doubt that at high speeds the resistance of the air exceeds by many times the internal and the rolling friction of the train.

The best work,— indeed, the only exhaustive work upon the subject,— is that written by Frederick U. Adams a few years ago, after an exhaustive and costly experimental study of the problem. At a speed of 60 miles an hour he estimates that the total front surface exposed squarely to the wind on a six-car Pullman train is 605 square feet, and the total air pressure 11,374 pounds. He urged upon the railroads the necessity for building their trains with a wedge-shaped front and flush and continuous sides extending to the rails, with vestibuled connections, and an absence of all deep recesses for windows and ventilators. It is a curious coincidence that the cross-section of the car proposed by Mr. Adams is almost identical with that of the shield built for the bicycle trial.

It is strange that with all of our earnest effort to reduce fuel expenses and increase the hauling power of our locomotives, by improving the track, compounding the cylinders, enlarging the boiler and so on, we have taken not one of the obvious and simple precautions by which the greatest of all train resistances might be overcome.

If at 60 miles an hour 7 horse power is consumed on the 3 square feet surface of a bicyclist, how much is consumed on the 400 to 600 feet front surface of an express train of the same speed? We commend the subject to the consideration of our master mechanics and railroad superintendents throughout the country. — *Scientific American.*

The Liquid Air Delusion in England. — At Taunton, last week, the electric-lighting committee presented a report from the consulting engineers, advising certain further improvements and extensions in connection with the electric supply works, and asked the Council for sanction to obtain tenders for the plant required. The chief opposition to the adoption of the committee's recommendations came from a certain Mr. Standfast, who read an extract from *Tit Bits* stating that "liquid air would supercede boilers and engines, and that coal, wood, and water would be required no longer. Factories would be worked by liquid air, which would be drawn from a source that was inexhaustible." From this he argued that there is a possibility of the new boilers and condensers not being required for the Taunton electricity works, and it was well to pause before laying out money on them. "It is a pity," he said, "that men's minds are so shallow . . . ." It is. — *The Electrician* (London).

[The foregoing item, which we take from the *American Machinist*, reads to us something like a joke. Mr. Standfast's name hath a ring to it that would justify suspicion, and his citing *Tit Bits* as an authority on engineering matters may also be intended to stimulate our risibles. We say these things because we don't want to go on record as having swallowed the bait without smelling of it first. However, if the thing *is* a joke, it is such a poor one that we shall pay its originator the compliment of taking it as a fact; and, taking it as a fact, we choose to see in it an excellent example of the unfortunate influence that the magazines have upon the general public when they publish articles on scientific subjects by men who don't know anything worth mentioning about those subjects. We don't doubt that this item is an echo from the shores of Europe of the impossible claim of Mr. Tripler's, which was widely circulated by *McClure's Magazine*, and which we exposed at some length in The Locomotive for April, 1899, — the claim, namely, that a liquid air motor can be made which will automatically transform the natural heat of the atmosphere into available mechanical energy.]

The winter of 1898–99 appears to have been remarkable for the number of kitchen boiler explosions that occurred during the season. Many of these explosions were attended by serious personal injuries. We have recorded but few of them, however, because they do not properly belong in the class of explosions that would interest readers of The Locomotive.

The Locomotive.

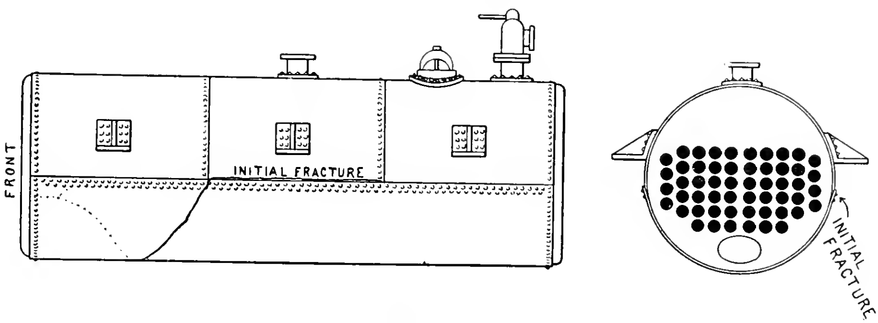
PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XX. HARTFORD, CONN., SEPTEMBER, 1899. No. 9.

Boiler Explosion in a Tramway Power House.

We shall take, as the subject for our leading article this month, the explosion of a boiler in a street-railway power house in the West. This explosion is of interest both because it was of a disastrous nature, and because it illustrates a point that we have touched upon several times in connection with boilers of the same type.

The power house in question contained a battery of twelve boilers, arranged side by side, as indicated in Fig. 3, and No. 5 was the boiler that exploded. No. 5 boiler was 66 inches in diameter, and 16 feet long, and was made of Park Bros. & Co.'s shell steel, $\frac{3}{8}''$ thick, and stamped 60,000 pounds tensile strength. The bottom half of the boiler consisted of a single big sheet, as shown in Fig. 1, and the top half consisted of the usual three courses of smaller plates. It contained 54 tubes, each 4″ in diameter



FIGS. 1 AND 2.—SHOWING THE INITIAL FRACTURE.

and 16 feet long, and it was operated at a stipulated pressure of 100 pounds per square inch. The heads were $\frac{9}{16}''$ thick, and each had eight braces above the tubes and two below them, all of which were one inch in diameter. There was a manhole in the front head, under the tubes. The middle sheet carried the steam nozzle, 5″ in diameter, and the rear sheet carried a manhole and a $3\frac{1}{2}$-inch nozzle for the pop safety-valve. The longitudinal joints were double riveted lap joints, with $\frac{13}{16}''$ holes, and a pitch of $2\frac{13}{16}''$. The girth joints were single riveted, with $\frac{13}{16}''$ holes, and a pitch of $2\frac{1}{8}''$.

The pressure at the time of the explosion was indicated by a recording steam gauge with which the boiler was provided. The reading of this gauge at the moment of explosion was 105 pounds per square inch; but as the gauge was known to be five pounds "fast," the actual pressure of the steam was precisely 100 pounds.

The primary rupture occurred in the horizontal lap joint on the right hand side of the boiler, where indicated in Fig. 1 by the words "initial fracture," the upper plate breaking along its entire length through the line of rivet holes. The front head, with the first ring of the upper part of the shell and a fragment of the bottom sheet, was thrown to the left about 175 feet. The back head was released by the shearing or fracture of its rivets, and was thrown to the right about 150 feet, with seven tubes still attached to it. The single bottom fire-sheet, with the two rear courses of the upper half of the shell attached, was thrown into the air, and fell about 120 feet from its original position, crushing the roof of the dynamo house. Boiler No. 4, adjoining the exploded boiler, was also a total loss, and Nos. 1, 2, and 3 were injured more or less, and the brick settings and connections and fittings were dismembered. Boilers Nos. 6 and 7 were stripped of fittings and connections, but not otherwise injured; and Nos. 8, 9, 10, 11, and 12 had all their steam connections disrupted, and their brick settings badly shaken. No warning was given of this explosion, and no evidence of weakness or distress was noticed. Only a few minutes before it happened the night engineer stood in front of this boiler, broiling a steak for his supper over some live coals taken from the furnace.

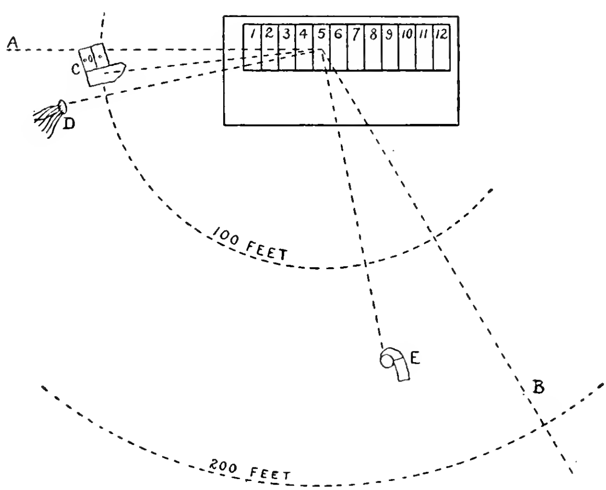


FIG. 3. — DIAGRAM SHOWING THE COURSE OF THE FRAGMENTS.

A, B, general courses of the tubes. C, where the chief portion of the boiler fell, in the dynamo room. D, back head, with seven tubes attached. E, front head, with a portion of the sheets attached.

There was no evidence whatever of low water in the boiler, and we are convinced that the explosion was due mainly to the gradual deterioration of the plate, at the point of initial fracture, from exposure of the joint to the action of the heat of the furnace. The single fire-sheet is used with the idea that much is gained by avoiding the use of girth joints exposed to the fire; and undoubtedly the construction in question is good, so far as this one point is concerned. But since the longitudinal joints are always subjected to greater strain than the girth joints, we hold that it is far more important to keep the former out of the fire than the latter. The largest boiler plates that are made are not wide enough to go more than half way around a big modern boiler; and hence it follows that the longitudinal joints of single-sheet boilers cannot yet be made to come much, if any, above the center line of such a boiler. In the boiler now under discussion, these longitudinal joints were seven inches below the center line of the boiler, and some 11 or 12 inches below the fire-line, where the walls of the setting closed in against the boiler. To protect the longitudinal joints of boilers with these big single fire-sheets, the brickwork should close in against the boiler down far enough so that the entire joint may be well covered in; and this mode of setting, although it cuts down the heating surface of the shell to some extent, is now required by the Hartford Steam Boiler Inspection and Insurance Company, in the interest of safety.

Fig. 4 shows the largest fragment of the exploded boiler in detail. It needs but

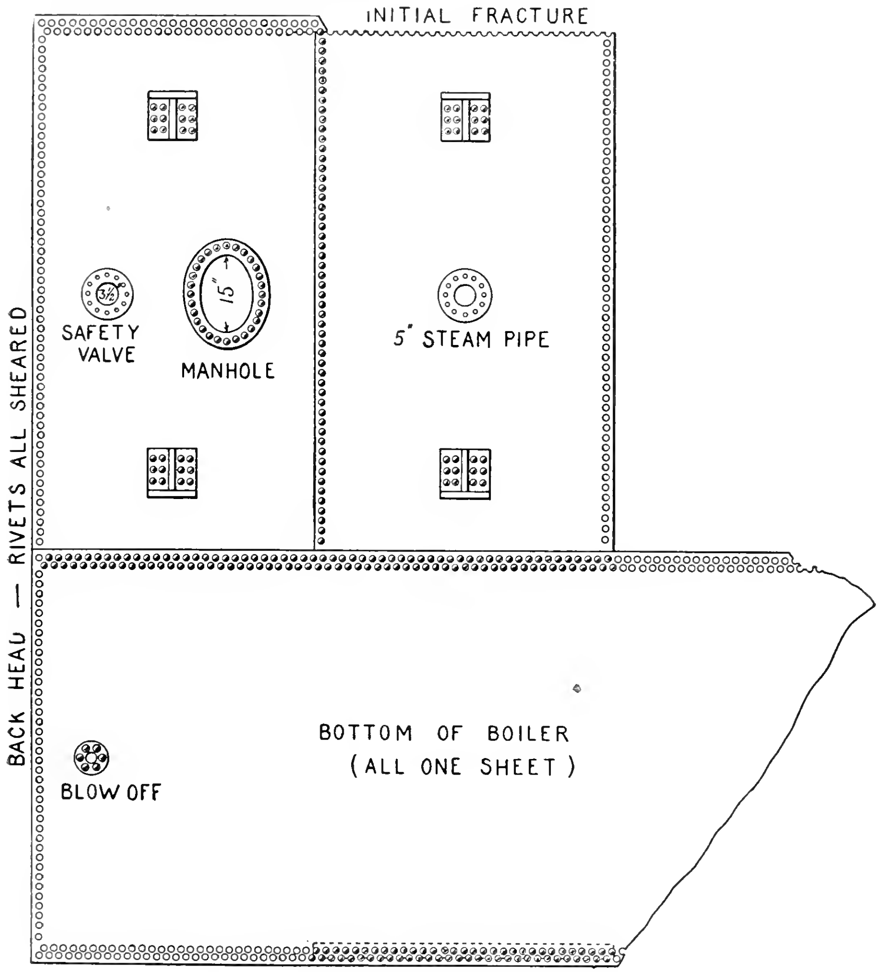


Fig. 4. — Largest Fragment of the Boiler.

little explanation. The rivets that remained in position after the explosion are shown shaded, while those that were sheared or pulled out or broken apart are indicated by small unshaded circles. The explosion killed two persons and injured three others, and the property loss is estimated at $50,000. In our issue for June of the present year we illustrated another explosion from the same cause, in which one man was killed, and the property loss was from $18,000 to $25,000.

Inspectors' Report.

MAY, 1899.

During this month our inspectors made 9,536 inspection trips, visited 18,148 boilers, inspected 7,713 both internally and externally, and subjected 854 to hydrostatic pressure. The whole number of defects reported reached 14,250, of which 1,257 were considered dangerous; 69 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,190	51
Cases of incrustation and scale,	2,637	52
Cases of internal grooving,	170	19
Cases of internal corrosion,	815	35
Cases of external corrosion,	707	40
Broken and loose braces and stays,	355	217
Settings defective,	352	35
Furnaces out of shape,	448	11
Fractured plates,	299	54
Burned plates,	284	21
Blistered plates,	161	10
Cases of defective riveting,	1,521	187
Defective heads,	135	17
Serious leakage around tube ends,	2,860	264
Serious leakage at seams,	455	17
Defective water-gauges,	266	52
Defective blow-offs,	155	48
Cases of deficiency of water,	14	1
Safety-valves overloaded,	59	39
Safety-valves defective in construction,	70	19
Pressure-gauges defective,	427	55
Boilers without pressure-gauges,	13	13
Unclassified defects,	857	0
Total,	14,250	1,257

Boiler Explosions.

APRIL, 1899.

(115.) — On April 3d a sectional safety boiler exploded in S. J. Reuter's greenhouse, at Westerly, R. I., destroying the boiler house, and depriving three 200-foot greenhouses filled with roses, and one 175-foot greenhouse filled with carnations and young stock for the coming season, of heat. The owner and the engineer left the boiler about ten or fifteen minutes before the explosion, and they state that at that time the glass was half full of water, and the steam gauge registered 20 pounds.

(116.) —The boiler of the locomotive of the train which left Portland, Me., at 7.30 A. M., on April 5th, over the Portland & Rochester railroad for Rochester, N. H., exploded while crossing one of the streets in a thickly-settled part of the town of Westbrook, Me. Fireman William Eldredge was killed instantly, and Engineer James

Bickford was injured so badly that he died within a few hours. Frederick St. Pierre, E. H. Lawrence, and three boys, who were playing near the scene of the disaster, were more or less seriously injured.

(117.)—A boiler exploded, on June 7th, in Smith Bros'. sawmill, at Stearns, near Saginaw, Mich. The accident consisted in the failure of the crown sheet. A young man named Smith was badly scalded about the body, and Fireman Sherman Osborn was injured about the legs. The other employés escaped injury, as the explosion occurred during the noon hour, while they were absent from the mill.

(118.)—On April 7th a boiler exploded in A. C. White's mill, on the corner of Euclid street and Jefferson avenue, Saginaw, Mich. The explosion occurred about midnight, and nobody was injured.

(119.)—On April 8th a boiler exploded in the Stump & Brotherton feed mill, at Terre Haute, Ind., wrecking the building, and seriously injuring Charles H. Baxter, who was passing the mill at the time. The explosion occurred during the noon hour.

(120.)—A boiler exploded, on April 11th, in Satterwhite's mill at Sweet Owen, near Owenton, Ky., instantly killing Engineer S. J. Lyon, and severely injuring James Lynn, and a mill hand whose name we have not learned.

(121.)—On April 11th a boiler exploded in Lewis & Fattic's grain elevator, at Markleville, near Anderson, Ind. The boiler house was wrecked, and the elevator building was badly damaged, but it does not appear that there were any personal injuries to record. The machinery about the boiler and engine house had been in need of repairs for some time, and, on the morning of the accident, one of the owners of the plant was in Anderson to get a man to do the work. While there he received a telephone message saying, "Never mind about the *man*. Bring a new engine and boiler. Old one gone to thunder."

(122.)—A boiler exploded, on April 12th, at Oshkosh, Wis., during the course of a big fire, which originated in the Choate-Hollister furniture factory.

(123.)—An upright boiler exploded, on April 12th, in the quarries and lime-kilns operated by F. M. Lee at Texas, Md. Engineer George Beatty was fearfully injured and may not recover. The boiler itself was torn into fragments, one of the largest of which was hurled a distance of 50 yards up the Northern Central railroad track. Another section weighing four or five tons was thrown over the tops of several trees and three houses, 200 yards away.

(124.)—A boiler exploded, on April 14th, in the White Star Mills, at Cismont, some 15 miles north of Charlottesville, Va. William O. Broadhead was fatally injured, and Thomas Walker and a little daughter of Mr. Broadhead were injured so seriously that their recovery is doubtful.

(125.)—On April 15th a boiler exploded in Taylor & Cregg's mill, at Drywood, near Chippewa Falls, Wis. Alonzo Wilcox and Joseph Burion were instantly killed, and John Briggs, P. J. Ried, and William Olson were more or less seriously injured. The mill was partially wrecked.

(126.)—On April 17th a boiler exploded in the Standard Brewing Company's plant at Rochester, N. Y., instantly killing Engineer Thomas Costello, and wrecking the boiler house. (This explosion was illustrated in the issue of The Locomotive for June, 1899, where further information concerning it may be had.)

(127.) — On April 17th a boiler exploded in Harrison Fletcher's sawmill at South Ottumwa, Iowa, blowing the mill to atoms. The proprietor's eight-year old son, Icle, was instantly killed, and four men who were working about the place were slightly injured. Bricks and fragments of timber were hurled to a distance of 300 yards.

(128.) — The boiler of a locomotive belonging to the Hastings Lumber Company exploded, on April 18th, near Camp Five, on the Wild River railroad, near Gilead, Me. Engineer Henry Belmont, Fireman E. F. Johnson, and Brakeman Cyril Lamore, who were in the cab, were instantly killed, and the locomotive was blown to fragments.

(129.) — On April 19th a boiler exploded in Shrubers' flouring mill at Morefield, on the White River branch railroad, near Newport, Ark. Engineer Henry Massey was killed, and the boiler house was wrecked.

(130.) — A boiler exploded in the basket factory at Swayzee, near Marion, Ind., at 5.50 A. M. on April 20th. The night man had been gone half an hour, and the day engineer had not yet arrived; so that nobody was injured. The boiler house was wrecked, and the roof was torn away from the machine room. A part of the machinery was also damaged.

(131.) — A boiler exploded, on April 20th, in B. F. Renfrow's whisky distillery, near Woodland, N. C. Thomas Jones and Charles E. Odom were instantly killed. Mr. Jones was the United States gauger.

(132.) — On April 21st a boiler exploded in a sawmill at Carter, a small station on the Chicago & Eastern Illinois railroad, some nine miles south of Salem, Ill. The mill was totally wrecked. Charles Sager, Seth Hammond, Walter Malcom, and a stranger, whose name we have not learned, are believed to be fatally injured.

(133.) — On April 21st a boiler exploded in Sargent & Dow's factory, at South Brewer, near Bangor, Me. We have not learned further particulars.

(134.) — A boiler exploded, on April 21st, in Rayburn's sawmill, at North Murray, Ky. John H. Rayburn and Berry Sutherland were killed, and Stanley Rayburn, J. H. Farley, Joseph Raines, and Charles Bogard were seriously injured. The mill was wrecked.

(135.) — The boiler of a ferry-boat exploded, on April 29th, at Chamberlain, near Winona, Minn. The boat took fire and burned to the water's edge.

The Atbara Bridge.

If we except the monuments of engineering skill, such as the Conway and Menai bridges, of the early period, and the Forth bridge of later times, no piece of bridge construction has attracted so much public interest and special attention as the very modest structure now in course of completion across the Atbara river [in Africa], to make a connecting link of the railway, the construction of which was no small part of Lord Kitchener's great achievement during his last two campaigns. And what is of higher interest to our own [*i. e.*, to British] engineers and bridge constructors, it was to the United States that the Soudan government was forced to resort, because no one in this country [*i. e.*, England], was able to compete, either as regards price or time of delivery, with the American firm that secured the contract. It is probably too much to hope that the object lesson taught by the Atbara River Bridge may be learned and fully set to heart in this country. But it will certainly do something to teach us that methods at least equal to those followed in America must be adopted here in England, unless we are content to see American workshops filled with British orders, and the name-plates of the Pencoyd and other similar works replace those of the time-honored British makers, who till now have gone on in their quiet way, secure in a false sense of imaginary superiority. It was near the site of the bridge that was fought one of the series of brilliant actions that culminated in the conquest of the Soudan, adding another victory to the long British record. And since the surprise of the Atbara bridge contract — a surprise as great as that of the Khalifa's hosts when British and Egyptian troops scattered them — another object lesson has been taught. On one of the Government railways now building in Burmah, a large steel viaduct is required — the longest, it is said, hitherto built. The Government invited tenders from four British and two American firms. Three of the former declined to tender, and one firm that had not been asked, requested, and received, permission to do so. Thus two British and two American firms tendered. The lowest offer of the British firms was $575,000, and three years for the completion of the work; while the lowest offer of the American firms was $325,000, and one year for completion. No amount of patriotism could condone a loss of $250,000 and two years' delay, so the order has gone to Philadelphia, to the shops that built the Atbara bridge. Bridge construction in the United States has long been reduced to a system of manufacturing a few special and standard types (except, of course, in special cases); and under these conditions a plant of the most complete and efficient kind can be laid down with confidence, for it can be employed in the rapid manufacture of the various standard types of bridges. Moreover, no machine or plant is allowed to become obsolete, and in such works as those of Pencoyd (and there are a dozen of the same class in the United States), a machine or a plant becomes obsolete as soon as it can be replaced by other machinery that can give better paying results. In this way American shops of the best class are kept always in the highest state of efficiency, and the vast outlay incurred in the frequent renewal of the plant is more than repaid by the increased output. In England, on the other hand, it has been the custom, since iron bridges were first constructed, for each engineer to design his own bridges, with the main object of making them somewhat different from every other engineer's design. Thus a bridge-constructing plant of high efficiency could not be erected with profit by the British manufacturer; and hence slow and costly production is unavoidable. It is the old story over again, on a large scale, of the American and British lock-making industry, and a dozen others. . . . Since the foregoing was written, we have received information of an interesting incident in connection with the Atbara bridge. On April 26th there was received at the Pencoyd works in Philadelphia, a telegram from the Egyptian War Department, stating that the top chord of one panel of the bridge had been lost in trans-shipment, and must be replaced without delay. This telegram was received at 4 P. M., and a duplicate of the missing part was at once set in hand; and it was completed, packed, and on its way to New York at 9 o'clock on the following morning. The duplicated part arrived duly in Liverpool, where it remained, awaiting further instructions, for at least three weeks! — *London Engineering.*

THE ocean steamship record, from Cherbourg to Sandy Hook, was broken, on September 5th, by the big liner, *Kaiser Wilhelm der Grosse*, which crossed in five days, eighteen hours, and five minutes. She had covered 3,049 knots, at an average speed of 22.08 knots per hour.

The Locomotive.

HARTFORD, SEPTEMBER 15, 1899.

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, with the compliments of Col. E. D. Meier, a copy of the *Proceedings* of the tenth annual convention of the American Boiler Manufacturers' Association, held at St. Louis, Mo., on October 3d, 4th, 5th, and 6th, 1898. It contains a great deal that every boiler manufacturer ought to read; notably the *Report* of the committee on Uniform American Boiler Specifications, and the interesting and sometimes lively discussion that followed it.

MESSRS. Griffin & Winters, publishers, of Chicago, Ill., send us a copy of the latest edition of Mr. Charles McShane's *The Locomotive up to Date* (price $2.50). We have examined it carefully, and find that it contains a great deal of information which should be of real value to railroad men who have to do with the erection, the repairing, or the running of locomotives. It contains some 700 pages, and is copiously illustrated. We wish the author had credited THE LOCOMOTIVE with what he has to say about the "history of the meter," on pages 578, 579, and 580. We note, however, that he does give us full credit for an article on stay-bolts, beginning on page 463, so we have no doubt that the omission of credit for the other matter was accidental.

WE desire to acknowledge the *Engineers' and Electricians' Handbook*, a book of 150 pages, whose character is indicated by its titie, and which is issued in Philadelphia, Pa., by "Welcome Council No. 2," of the American Order of Steam Engineers. It contains a great deal of useful information, and appears to be well edited. We are afraid, however, that it contains more formulae than the general run of engineers will want to find there. We note that on pages 35 and 37 this handbook gives a suggestion of the way in which the well known decimal number 3.1416 may be calculated; we mention this particularly because it was only in the last issue of THE LOCOMOTIVE that we said that we could not recall ever having seen it discussed in any of the manuals of this class.

The American Industrial Publishing Co., of Bridgeport, Conn., has issued an attractive volume by Mr. William Houghtaling, entitled *The Steam Engine Indicator and Its Appliances.* It is intended especially for inexperienced men, and it gives a good deal of thoroughly practical information, which ought to make it a valuable engine-room companion. We note that the language is a little confusing in places. For instance, on page 150 we read that "any inclination or leaning of the admission line . . . is usually constructed and considered to be an improper adjustment of the valves." Again, on page 179 we read that "the fact of their disagreement is caused principally to undue friction." These and other similar peculiarities should have been eliminated by the proof-reader; for they mar, to a certain extent, what appears to be an otherwise excellent contribution to engineering literature. (Price, $2.00.)

The Utility of Science.

Professor Cleveland Abbe recently delivered an address before the Franklin Institute, entitled "The Relations of Physics and Astronomy to the Development of the Mechanic Arts." It is exceedingly interesting, and is reprinted in the *Journal* of the Franklin Institute for August, 1899. In discussing the paper, Dr. T. C. Mendenhall made the following remarks, which are of interest in themselves, apart from their connection with Professor Abbe's paper.

"The world," he said, "has produced few, if any, more brilliant men than Benjamin Franklin. There is one quality of his scientific work to which I want to invite especial attention; it is the almost ever-present practical end towards which nearly every investigation was directed. On account of the great luster of his researches in electricity, it is often forgotten that he enriched nearly every department of physical science, and, although he evidently did not lack capacity for that keen enjoyment of discovery which depends upon discovery alone, and is indifferent to practical results, it is everywhere evident that with him the possibility of turning a scientific experiment or principle to good account as a means of bettering the condition of his fellows was paramount. There is a certain class of scientific men, not large and not increasing, we are glad to note, among whom it is the fashion to speak with what they believe to be a 'fine contempt' of applied science, and who, having never succeeded in discovering anything of any particular value or use, pride themselves on pursuing science for the sake of science. And we have all heard of the mathematician who thanked God that he had at last discovered a formula of which it would be utterly impossible ever to make any practical use. But this doctrine has not been held by those most entitled to distinction in the annals of science, and Franklin was a notable example of those who believe that the noblest ambition by which a man of science may be stirred is the ambition to discover laws which may be utilized in the amelioration of the almost necessarily harsh conditions by which mankind is surrounded.

"During the life of this nation the most marvelous changes have been wrought in the material condition of man and his relations to the planet which he inhabits. We have ourselves witnessed so many of these changes that detailed reference to them is unnecessary, but we may profitably inquire concerning the underlying cause of such a prodigious revolution. To my mind it is found and found only in the discoveries in physical science, and in their application to the control and direction of the forces of nature. Man lives in this world only by the continued transformations of energy, and his comfort and happiness depend largely on the amount of energy he is able to transform. It is not long since his only supply was that furnished by the muscles of his own body; but during the nineteenth century he has been able, thanks to physical science, to draw upon almost inexhaustible sources from without, and this is why he has progressed by leaps and bounds that have exceeded the most extravagant imaginings of our ancestors. This progress cannot be attributed to war, for war has existed since the dawn of history, and it has failed to lift man above the slavery of unintelligent toil. Nor is it due to religion, nor literature, philosophy or art, for all these have flourished for ages without materially altering the relation of man to his environment. Science, with its unerring processes of observation, experiment, and precise measurement, has inaugurated the peaceful revolution in social relations and material conditions which the nineteenth century now passes on, still incomplete, to the twentieth. The pen has conquered the sword, but the yard-stick is potentially the master of both."

ON March 13th a water-tube boiler exploded on the British first-class cruiser *Terrible*, while she was at sea en route from Malta to England. One stoker was killed and another was fatally injured. Several other men were badly scalded. The *Terrible*, and her sister ship, the *Powerful*, are steel sheathed vessels of 14,200 tons displacement, and were launched in 1895. Both vessels have been unfortunate since their completion, especially the *Powerful*, whose machinery has frequently given trouble. A boiler tube bursted, also, on the British torpedo-boat destroyer *Earnest*, while she was maneuvering at Gibraltar, on May 18th. Three men were injured on this occasion.

The American Boiler Manufacturers' Association.

In the *Proceedings* of the American Boiler Manufacturers' Association, the receipt whereof is acknowledged elsewhere in this issue, we find the Report of the Committee on Uniform American Boiler Specifications. We cannot reprint the Report in full, but some of its sections will be of especial interest to our readers.

On the subject of riveting, the Report says: — "The holes should be perfectly true and fair, made so by the use of clean-cutting punches or drills; all sharp edges and burrs are to be removed by slight counter-sinking and burr-reaming, before and after the sheets are joined together. The under sides of the original heads of the rivets must be flat, square, and smooth, so as to ensure perfect contact with the plate. For rivets from $\frac{5}{8}$ inch to $\frac{13}{16}$ inch in diameter, allow $1\frac{1}{2}$ diameters for length of stock to form the head. For larger rivets allow less length. For button-set or snap rivets, five per cent. more stock may be allowed, to form the driven head. Light regulation rivet hammers are to be used until the rivet is well upset in the hole; after that, the snap and heavy mauls. For machine riveting more stock may be left for the driven head; this to be fixed by experimenting. The amount of pressure on the die should be about 80 tons for $1\frac{1}{2}$-inch or $1\frac{1}{4}$-inch rivets; 65 tons for 1-inch; 57 tons for $\frac{15}{16}$-inch; and 35 tons for $\frac{3}{4}$-inch rivets. Rivets should be tested both hot and cold, by driving down on an anvil with the head in a die, by nicking and bending, and by bending back on themselves, all without developing cracks or flaws. The heads of the rivets should be of equal strength with the shanks; this condition is fulfilled by giving the head at the periphery of the shank a height equal to one-third of the diameter of the shank. A slight fillet at this point is advisable. The rivets should have a diameter about double the thickness of the thinner plate; the pitch should be about three times the diameter of the rivet hole. The distance between staggered rows of rivets should be half the pitch; the lap for single riveting should be about equal to the pitch, and the lap for double riveting should be about $1\frac{1}{3}$ times the pitch, with $\frac{1}{3}$ of the pitch extra, for each row of rivets in excess of two. All these are approximations, and the *exact* dimensions are to be determined by making the resistance to shear of the total rivet section at least ten per cent. greater than the tensile strength of the net or standing metal. A factor of safety of $4\frac{1}{2}$ shall be used where the tensile strength of the plate and the shearing strength of the rivets have been determined by actual tests. Where this has not been done, a factor of safety of 5 shall be taken. The greatest tensile strength to be allowed for steel plates shall be 55,000 pounds per square inch, and the greatest shearing strength to be allowed for rivets shall be 40,000 pounds per square inch. The judicious use of the drift pin with light hammers in pulling the plates into place and rounding up the hole is not objectionable; but enlarging holes, or gouging them to a fit, by driving in a drift pin with heavy hammers or mauls is condemned as a barbarous practice. When drawn into an approximate fit, the holes must be trued up by means of reamers."

On calking the Report says: — "The old style, known as split calking, is unfit for boiler work. Excellent work can be done both by hand calking or calking with the pneumatic hammer and the conery or round tool. Excessive calking throws undue strains on the rivet heads, and must be avoided. The square-nosed tool should be used only in corners where the round-nosed form cannot reach, and in taking up small local leaks. Extreme care is necessary to avoid nicking the lower plate. The fit should be made in the laying of the plates, and the calking should be employed only to correct the natural and unavoidable roughness of the surfaces of contact. Calking edges should be prepared by bevel planing, bevel shearing, or bevel chipping."

"Stay bolts," says the Report, "should be made of iron or mild steel, specially manufactured for the purpose. If made of iron, the material should have a tensile strength of not less than 46,000 pounds, and not less than 26,000 pounds elastic limit. The elongation should be not less than 22 per cent. in eight inches, for bolts of less than one square inch of net area, and it should not be less than 20 per cent. in eight inches for bolts whose net area is one square inch or more. If the stay-bolts are made of steel, the material should have a tensile strength of not less than 55,000 pounds, and its elastic limit should not be less than 33,000 pounds. The elongation should not be less than 25 per cent. in eight inches for bolts of less than one square inch net area, nor less than 22 per cent. in eight inches for bolts of one square inch and more in net area. Stay-bolts should be subjected to the following tests: — (1) A bar is to be selected at random from a lot of one thousand pounds or a fraction thereof. After being threaded with a sharp die to a 'V' thread with rounded edges, it should bend cold one hundred and eighty degrees around a bar of the same diameter as itself, without showing any crack or flaw. (2) Another piece, similarly threaded, is to be screwed into well-fitting nuts formed of pieces of the plates that are to be stayed, and it is then to be riveted over so as to form an exact duplicate of the bolt in the finished structure. It is then to be pulled in a testing machine, and the ultimate stress carefully noted. If it fails by pulling apart, its tensile stress per square inch, figured on the original net section, is to be used in figuring the safe load. If it fails by shearing the thread, the shear stress per square inch of the mean section in shear is to be so used. (This 'mean section in shear' is found by multiplying half the thickness of the plate or nut by the mean between the circumferences at the base and at the crown of the thread.) The safe load is to be determined by applying a factor of safety of five to the ultimate stress per square inch thus found. Stay-bolts should be carefully threaded with sharp, clean dies. They should be cut on a threading machine equipped with a lead screw, so that there will be no variation in the pitch of the stay-bolt threads. Holes should be tapped with a tap extending through both sheets, and to a neat, smooth fit, just easy enough to enable the workman to put the bolt in by a hand lever or wrench with a steady pull. Great care should be taken to make full, clean "V" threads with rounded edges, making a close, neat fit, so that very little riveting will be required. One-fifth of the diameter is the proper height for projecting and riveting. Riveting is detrimental to the threads both in the sheets and on the stay-bolts. In the case of hollow stay-bolts, a long slender drift pin should be driven into the bore before the riveting, and kept there until the riveting is completed. The pin should then be driven home firmly, so as to slightly expand the bolt and counteract the tendency to loosen the thread, due to the riveting. The pin is to be finally removed by loosening it by slight taps of the hammer all around, or by driving it out by a bar from the other end. When nuts are used on screw-stays, the height or thickness of such a nut shall not be less than sixty per cent. of the diameter of the bolt."

"The Two Berlins."

The Berlin Iron Bridge Company, of Berlin, Conn., is a corporation of which Connecticut may well be proud. It has grown steadily and rapidly, until it has now reached enormous proportions, and sends out its work to every part of the world, civilized and uncivilized. Considerable interest was recently aroused by the erection of a big structural iron building, in Berlin, Germany, by the company whose home is in Berlin, Connecticut. The general facts concerning this operation are given in a recent issue of the Hartford *Courant*, together with an interview with Mr. George Klimm, who superintended the erection of the building. The *Courant's* article is as follows :

Some six years ago, representatives from a large German manufacturing corporation, who were traveling through the United States with a view of examining our methods of manufacturing, were forcibly impressed by the superior design and construction of many of our large manufacturing buildings. These they found to be better lighted, better ventilated, and in every way more attractive in appearance than those occupied by the best of German manufacturers. Deeply impressed by these facts, they consulted with the Berlin Iron Bridge Company, of East Berlin, Conn., and employed that company to design a new machine shop, the erection of which they at that time contemplated. Owing to the very low price of structural material then prevailing in Germany, and the higher prices at which it was selling in America, the Connecticut Berlin people found it impossible to compete for the construction with the Germans ; and the shop was therefore built by German workmen. About a year ago, however, the same German company, contemplating a large foundry building, again sought the assistance of the Berlin Iron Bridge Company in designing the plant, and were gratified when the American builders were able to give them a price for the construction of the building, which compared favorably with that quoted by the German manufacturers. As a result, the contract for this building was placed with the Berlin Iron Bridge Company, and the steel framework was manufactured at East Berlin, in Connecticut, and shipped by steamer to Berlin, Germany; and employés of the Berlin Iron Bridge Company were sent to Germany to place the steel framework in position.

Mr. George Klimm, himself born of German parents, was superintendent in charge of the work, and has just returned with his men. As Mr. Klimm and his men were in Germany soon after the breaking out of the Spanish-American war, they naturally excited considerable attention among the German mechanics. Mr. Klimm says that as soon as he reached Berlin he found that the feeling among all the classes of German workmen with whom he came in contact was decidedly against the United States. They had no doubt whatever but that Spain would defeat us; and after the destruction of the Spanish fleets and the fall of Santiago they claimed, even then, that our victories were due to the fact that our army and navy were full of German officers and gunners. Under no circumstances would they admit any superiority in anything American.

Mr. Klimm described the customs of the German workingman as follows: "The ordinary German mechanic takes a cup of coffee as soon as he gets up, and starts in to work at six o'clock in the morning. At 8.30 he knocks off for breakfast, at noon for dinner, and at 4 in the afternoon he knocks off for lunch, but works until 7 in the evening, when he quits for the day and for supper. The food of the ordinary German mechanic is much plainer than we are in the habit of receiving in this country. You must be aware of the fact that bridge builders like myself are in the habit of traveling all over the United States, and are familiar with all kinds of fare; but the poorest and plainest I have had in my twenty years of experience was that which I received in Germany. We had very little meat, and no pastry whatever; but of beer we had any quantity at all times, in all places, and under all circumstances. In fact, beer seems to take the place of bread with the German workingman."

"I suppose you employed some German workingmen?" asked the *Courant* reporter.

"Yes, sir. I took over with me ten men from here, and employed from ten to fifty Germans on the work at Berlin, while it was progressing."

"How does the ordinary German workingman compare with the American?"

"The German workingmen are not in it with the Americans. As a rule, they don't show any ambition. Of course there are exceptions, and I had many Germans in my gang who were good men; but after an experience in all parts of the United States, from the negroes of the South to the lumbermen of the North, I have no hesitation in saying that the ordinary Yankee will do as much as any two Germans. At least, that is my experience. They pay their men about the same as we do here. In fact, I found I had to pay my help in Berlin, Germany, as much as I did in almost any part of the United States; but they are not good mechanics, and they do not seem to have any idea of taking any advantage of their work. They stand around for the boss to show them how to do anything, rather than to go ahead on their own hook. This was especially the case with men working aloft. In fact, where an ordinary American bridge builder would hang on with his legs and work with his hands, the Germans insisted that they must have a staging built; while in ninety-nine cases out of a hundred the American would have taken less time to do the work than the German would have, to put in the staging."

"How does the quality of our work compare with the quality of the work furnished by the German bridge builders?"

"I had very little opportunity to observe, but the work which I saw at Berlin, built by German bridge builders, appeared to me much inferior to that furnished by my own company. All our work was carefully punched and fitted before it went from here, so that my task consisted entirely in putting it in place. The German erectors were very much interested in our methods of handling this work, and they were all much astonished to find that I did not have a lot of reamers and hack saws in my outfit. In America a bridge builder's kit contains a hack saw and a reamer; but in Germany these are the principal tools, as the work is so poorly fitted at the shops that the greatest portion of it must be reamed and fitted in the field.

"I am, of course, employed by the Berlin Iron Bridge Company as a foreman, to erect their work, and I know nothing about prices; but from what I saw in Germany, I am satisfied from our improved methods of manufacturing, that the American bridge builder can compete successfully with the Germans, and I believe this business will develop rapidly; for certainly they have nothing in Berlin to compare with the building that we lately completed."

"How large a building was it?"

"Well, I do not recall the exact dimensions, but it covered an area of somewhere about 60,000 square feet, or about an acre and a half of floor surface. It was a very large building. In fact I did not see any manufacturing buildings quite as large as this, anywhere throughout Germany. The concern for which we put up this building is very large, and is one of the principal manufacturing companies in Berlin — perhaps *the* principal one."

At Windsor Locks, in Connecticut, the New York, New Haven & Hartford railroad is carried on an iron bridge that was designed and put up by English mechanics, something like thirty years ago. At that time there were few companies in America that did this class of work, and the railroad company could buy the bridge cheaper from the English bridge builders than any other place in the world. That was less than forty years ago; and to-day American bridge builders are shipping material to all parts of the world. It seems to be a strange thing, to one who has not closely followed the manufacturing industries of the world, that Berlin, Connecticut, should furnish steel buildings for Berlin, Germany; but this is the fact, and the German, English, French, and Belgian mechanics are beginning to realize that the United States is a great and powerful factor in the manufacturing industries of the world.

Two Notable Railroad Projects.

In the August issue of *McClure's Magazine* we find an interesting article by Mr. W. T. Stead, entitled, "The Cape to Cairo Railway." A portion of this article deals with the telegraph line that has been projected, to extend along the whole length of the continent of Africa, from Cairo on the north to Cape Town on the south, and the remainder of the article deals with the railway that Mr. Cecil J. Rhodes proposes to build between the same two points. Mr. Stead evidently does not believe that the projected and partially built railway will be a financial success. He quotes a noted Russian financial authority as saying of the great trans-Siberian railway (which, from St. Petersburg to the Pacific, will be twice as long as the distance from New York to San Francisco), "This railway, like many others of the same nature, is building under the compulsion of an impulse, or an instinct, which it is impossible to justify on financial, political, or military grounds. The sacrifices which the construction entails will never be repaid, at least to the men who make them. From a financial point of view I could name a score of other methods of investing money within the empire that would pay handsomely, pay far better than this transcontinental railway can ever hope to do. But nations appear to be sometimes possessed by an uncontrollable passion to bring together the uttermost ends of a continent, quite irrespective of rational motives. It is a kind of demon which drives them; and I can only suppose that the impulsion is intended to promote the general good of mankind. Certainly, in our case, the sacrifices are much more obvious than the gain to Russia." Mr. Stead then points out that there is still less to be said in favor of the "Cape to Cairo" railway; for the Londoner can hardly hope to reach Cape Town by rail, when the railway is completed, in less than fifteen or sixteen days, and he can now get there by sea in some seventeen or eighteen days. After saying that there may be something in the theory of his Russian friend, he adds: "But the outer and visible reasons why the Cape to Cairo line is coming into being are simple and obvious enough. The first, and dominating cause, is the fact that the idea has fascinated the imagination of Mr. Rhodes; and the second and hardly less potent reason is the fact that the Cape and Cairo both begin with the letter C. Possibly this second reason ought to have precedence over the first; for who knows how much of the fascination which has caught Mr. Rhodes's fancy was due to 'apt alliteration's artful aid'?" To be sure, Mr. Stead recognizes the existence of other motives, such as the desire of Englishmen to increase "the security of their somewhat precarious position in Egypt and the Nile valley"; but, nevertheless, he appears to think that the pleasant ring of the phrase, "Cape to Cairo," is the most important feature in the case. It might be supposed that it would be hard to get sound-headed capitalists to put their money into a scheme of this kind; but then it must be remembered that Mr. Rhodes is looking after this part of the programme very assiduously; and Mr. Rhodes has done many an impossible thing before now. We cannot undertake to give the exact present status of the railway; that will be found in some detail in the latter part of Mr. Stead's article. We may say in general terms, however, that a completed railway connects Cairo with

Assuan. There is then a gap of perhaps a couple of hundred miles to Wady Halfa, from which point a completed line now extends to the Atbara river — a distance of three or four hundred miles. This stretch was laid down under the direction of Lord Kitchener, chiefly for military purposes. Progress beyond this point, as Mr. Stead says, "was stopped by the difficulty of bridging the Atbara river. It was decided to throw a bridge across the river before the July floods. The time was short. Tenders were invited from British bridge builders on a specification which was so elaborate that, when the tenders arrived, it was discovered that the structure would take two years to erect. Fresh tenders had to be invited in hot haste, and to the infinite dismay of the British public it was discovered that the Americans beat their rivals hollow both as to time and as to price. The order was not a very large one. The total cost of the bridge was only $32,500. But no incident in recent years has brought home to the British public the extent to which the British manufacturer has been beaten by his American rival, more forcibly than this matter of the Atbara bridge. No English firm could undertake to deliver the bridge either at the cost or in the time in which it was supplied by the Americans. Within thirty-seven days of the receipt of the order the seven spans of the Atbara bridge left New York harbor for their destination in Egypt." (We have referred to this matter elsewhere in the present issue of The Locomotive.) From the Atbara south to Khartum a railway is now in course of construction. There is then a great gap of somewhere about 3,000 miles, to the gold and coal regions of Rhodesia. A section some three hundred miles long, running from this region to Bulawayo in Rhodesia, is now under way; and from Bulawayo to Cape Town there is a completed railway. We have little doubt that the three-thousand-mile gap that has not yet been definitely surveyed or otherwise arranged for, will be bridged over — ultimately; but if Mr. Rhodes intended his invitation to Mr. Stead, to be present at the laying of the last rail on January 20, 1909, as anything more than a joke, we have a large idea that he is going to be disappointed, somewhere about that time, or before. Labor down in the Zambesi region is pretty cheap, though, and an able-bodied man can be hired there, it is said, for eighteen dollars a year! "The men employed in pegging out the telegraph line between Nyassa and Tanganyika," says Mr. Stead, "are paid in a currency of calico, estimated at less than a dollar a month."

Another railway of much interest and importance is described by Mr. Harrington Emerson in the August issue of the *Engineering Magazine*, under the heading, "The Road to the Gold Fields." The gold fields here referred to are those of the Klondike region, and the railway is the one that starts from Skagway and extends over the White Pass to the summit of the mountain range, from which point it is to be extended inland to Fort Selkirk, at the junction of the Pelly and Yukon rivers.

We recently gave a brief account of a "hurry job that the Baldwin Locomotive Works did, in getting out a couple of locomotives for the White Pass & Yukon railroad. These locomotives are now in service there; and the first passenger train was run from Skagway up to the summit of the White Pass on February 20, 1899. "This railroad," says Mr. Emerson, "is a great example of engineering and constructive skill. It would have been a great feat to grade forty miles and build twenty over a similar rocky pass under the most favorable conditions; but this work was done in seven months, in a region without laborers, one thousand miles from supplies, three to four thousand miles from rolling mills and car shops, and against fearful climatic conditions. Day after day fresh snow drifted over the road bed, and day after day it had to be shoveled off, sometimes to a depth of six to eight feet. Supplies, bridge timbers, fire wood, even, for the enormous camps, had to be carried over almost impassable snow trails. There were days when men could not work on account of the storms or the intense cold; but they had to be fed and warmed." In concluding his article, Mr. Emerson says: "Nowhere else as on this gold trail has the genius of engineers wrought such beneficent and rapid change in so short a time. The evolution from hunter's path to railroad, through the intermediate steps of pilgrim path, mule trail, and wagon road, was two thousand years in making, in the Saint Gotthard Pass, the great high road between the most civilized portions of the ancient world and of the mediæval world, the road that led from the gloomy north to the rich south,— rich in treasures, in food, in spiritual tradition and comfort. Two short years as against two thousand have evolved the same succession of improvements on the highway over the White Pass, back to a north hideous in climate, without history, without sentiment, without food, but abounding in gold."

The Locomotive.

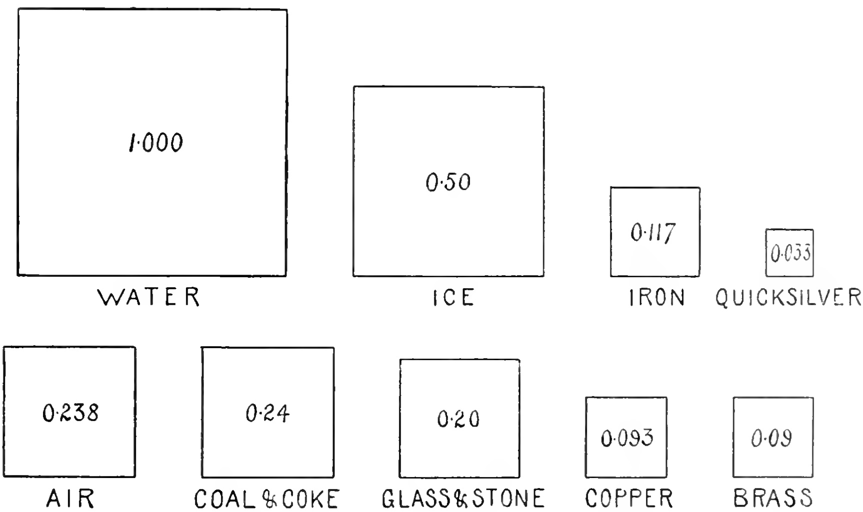
PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XX. HARTFORD, CONN., OCTOBER, 1899. No. 10.

On "Specific Heat."

In the issue of THE LOCOMOTIVE for October, 1894, we printed an article entitled "What is a Heat Unit?" In that article the heat unit that is in practical use among engineers is defined and explained in the following words:

"We might define a 'unit of heat' as the quantity of heat required to raise the temperature of a pound of some given substance one degree; and, in fact, this is the kind of unit that is actually used in practice. We could base the proposed unit on any substance we chose, but as water is both cheap and convenient, and as it can nearly always be obtained in a condition of reasonable purity, it has been adopted by universal



"SPECIFIC HEATS" OF VARIOUS SUBSTANCES.

consent; and a 'heat unit' is defined to be that quantity of heat which will raise the temperature of one pound of water one degree. Before we could adopt any such general definition as this, we should have to find out whether or not it takes the *same* quantity of heat to raise the temperature of a pound of water from (say) 39° to 40°, that it does to raise it from (say) 210° to 211°. If this is not the case, it will be necessary to modify our definition of a 'heat unit' to the extent of specifying at what temperature the pound of water is to be taken. To guard against a possible ambiguity of this kind, some writers define a heat unit as 'the quantity of heat required to raise the temperature of a pound of water from 39° to 40°'; while others define the temperature range to be 'from 32° to 33°,' and others 'from 59° to 60°.' In order to judge of the importance (or unimportance) of specifying the temperature of the water in defining the heat unit, let us examine some of the experimental data that have been obtained relatively to this point. If the heat required to raise the temperature of a pound of water one degree were the same, all the way from the freezing point to the boiling point, it would follow that if we should stir together two pounds of water, one of which is at 212° and the other at 32°, the temperature of the mixture would be $\frac{212^\circ - 32^\circ}{2} = 122^\circ$; and conversely, if the temperature of the mixture is found to be *different* from 122°, we should know that the quantity of heat required to raise the temperature of a pound of water by one degree is *not* the same at all points on the thermometer scale. Careful experiments, performed by Regnault after taking all possible precautions against loss of heat by radiation and conduction, have shown that when a pound of water at 212° is mixed with a pound of water at 32°, the temperature of the mixture is 122.29°. (It is known that Regnault's experiments on this point are vitiated by some unknown source of error. The figure here given must therefore not be taken as strictly accurate. In fact, no entirely satisfactory determination of the deviation of the specific heat of water from absolute constancy has ever been made. Such a deviation certainly *exists*, however, and Regnault's data will therefore serve very well to illustrate the idea of the thing.) The fact that the temperature of the resulting mixture is 122.29° instead of exactly 122°, shows that the quantity of heat required to raise the temperature of a pound of water one degree is *not* the same at all points of the thermometer scale, but it indicates, at the same time, that the total variation between the freezing point and the boiling point is very slight. Similar experiments, made by mixing water at other temperatures, give analogous results; and hence we conclude that although a 'heat unit' is not the same at all temperatures, the variation in its value is so slight that for most purposes it can be neglected. In calculating tables of the properties of steam and water, allowance should be made for the fact that the 'specific heat' of water is not the same at all temperatures; but in all the ordinary work of testing boilers and engines, and laying out steam plants and heating systems, it is customary to consider the specific heat of water to be *constant*; and the 'heat unit' is defined simply as 'the quantity of heat that will raise the temperature of one pound of water one degree.' When we say that a pound of steam, in condensing, gives out 967 heat units, we merely mean that it gives out an amount of heat that would be sufficient to raise the temperature of 967 pounds of water 1°, or 96.7 pounds of water 10°, or 9.67 pounds of water 100°, etc. Similarly, when we say that a pound of good coal gives out 14,000 heat units when it is burned, we mean that each pound of this coal can heat 14,000 pounds of water 1°, or 1,400 pounds 10°, or 140 pounds 100°, etc."

This much being understood with regard to the thermal properties of water, we are ready to touch upon the matter for the elucidation of which this article was prepared — the problem, namely, of the thermal properties of bodies other than water. It often becomes necessary, in the operations that are included under the general head of "steam engineering," to heat certain masses of iron, copper, air, and other bodies, through some definite range of temperature; and when this has to be done, it is frequently desirable to know, in advance, how much heat will be required to do the work, in order that we may decide intelligently upon questions of economy and design. In order to obtain data which shall make a prediction of this sort possible, it is necessary that somebody should make experiments with a great variety of bodies, to find out how their capacity for heat compares with that of water. Experiments of this sort have been made with almost every conceivable kind of substance, and their results have been tabulated and printed in reference books, where we can find them conveniently when we have need for them.

No matter what substance we may have to deal with, the same question is bound to arise, that we considered above in connection with water; — that is, the question as to whether or not it takes the same amount of heat to raise the temperature of the body one degree at one part of the thermometer scale as it does at any other part. A perfectly general answer to this question may be given, once for all; for it is found that when the heat measurements are made with sufficient accuracy, we can *always* see that there is a measurable difference in the quantity of heat required to raise the temperature of the body by a given amount, at different points on the thermometer scale. No substance yet discovered forms any exception to this. Yet the variation in the quantity of heat required to warm the body one degree, as we pass from one part of the scale to another, is so small that it is important only when we have to make more or less refined experiments in the physical laboratory. In most of the operations that arise in connection with steam engineering, it is permissible to assume, as we did in the case of water, that it takes the same amount of heat to warm any given body from 39° to 40°, as it does to warm it from 99° to 100°, or from 211° to 212°, or through a similar range of one degree on any other part of the scale. This, as we have said, is not *accurately* true, but it is near enough to the truth to serve most of the purposes of the steam engineer; and by proceeding on the hypothesis that it *is* true, we can perform our calculations with an expedition and convenience that would be impossible if we tried to introduce the utmost refinement — a refinement that would be, for practical purposes, both useless and misleading.

As soon as we admit that any given body requires substantially the same amount of heat to raise its temperature by one degree on one part of the thermometer scale that it requires for an equal rise of temperature on any other part of it, the calculation of heat-quantities becomes reduced to its simplest terms. For to find how much heat it will take to raise the temperature of a given body by a given amount, we first calculate how many heat units would be required to warm *an equal weight of water* by this amount, and then we multiply the result by a certain constant number, which must be found by experiment for each substance that we propose to figure upon, and which is called the *specific heat* of that substance.

To illustrate this statement, let us suppose that a mass of iron weighing 3,600 pounds is to be heated from 56° Fahr. to 220° Fahr., and that we wish to know how many heat units will be required to do it. In the first place, we allow ourselves to forget, for the moment, that the proposed substance is *iron*, and we calculate how many heat units would be required to raise the temperature of 3,600 pounds of *water* through this range of temperature. Since the initial temperature is 56° and the final temperature is to be 220°, the total *rise* in temperature will be $220° - 56° = 164°$; and therefore 164 heat units will be required to raise one pound of water from 56° to 220°. To raise 3,600 pounds of water through this range, we shall have to have 3,600 times as many heat units as this; and we find, by a simple multiplication, that

$$3{,}600 \times 164 = 590{,}400,$$

so that 590,400 heat units would be required, in order to raise the temperature of 3,600 pounds of *water* from 56° to 220°. Having found out this much, we come back to the actual conditions of the problem, where the substance to be heated was *iron*, instead of water. By looking in the reference books we find that the "specific heat" of iron is about 0.117; — which means, that to raise the temperature of a mass of *iron* through a given range of temperature will require 0.117 times as much heat as would be required to raise an equal weight of water through the same range of temperature. Hence, to obtain the complete solution of the problem before us, we have merely to multiply 590,-400 heat units (which we found would be required for an equal weight of *water*) by the decimal number 0.117. Thus we have

$$590{,}400 \times 0.117 = 69{,}076.8 \text{ heat units,}$$

or, in round numbers, 69,100 heat units. It will therefore take 69,100 heat units to raise the temperature of 3,600 pounds of iron from 56° to 220°.

As a further illustration of the way in which the "specific heat" enters into such calculations, we may refer briefly to a problem that came to our notice not long ago, in which it was proposed to construct a special boiler which should raise steam from cold water in twenty minutes. We do not need to discuss the design of the boiler, but it will suffice to say that the body of water that it was proposed to heat up to the boiling point weighed about 7,000 pounds, while the boiler itself (which was of iron) was to weigh something like 18,000 pounds. The heating surface, grate, and other essential features, were designed with reference solely to the *water* that was to be heated, no account being taken of the fact that some nine tons of iron would also have to be heated through an equal range of temperature. Let us see how much difference it would make, if we were to take this iron into consideration. The pressure to be carried was 70 pounds, which corresponds to a temperature of about 316° Fahr. The water, at the start, was to be at 60° Fahr. The rise in temperature, from the time the fires were started until the boiler was under steam at 70 pounds would therefore be 316°—60°=256°. To raise the temperature of 7,000 pounds of water by 256° we should have to put into the boiler 7,000×256=1,792,000 heat units, which (together with an appropriate allowance to take account of such water as would evaporate into the closed steam space of the boiler) was the quantity of heat that the boiler in question was supposed to be capable of absorbing within the proposed twenty minutes. Let us assume that the boiler, as designed, would actually accomplish this, and then let us see how much the actual time of raising steam, as realized in practice, would be likely to exceed the stipulated twenty minutes, on account of the heat absorbed by the iron of the boiler itself — the heat required for this purpose (as we have already intimated) not being taken into account by the designer, presumably through an oversight. The iron of the boiler weighed about 18,000 pounds, and was to be heated through 256°, just as the water was. Figuring it as though it were water instead of iron, we have 18,000×256=4,608,000 heat units. Then multiplying by 0.117 (which is the "specific heat" of iron) we have

$$4{,}608{,}000 \times 0.117 = 539{,}136 \text{ heat units,}$$

which is the quantity of heat that would be required to heat the *iron* of the boiler up to the temperature that the boiler must attain before 70 pounds of steam could be realized. This, added to the 1,792,000 heat units that would be absorbed by the *water*, gives a total of

$$539{,}136 + 1{,}792{,}000 = 2{,}331{,}136 \text{ heat units,}$$

which the boiler must absorb, in order to achieve the desired result of raising steam in 20 minutes. But if it were actually designed as it purported to be, it could only heat the *water alone* in this time; — that is, it could only absorb 1,792,000 heat units. The actual time of raising steam would therefore be longer than 20 minutes, approximately in the proportion of 1,792,000 to 2,331,136. Hence we have the proportion

$$1{,}792{,}000 : 2{,}331{,}136 :: 20 \text{ minutes} : \text{actual time.}$$

From this proportion we find that the actual time of raising steam, when the heat absorbed by the *iron* of the boiler is taken into account, would be about 26 minutes, or

30 per cent. longer than the specifications required. We have introduced this particular illustration simply to familiarize the reader with the way in which the heat-absorbing power of iron is calculated — namely, by first figuring the proposed body as though it were composed of an equal weight of water, and then multiplying by the iron's "specific heat."

Other problems of this nature are solved in precisely the same fashion; only when the material under consideration is not iron, we must not use the decimal number 0.117, but must employ, in the place of it, the "specific heat" of the particular kind of substance to which the problem relates. The "specific heats" of various common substances are given in the cut which accompanies this article. Each of the numbers which are there given is to be understood as representing the number of heat units that are required to raise one pound of the corresponding substance one degree in temperature. The squares that enclose these numbers are drawn in proper proportion, so that they represent, to the eye, the amount of heat required to raise the temperature of a pound of each of the several substances by one degree. The smallest of all of these, it will be seen, is the one for quicksilver, which has a "specific heat" of only 0.033. Ice is included, not because its specific heat is likely to be of any practical use to the engineer, but to illustrate the effect that a change of physical state may have upon the "specific heat" of a body.

The reader must be careful not to use the figure given for ice in calculations concerning the *melting* of ice, or the freezing of water; for the number given for ice, and the square that contains it, have nothing to do with freezing or thawing, but relate, as in the other cases, simply to the quantity of heat that is required to raise the temperature of a pound of ice one degree. There is a good deal of misapprehension abroad concerning the temperature of ice, and many persons believe firmly that ice always has the temperature 32°, and can never be warmer nor colder than this. Such is not the case, however. It is quite true that ice cannot be *warmer* than 32°, for if the attempt were made to heat it above this point, we should merely change it into water; but there is no reason why it cannot be *colder* than 32°, and in fact it always *is* colder than this, when the weather is colder. Ice can be cooled as much as we please, just like any other body; and there is no reason, in the nature of things, why we cannot cool it to three or four hundred degrees below zero, if we should happen to want to, and should possess the apparatus necessary to enable us to produce such a degree of cold. The significance of the figure 0.50, which is given for ice, will be made clear by this simple statement: If a pound of ice were at the temperature 28°, and we wanted to warm it to 29°, we should have to communicate 0.50 of a heat unit to it, in order to accomplish the result desired.

The number (0.20) given for glass and stone may also be used for brick work. No great degree of accuracy can be expected in calculations involving masonry, however, because the "specific heat" will vary somewhat with the composition of the stone or brick, and also with the proportion and composition of the mortar or cement that is used. For the specific heat of wood, the handbooks give the following values: pitch pine, 0.467; pear, 0.500; oak, 0.570; fir, 0.650. The specific heat of wood will vary largely with the amount of moisture that the wood contains, being smaller for the drier specimens. We should be inclined to think that the values here quoted refer to wood that has not been thoroughly seasoned.

The value given for *air* requires a few words of caution and explanation, so that it may not be used erroneously. Air, in common with all other gaseous substances, possesses the property of requiring various amounts of heat to raise its temperature through a given range, according to the circumstances under which the heat is applied. This point is of so much importance that an entire article would be needed to elucidate it properly; but for the present it will be sufficient to say that the "specific heat" here given for air (*i. e.* the number 0.238) assumes that the air that is to be heated is constantly at atmospheric pressure — that is, it assumes that throughout the entire process of heating, the air is never exposed to a pressure that is sensibly higher or lower than that of the atmosphere. This condition is often fulfilled in practice, and the specific heat here given will therefore be found useful. When other conditions prevail, however, some different value must be used for the specific heat, — a value that can be determined only when the new conditions are fully given.

In calculating the number of heat units required to warm a given mass of air from one temperature to another one, we proceed precisely as we did in the case of iron; that is, we first calculate the heat that would be absorbed by an equal weight of water, and then we multiply by 0.238, which is the "specific heat" of air (at constant pressure). Air is usually estimated in cubic feet instead of in pounds, because it is much easier to measure its volume than its weight. If, therefore, we have a certain volume of air given, and we wish to find out how much heat will be required to warm it through a certain range of temperature, we must first find out how much it weighs. To accomplish this without too much labor we may make use of the accompanying table, which gives the weight (in pounds) of a cubic foot of air at various temperatures, but always at atmospheric pressure.

Weight of a Cubic Foot of Air, at Atmospheric Pressure.

Temperature of Air. (Fahr.)	Weight of a Cubic Foot. (Pounds.)	Temperature of Air. (Fahr.)	Weight of a Cubic Foot. (Pounds.)	Temperature of Air. (Fahr.)	Weight of a Cubic Foot. (Pounds.)	Temperature of Air. (Fahr.)	Weight of a Cubic Foot. (Pounds.)
0°	.0864	100°	.0710	200°	.0603	300°	.0523
10	.0846	110	.0698	210	.0594	320	.0510
20	.0828	120	.0686	220	.0585	340	.0497
30	.0811	130	.0674	230	.0576	360	.0485
40	.0795	140	.0663	240	.0568	380	.0474
50	.0780	150	.0652	250	.0560	400	.0463
60	.0765	160	.0641	260	.0552	450	.0437
70	.0750	170	.0631	270	.0545	500	.0414
80	.0736	180	.0621	280	.0538	550	.0394
90	.0723	190	.0612	290	.0531	600	.0376

To illustrate the use of this table, and the method of calculating the number of heat units required to heat a given mass of air through a given range of temperature, let us take the following problem: It is proposed to heat a mass of air from 50° Fahr. to 110° Fahr., by passing it, at atmospheric pressure, over a coil of steam pipe. The proposed mass of air, when measured at 50° Fahr., occupies 500,000 cubic feet. How many heat units will be required? To solve this problem we first find out how much the air *weighs*. By referring to the table we see that one cubic foot of air, at 50° Fahr. and atmospheric pressure, weighs 0.078 of a pound. Hence 500,000 cubic feet (measured under these same conditions) will weigh

$$500{,}000 \times 0.078 = 39{,}000 \text{ pounds.}$$

Having found the weight of the air in this manner, we proceed to calculate the amount of heat required by first figuring it as though the substance to be heated were water. Thus the initial temperature is 50° and the final temperature is 110°, and the difference between these is $110° - 50° = 60°$, which is the number of degrees through which the temperature of the mass must be raised. There being 39,000 pounds of the air, we should have to communicate

$$39{,}000 \times 60 = 2{,}340{,}000 \text{ heat units}$$

to it, if it were *water*, in order to heat it from 50° to 110°. To take account of the fact that the substance is *air* instead of water, we multiply this result by 0.238 (the "specific heat" of air at constant pressure), just as in the case of iron we multiplied by 0.117. Thus we have

$$2{,}340{,}000 \times 0.238 = 556{,}920 \text{ heat units,}$$

which is the quantity of heat that would be required to raise 500,000 cubic feet of air from 50° to 110°, the air being measured at 50° Fahr., and its pressure remaining equal to that of the surrounding atmosphere throughout the operation.

Inspectors' Report.

June, 1899.

During this month our inspectors made 9,066 inspection trips, visited 16,976 boilers, inspected 8,406 both internally and externally, and subjected 847 to hydrostatic pressure. The whole number of defects reported reached 14,390, of which 1,131 were considered dangerous; 57 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,126	49
Cases of incrustation and scale,	2,613	57
Cases of internal grooving,	134	22
Cases of internal corrosion,	1,050	34
Cases of external corrosion,	789	51
Broken and loose braces and stays,	149	38
Settings defective,	385	26
Furnaces out of shape,	459	22
Fractured plates,	387	33
Burned plates,	362	33
Blistered plates,	237	1
Cases of defective riveting,	1,681	258
Defective heads,	94	19
Serious leakage around tube ends,	2,712	248
Serious leakage at seams,	400	39
Defective water-gauges,	252	60
Defective blow-offs,	176	59
Cases of deficiency of water,	12	6
Safety-valves overloaded,	53	26
Safety-valves defective in construction,	75	17
Pressure-gauges defective,	471	26
Boilers without pressure-gauges,	7	7
Unclassified defects,	766	0
Total,	14,390	1,131

The Locomotive.

HARTFORD, OCTOBER 15, 1899.

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.

Boiler Explosions.

MAY, 1899.

(136.) — On May 1st a boiler exploded in the R., I. & P. pump house, at Bishop Hill, near Cambridge, Ill. The boiler was thrown 285 feet, carrying with it the entire north side of the engine-house. A heavily loaded passenger train had just passed the place when the accident occurred. Nobody was in the building at the time of the explosion, and there are no fatalities to report.

(137.) — A boiler exploded, on May 3d, in J. Frank Coppage's sawmill, at Hayden's Station, near Centerville, Md. Edward Pinder was instantly killed, William Hutchins was fatally injured, and Harrison Thomas was badly scalded, and otherwise hurt. The mill was blown to atoms.

(138.) — A pulp cooker exploded, on May 3d, in the Kennebec Fiber Company's plant, at Benton Falls, Me. The accident consisted in the failure of the flat cast-iron head, which was broken in a dozen pieces. James Noseworthy and Charles E. Skillings were killed, and Eugene Cane and Boyd Boston were somewhat injured. The cooker contained three cords of pulp blocks that were to be steamed before receiving the usual chemical treatment; and these were thrown all about the place. The machinery of the plant was badly damaged. This explosion formed the subject of the leading article in the issue of THE LOCOMOTIVE for August last, where further particulars may be had by those who wish them.

(139.) — A boiler exploded, on May 4th, in Barrett McKnight's sawmill, some eight miles west of Crofton, in the northern portion of Christian County, Ky. The explosion resulted in the instant death of Barrett McKnight and his brother, Effie McKnight, the fatal wounding and scalding of John White, probably fatal injuries to T. T. McKnight, Jr., and the serious wounding of Ephraim Osbrooks. The roof of the boiler-house was blown away, and the boiler itself whirled through the air for a quarter of a mile, and was finally brought to rest through a collision with a hickory tree.

(140.) — On May 4th, an explosion occurred in the works of the Brookline Gas Company, at Allston, Mass. It was supposed, at first, to be a gas explosion; but according to later information it appears to have been due to the failure of a boiler. The boiler-house is said to have been considerably damaged, and the *Boston Globe* reports that "the interior of the brick structure looked as though the building had been through a severe bombardment." We have not learned of any personal injuries.

(141.) — On May 6th a boiler exploded in Strobach, Faber & Co's. brick yard, at Chaska, Minn. Andrew Cornschack was seriously injured.

(142.) — An auxiliary boiler exploded, on May 7th, in the Paine Lumber Company's plant, at Oshkosh, Wis. Mrs. Eugene Du Bois was killed, and her infant child, Amy Du Bois, was fatally injured. Eugene Du Bois, Lydia Dubois, and Andrew Freeman were also painfully hurt. The brick boiler-house was destroyed, and the property loss is estimated at $10,000.

(143.) — On May 9th a boiler exploded at the Inman Cotton Compress, Atlanta, Ga. Andrew Campbell, a cotton tyer, was struck on the head by a piece of iron; but the wound, while painful, is not considered to be dangerous. We do not know the extent of the property loss, but we understand that the plant was shut down for three weeks or so, for repairs.

(144.) — A boiler exploded, on May 9th, at West Wheeling, W. Va., on the transfer steamer *Lizzie Townsend*, owned by the Cleveland, Lorain & Wheeling Railroad. The boat was at her landing, and the firemen, fortunately for themselves, were not at their posts; and they and the others of the crew escaped injury by jumping into the river and making their way to the shore. The boat was considerably damaged.

(145.) —A boiler exploded, on May 10th, in one of the mills of the New Jersey Steel and Iron Company, at Trenton, N. J. John Smith was injured so badly that he is not expected to live, and Enoch C. Jenkins, Edward Gaggin, Charles Multop, and Antonio Mosky were badly scalded and otherwise injured. The frame building in which the boiler stood was shattered. The mill is a part of Abram S. Hewitt's big iron industry.

(146.) — The tugboat *William Sheffield*, of Watervliet, N. Y., was totally destroyed by a boiler explosion, on May 10th, at Douw's Point, on the Hudson River, about two miles below Albany. The crew, with the exception of one man, were on board a canal boat that was moored alongside the tug. The *Sheffield's* engine was thrown through her hull, and her boiler passed over the canal boat *Baker*, wrecking the top of the cabin and striking the end of the *Baker* and the canal boat *McDonald*, loaded with coal. The *Baker* was towed to Rensselaer, where she sank. The *McDonald* also sank, shortly after being injured. George Bernard, who was the only man on the *Sheffield* at the time, was struck on the head by a timber, and badly injured. The wreck of the *Sheffield* drifted out into the river, and a towboat came into collision with it, with the result that the towboat promptly dumped her cargo of 500 tons of stone into the channel of the river. The night boats on the river were notified of the obstruction, and all succeeded in passing it without trouble.

(147.) — The boiler of passenger engine No. 565, of the Wabash Railroad, exploded, on May 13th, just after the train that it was drawing stopped at Centralia, Mo. The front course of sheets in the barrel of the boiler was torn entirely away, and the sand box, or some other heavy object, was thrown through the top of a mill near by, doing an amount of damage estimated at $2,500. The engine was wrecked. The engineer and firemen escaped unhurt, but two tramps who were stealing a ride were thrown a hundred feet or so, and badly shaken up.

(148.) —A boiler exploded, on May 13th, in Root & Co's. brick works at Sheridan, Ind. One-half of the boiler passed over the company's office and struck the ground near the Monon railroad, some 400 feet from its starting point. The other half was blown equally far in the opposite direction. Night watchman Joseph Pastle was buried beneath a pile of bricks, and was burned and bruised so badly that he cannot recover. The plant took fire after the explosion, and while we cannot give the losses due to the explosion and to the fire separately, it is understood that the total loss was fully $25,000.

(149.) — On May 13th a boiler exploded in Jelk's brick yard, at Macon, Ga. Engineer Charles Quinn was killed, and Henry Howard, Jackson Taylor, and William Glover were painfully injured. The building in which the boiler stood was almost totally wrecked.

(150.) — On May 15th a flue failed in a boiler in Kingsford's box shop, at Oswego, N. Y. Nobody was injured.

(151.) — On May 16th a boiler exploded in D. O. Smith's mill at Marion, some six miles from Howell, Mich. Edward Carlin was instantly killed. D. O. Smith was pinned down by falling timbers with two ribs broken, and was nearly crushed to death. Mark Hiscott was also seriously bruised and cut, and Edward Smith received lesser injuries. The mill was wrecked so completely that one of our accounts says that "it might do for kindling wood, and that is about all."

(152.) — On May 17th a boiler exploded in a sawmill at Bowdle, near Aberdeen, S. D. Both heads of the boiler were blown out. We have not learned further particulars, except that it is "suspected" that somebody blew the boiler up intentionally. The accident occurred about midnight, and nobody was hurt.

(153.) — The boiler of a portable sawmill exploded, on May 17th, about a mile and a half east of Carrollton, Mo. Rev. W. T. Johnson, who happened to be near the boiler, was badly injured.

(154.) — On May 19th an upright hoisting boiler exploded at the Yellow Dog mines on the Bonanza lease, near Galena, Kan. Joseph Beatty, who was firing the boiler at the time, was horribly injured, and cannot recover. P. T. Lowry and Clarence Board were also injured, though they will recover. The derrick and the machinery were wrecked.

(155.) — A locomotive on the Chesapeake & Ohio Railroad that pulls the Maysville and Cincinnati accommodation train, bursted its boiler, on May 20th, just after its arrival at Maysville, Ky. Alfred Maddox, the engineer, was sitting in the cab at the time. He was thrown fifty feet, and received injuries from which it is believed that he cannot recover. The bell of the locomotive and pieces of the boiler were found a quarter of a mile away.

(156.) — On May 21st, as a freight train drawn by a Western Maryland locomotive was nearing the station of Longsdorf, on the Philadelphia & Reading Railroad, the boiler of the locomotive bursted. Fireman Fleet Harbaugh was thrown fifty feet, and injured so badly that his recovery is doubtful. A young man who was in the cab was also painfully scalded. The engineer was not hurt.

(157.) — The boiler in Schlais Bros.' mill, at Medford, Wis., gave way on May 23d. We have not received a satisfactory account of this accident, but it does not appear to have been of any serious consequence.

(158.) — A boiler exploded, on May 23d, at Bald Island, near Rockland, Me. We have not received further particulars.

(159.) — On May 23d a boiler exploded in D. B. Pinckney's grist mill at Macksburg, near Winterset, Iowa. The entire south end of the mill was blown out. Mr. Pinckney and two of his children were injured painfully, but all three will recover. The machinery in the mill was wrecked.

(160.) — A boiler exploded, on May 24th, in Henry Myers's sawmill at Hinsdale, near Martinsville, Ind. Perry Morrison and two of the proprietor's sons, Virgil Myers and Herschel Myers, were instantly killed.

(161.) — A boiler exploded, on May 24th, in the Crompton Company's mills, at Crompton village in the Pawtuxet valley, near Providence, R. I. Fireman Paul Beaudreau was thrown through an open door, but suffered no injury, except some slight scalds. The boiler was thrown some seventy feet into the air, and bricks and other debris rained down all over the village, to the terror of the inhabitants. The boiler-house was wrecked, and the loss is said to have been about $5,000.

(162.) — An upright boiler exploded, on May 25th, in the plant of the Belle-Vernon Farms Dairy Company, at Cleveland, Ohio. The building was badly shaken, and considerably damaged. Nobody was hurt.

(163.) — On May 30th a boiler exploded in Leathem & Smith's ship yard, at Sturgeon Bay, Wis. The boiler stood in a shed, and the shed and all the machinery in it were destroyed. Engineer Paul Lavassor had left the shed a short time before to get some implement or other, and to this absence he doubtless owes his life.

The November Meteors.

In November of the present year the earth is scheduled to pass through the family of meteors that is technically known as the "Leonids"; and astronomers promise us a display of celestial pyrotechnics on this occasion, but they will not commit themselves far enough to say whether it will be likely to be of extraordinary brilliance, so as to arouse the enthusiasm of the general public, or whether it will be of a less spectacular character, and of interest merely to the sharps who study the heavens professionally. This uncertainty is due, not to the existence of any really erratic tendency on the part of bodies circulating around the sun as these meteors do, but because in making a mathematical investigation of the movements of the meteors we have to consider them in "the altogether"; we cannot investigate them singly, as we do the planets, but we have to treat them as vast clouds of stony particles that are all following the same *average* orbit. Some few of the meteors are strung along this orbit, over its entire circumference, so that we see a limited number of members of the family every November, as we pass through the place where the meteoric orbit cuts the orbit of the earth; but the great mass of these heavenly tramps travel together in a single cluster, and keep company all the way, in their tremendous journey around the sun. Yet even where they are thickest they are by no means *uniformly* thick, but are bunched together in clouds of considerable density, separated by strata that are relatively empty. When we come along to the critical point in our orbit where we cross the orbit of the meteors, it may be that we shall have the bad luck to arrive just as one of these sparsely occupied regions gets there, and in that case we shall whiz through the rift without meeting very many of the meteors, and the occasion will be disappointing. On the other hand, we may be fortunate enough to come to the crossing of the ways just as a big, dense cloud of them comes along; and if this occurs, we shall see a fiery storm that will be long remembered.

The first recorded appearance of this particular group of meteors was on October 13th, in the year 902 A. D. Since then they have been observed (according to Prof. H. A. Newton) on Oct. 15, 931; Oct. 14, 934; Oct. 15, 1002; Oct. 17, 1101; Oct. 19, 1202; Oct. 23, 1366; Oct. 25, 1533; Oct. 28, 1602; Nov. 9, 1698; Nov. 12, 1799; Nov. 13, 1832; Nov. 13, 1833; Nov. 14, 1866; Nov. 14, 1867, and Nov. 14, 1868. The brilliancy and unusual character of the displays on some of these dates may be inferred from references that exist in various writings still extant. "So-called flaming stars struck one against another violently," says one account, "whilst being borne eastward and westward, northward and southward, and no one could bear to look toward the heavens on account of this phenomenon." "Stars shot hither and thither in the heavens, eastward and westward," says another account, "and flew against one another like a scattering storm of locusts, to the right and left; people were thrown into consternation,

FIG. 1.—DIAGRAM OF THE SKY AT 6 A. M., ON NOVEMBER 16TH. (LOOKING SOUTH.)

and cried to God the Most High with confused clamor." "The phenomenon was grand and awful; the whole heavens appeared as if illuminated with sky rockets."

When these showers are observed, it is found that the meteors do not travel over the sky entirely without system; they move "eastward and westward, northward and southward," just as described by one of the accounts above quoted. Yet all of their paths appear to diverge from a single point (or, more correctly, from a region of very limited area) situated near the middle of the sickle in the constellation *Leo*. The meteors do not all become visible at this point, but if their apparent paths are traced backward they all meet at the place mentioned. Some idea of this peculiarity of their movement may be had from Fig. 1, which is supposed to represent the sky as seen at 6 o'clock A. M., on November 16th, by an observer who is looking due south. The "radiant point," or point from which the meteors appear to radiate, will then be a little above the bright star *Regulus*. For showing its position accurately, we have marked it, in the figure, by a small circle, though it is hardly necessary to say that the circle does not represent anything that will be actually visible to the eye. Young quotes an old lady as saying of the shower of 1833, that "the sky looked like a great umbrella," on account of the separate meteors radiating from one central focus in this manner. Some of the meteors may move in paths that are more or less curved, on account of the irregular resistance that the air opposes to their motion as they plunge down into it. Occasionally, too, a chance meteor may be seen cutting athwart the sky without any reference to the "radiant point." (Two of these are shown in Fig. 1.) But any meteor that does not come from the general direction of the "radiant" in *Leo* may safely be set down as an interloper, bearing no relation to the shower we are discussing, but coming from some entirely different source.

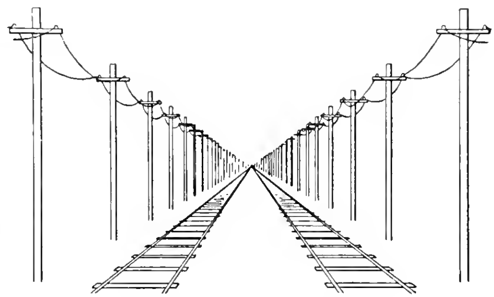


FIG. 2. — ILLUSTRATING THE "RADIANT POINT."

The fact that the November meteors appear to come from a point, or a limited area, on the heavens is of great interest to the astronomer, since it enables him to tell the direction in which the meteors are traveling through space, before we collide with them. By referring to Fig. 2 the reader will find it easy to understand the significance of the "radiant point." Fig. 2 represents some railroad tracks and telegraph poles, which are actually parallel to one another, although they appear, by the laws of perspective, to diverge from a point. Trains coming along these parallel tracks would appear to diverge from a sort of vanishing point or "radiant"; and so also would telegraph messages coming along the wires, if they were only tangible things, that could be perceived by the eye. Yet we know that the trains and the messages are really moving parallel to one another, and that their direction is the same as the direction of the line that joins their "radiant" to the observer's eye.

In the case of the meteors the facts are precisely similar. The meteors are all moving substantially parallel to one another when we encounter them, and their direction in space, relatively to the observer who is watching them, is the same as the direction of the line joining the meteoric "radiant" with the observer himself.

When we know the time it takes the meteors to go around the sun, and the direction in which they are moving as they cross the earth's orbit, it is possible to calculate the orbit of the meteor clouds, so as to know where they came from, and where they are going to, and when they will be back again. Their *direction*, as they cross the earth's orbit, is obtained by observing the position of their "radiant," as we have already explained; and the time that it takes them to go around the sun can be determined by reckoning back to the showers that have been recorded in previous years; and hence all the elements necessary for the calculation are obtainable. The late Professor H. A. Newton, of Yale, gave a great deal of attention to this matter, and he pointed out, in

1864, that the data that he was able to collect were consistent with any one of *five* different orbits, which he described in detail. He also pointed out that the earth has not always encountered the meteor stream on the same date, the date being October 19th in 902 (*i. e.*, according to our present calendar — it was October 13th on the "old style" calendar), and November 12th in 1833. This change, as he pointed out, is caused by a shifting of the "node" of the meteoric orbit, and is due to the perturbing influence of the various planets, acting upon the meteor swarms as they pass along on their travels. Now, if the orbit of the meteors were known, it would be possible to calculate the effect the planets would have upon them, and to determine just how much the "node" of the meteoric orbit would shift, for every revolution of the meteoric swarm. Professor Adams, who was already renowned for his laborious prediction of the planet Neptune, performed this calculation for each one of the five orbits described by

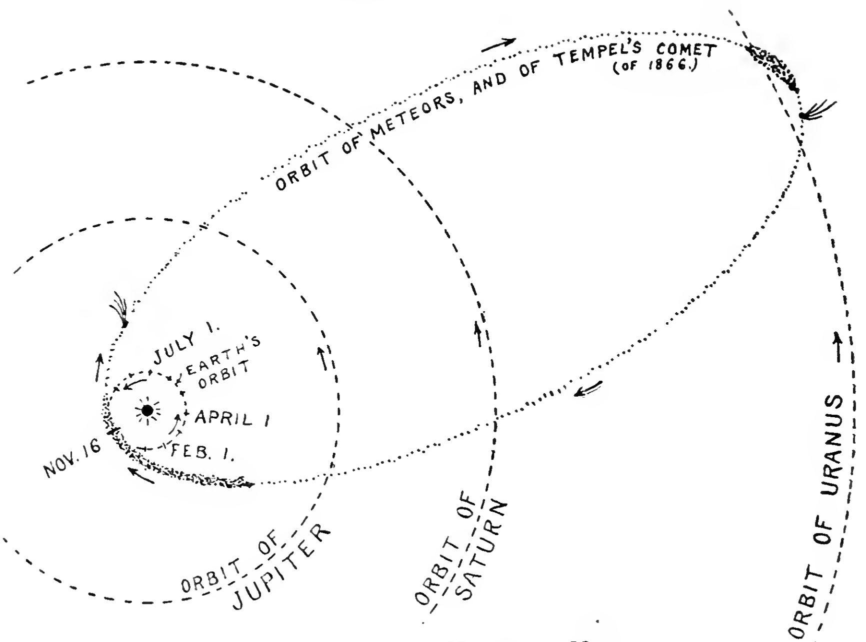


FIG. 3. — ORBIT OF THE NOVEMBER METEORS.

Professor Newton, and found that the result, for four of the five orbits, was widely at variance with the observed effects; while the fifth orbit gave a result that agreed very closely with these observed effects. In this way astronomers learned which of Professor Newton's five "possible" orbits is the one actually followed by the meteors.

The orbit determined in this way is shown in Fig. 3. It does not lie exactly in the same plane as the earth's orbit, but is tipped up a few degrees — not enough, however, to interfere with the substantial accuracy of our diagram. It will be seen that the meteors, when nearest the sun, are about as far away from it as the earth is; while when they are most remote from it, they are just beyond the orbit of Uranus. Leverrier (who also predicted the existence and position of the planet Neptune) has shown that previous to the year A. D. 126, this meteor cloud was roaming through space on its own account, without any especial reference to the sun; but that about the end of February or the beginning of March, in that year, it passed very close to the planet Uranus, and was pulled away out of the path in which it had been traveling, and turned into a new orbit, which made it a regular attendant upon our system, with a periodic time of about $33\frac{1}{4}$ years.

This is the story, in brief, of the November meteors, and of how their orbit was determined; but there is a sequel to it, which is of considerable interest. On December 20, 1865, William Tempel, of Marseilles, France, discovered the comet which has since been known as "Tempel's comet of 1866." This comet was round, thin, and diffuse, and had a tail about half a degree long. It had no definite nucleus, but showed, in the center, a condensed spot something like a star cluster. Astronomers gave this comet the usual amount of attention, and followed it as long as possible, as it retreated into the depths of space. It was last seen by Von Oppolzer, at Vienna, on February 9, 1866, so that it was under observation, in all, for about seven weeks. The orbit of this comet was calculated by Oppolzer, and he published his calculations almost at the same time that Leverrier published his results concerning the orbit of the November meteors, although he had no idea of any connection between the two. As soon as the two orbits were published, however, it was seen that they were practically identical — so nearly so, in fact, that the difference cannot be shown in an engraving drawn on the scale of Fig. 3. Several other cases are now known in which meteoric swarms are attended by comets, and it appears to be probable either that the meteors were formed by the disintegration of comets, or else (as Lockyer claims) that comets were formed by the aggregation of meteors. Tempel's comet was due at perihelion last March or April, but it was not seen. It may be that the astronomers overlooked it, or it may be that it has broken up entirely and will never be seen again as a comet, or (which is more probable) it may be that it was not situated favorably for observation on this return. The comet goes *before* the meteor shower, as represented in Fig. 3. This diagram, by the way, appears to represent two comets and two meteor swarms on the same orbit, one at each end of it. These are not to be understood as being distinct objects, but as merely representing the meteor swarm and the comet in two different positions. The meteors, as we have already said, do not travel in a single compact cluster, but are more or less drawn out along their orbit, even where they are thickest. So it happens that on two or three successive revolutions of the earth we may pass through some part of the swarm that is worth seeing.

Dr. G. Johnstone Stoney and Mr. A. M. W. Downing have calculated the perturbations that Jupiter and Saturn have caused in the swarm since its last appearance, and they find that the disturbance is unusually large, — the motion of the node, in fact, being some $3\frac{1}{2}$ times as great as it is ordinarily. They state that the middle of the shower may be expected at about 6 o'clock A. M. on November 16th, although the first of the shower is likely to be seen at any time after midnight. The sky-map given in Fig. 1 is prepared for the time of the probable middle of the shower.

In conclusion, we would warn our readers not to have their expectations too highly aroused by this sky-map, because its accuracy cannot be guaranteed in advance. Professor Young says that when this same family visited us in 1833, "the number that fell in the five or six hours during which the shower lasted was estimated at Boston as fully 250,000. A competent observer declared that he never saw snow-flakes thicker in a storm than were the meteors in the sky at some moments." At its next return, in 1866, the shower was somewhat disappointing. This year the moon will be about full, and her light will interfere with the beauty of the spectacle, even if it should prove to be satisfying in other respects.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XX. HARTFORD, CONN., NOVEMBER, 1899. No. 11.

The Safety of Petroleum Fuel.

[In the issue of THE LOCOMOTIVE for December, 1898, we published an article on "Liquid Fuel," in the course of which we cautioned our readers about the dangers incident to the use of petroleum, and stated that fatal accidents have occurred from time to time, through the neglect of certain precautions which we set forth quite fully. An extract from this article was published in *Cassier's Magazine*, where it was seen by Mr. James Holden, Locomotive Superintendent of the Great Eastern Railway, in England, who thereupon wrote us a note in which he intimated that such accidents are wholly unnecessary and inexcusable. Now while this may be true enough, when con-

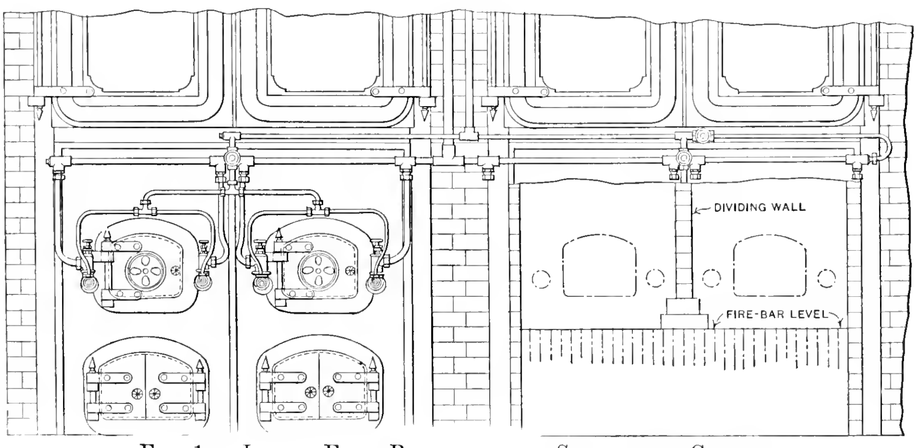


FIG. 1.—LIQUID FUEL BURNERS WITH SUBDIVIDED GRATES.

sidered as an abstract proposition, still it cannot be denied (as we stated, in noticing Mr. Holden's letter last August,) that accidents of the sort described *do* happen,—in the United States, if not in England. So we felt justified (and we still feel the same way) in pointing out the dangers that our observation has taught us are real. The enterprising editor of *Cassier's Magazine* has now persuaded Mr. Holden to write an article on this subject for the November issue of that magazine; and as Mr. Holden has had some twelve years of experience in handling liquid fuel, what he has to say will be of interest and value to those who are using fuel of this sort, or contemplate its use. By permission of the management of *Cassier's Magazine* we reproduce the article in question, below.]

In a paragraph which appeared in the issue of *Cassier's Magazine* for April, 1899, a statement is made that there is a grave risk of danger and trouble when using petroleum as fuel from the "snapping out" or sudden extinction of the fire, and its restarting. That some systems of burning oil with delicately adjusted apparatus may be liable to such defects, the present writer will not dispute; but from an experience extending over about twelve years he has not found such liability to mishap with the burners he has employed, and, further, he is satisfied that if only the most elementary precautions are taken in the storage and manipulation of the oil, there is no reason why it should not be one of the safest, if not the safest, of the heat-giving mediums.

As regards any liability of danger from the fuel itself, doubtless residues with a high flash point are to be preferred, not only on account of the safety with which they can be stored and handled without exceptional precautions, but also because, when being injected into the furnace, their high ignition temperature and dense specific gravity guarantee the whole being burnt without loss by vaporization through being brought into contact with the hot steam used for spraying. When, however, it

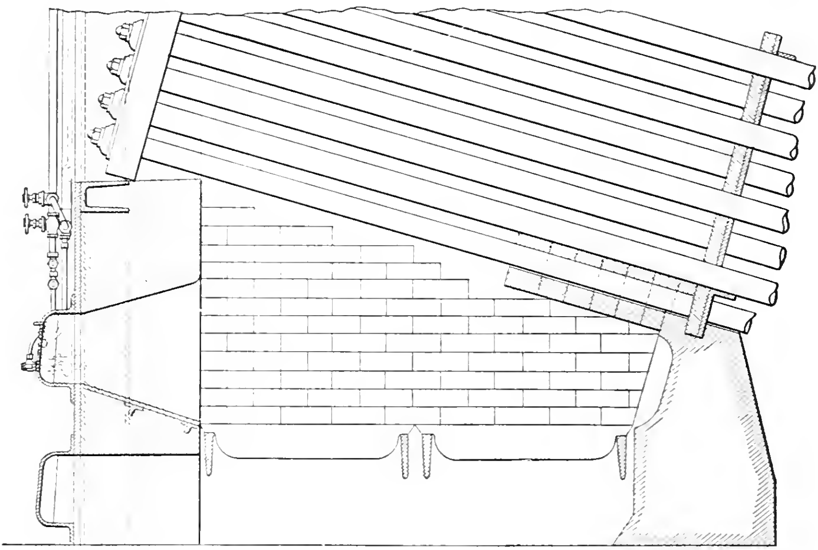
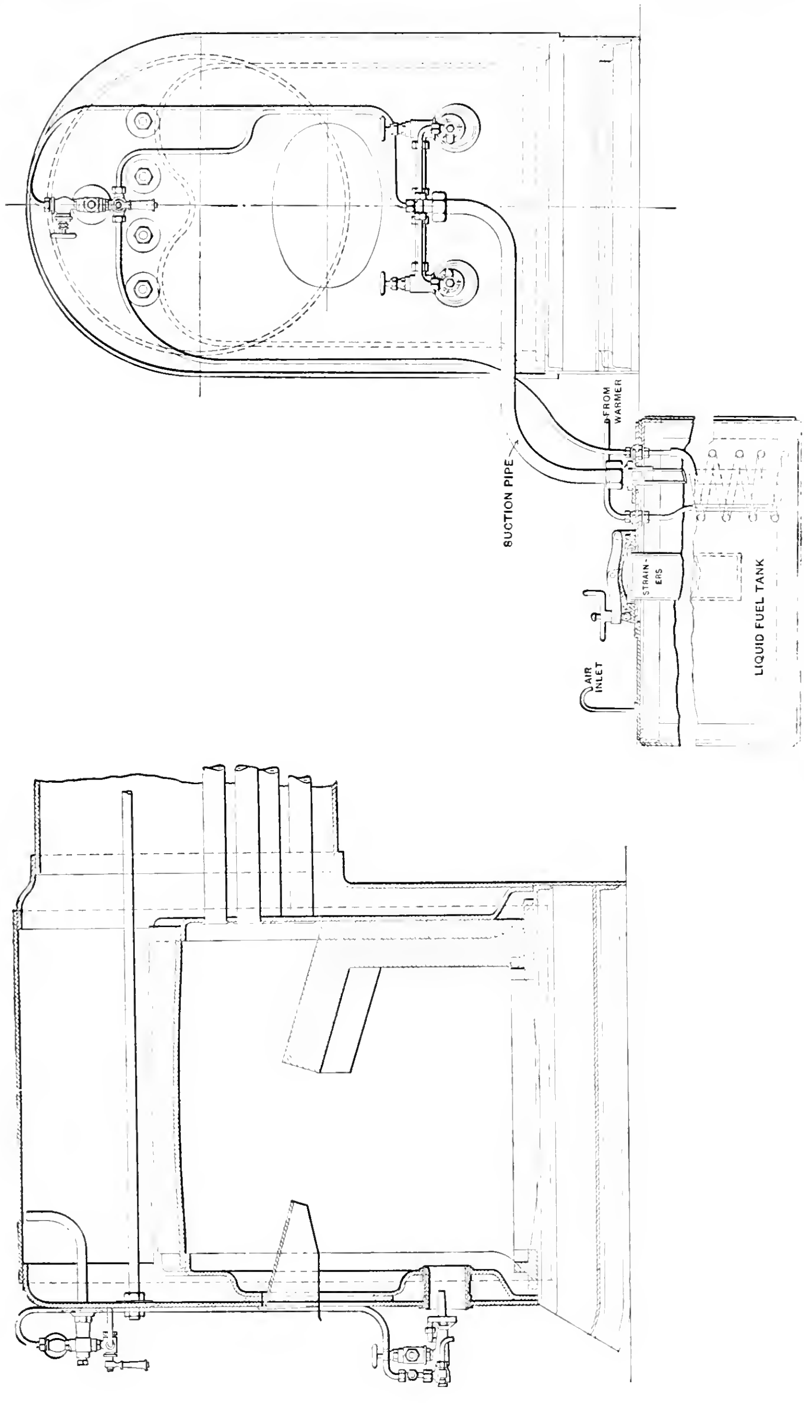


FIG. 2.—A SECTIONAL VIEW OF FIG. 1.

is necessary to employ lighter oils and products, some revision in the methods of storing, handling, and burning will satisfactorily remove any risks.

Of the many products used as fuel, the tar which is a residue from the manufacture of oil gas from petroleum is perhaps one of the most troublesome with which the writer has had to deal. The flash point varies considerably, as it depends largely on the grade of oil used for the gas, and the temperature of the retorts in which it is made. It is often as low as 70 degrees F., and to remove any risks which might accompany the employment of such material as fuel, it is desirable that it should be stored in underground tanks, away from the boilers fired, and the writer has accordingly arranged the burners to lift the fuel by suction from the tanks so placed. The tanks have suitable ventilating pipes to carry off any gas generated. All openings are provided with wire gauze strainers or sieves of such a mesh that flame cannot pass. At the filling manhole this gauze filters the fuel and removes all dirt and grit. Figs. 3 and 4 show the general arrangement.



FIGS. 3 AND 4. HOLDEN'S APPARATUS FOR BURNING LIQUID FUEL, APPLIED TO A STATIONARY BOILER

On locomotives such a method of storage as described is out of the question, and some other arrangement had to be devised when crude oil of low flash point was introduced as fuel on the railways of Southern California. The fuel tank there has been placed entirely within the water space of the tender, as shown in the outline sketch, Fig. 5. As a safeguard against oil escaping by any damage to the connecting pipes between engine and tender, through derailments, for example, an internal valve is provided in the oil tank at the outlet; this is held open when in use by a small chain secured to a hook in the cab of the locomotive, and breakage of this chain secures an instantaneous closing of the valve.

In Great Britain, although dealing with fuels of a high flash point (250 to 300 degrees F.), it was deemed advisable in the early days of oil firing to provide strong cylindrical tanks on the tenders, with separate connections so arranged that in case of mishap they would leave the tender and fall clear. As, however, during the number of years oil-burning engines have been running no accidents have occurred, it is now the practice to have one single tank of larger capacity, made to drop into the water space of the tender.

Before leaving this branch of the subject, it should be pointed out that any serious mishap to the tanks, their connections, or fittings, whether on board ship, attached to

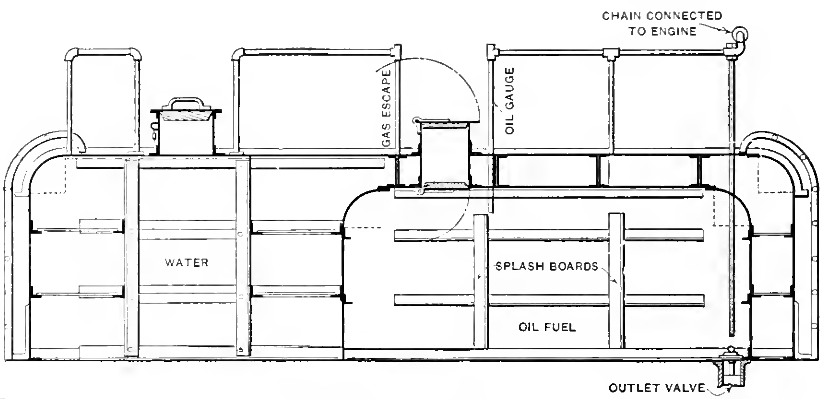


FIG. 5.—COMBINED OIL AND WATER TANK, FOR TENDERS ON THE SOUTHERN CALIFORNIA RAILROAD.

stationary plant, or on locomotives, means an interference with the oil fuel supply to the burners, and consequently an instantaneous extinction of the fire.

Referring now to the suggested cause of danger set forth in the paragraph which has instigated this article, it is quite clear that if any foreign substance, dirt, grit, or water, pass through the oil pipes and be delivered to the burners, a partial extinction of the fire may ensue, and then, if the obstruction is not quickly removed, the re-ignition of the oil is delayed by the cooling of the bricks, and gas is generated in the presence of a large quantity of air drawn into the furnace by the draught. An explosive mixture is thus formed, which requires only the presence of flame to lead to disastrous results. To prevent such a contingency arising, the oil fuel is passed through fine strainers, as already mentioned, having been previously allowed to stand for any water to separate out.

In cases where the specific gravity of the oil residue and water have been so nearly similar that there has been difficulty in separating them, two methods of treatment have been adopted. The specific gravity of the oil has been increased by the addition of some heavier product, thus securing separation, or recourse is had to a mechanical arrangement which may be novel to some. It is shown in Fig. 6, and consists of a long wooden trough, placed at an incline, and provided with a number of ledges or shelves of perforated zinc or wire gauze at angles along its length; the mixture of oil and water is admitted to the top of the trough from the tank, and, in its passage down, allows the oily portion to pass through the gauze ledges and along the bottom to the receiving tank. The water, on the other hand, forms globules, which run over the surface of the oily diaphragms and are guided by a little finishing ledge off each of the shelves into a second trough provided for their reception. With this rough apparatus, oil gas tar containing as much as 20 per cent. of water, entering at the top, has been collected at the bottom with only about 3 per cent. remaining.

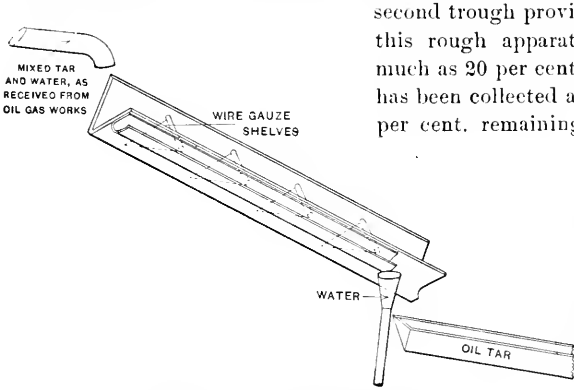
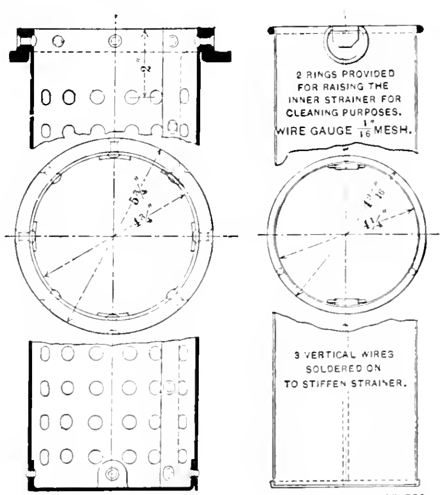


Fig. 6. — An Oil and Water Separator.

Generally, in Great Britain, where tar or tar products have been employed as fuel, the water present has been allowed to collect on the surface of the storage tanks and then run over by filling up with heavy gravity mixture. With petroleum fuels, however, the procedure must be reversed, and on engines with tanks intended for this class of fuel suitable depressions should be provided for the water to be collected in, and facilities given for drawing off at intervals.

To obviate stoppage of the burners by grit and dirt, the writer uniformly employs pipes of large dimensions with easy bends, straightway regulating valves, and burners with clear, straight passages of reasonable dimensions. Further, he never places any strainers or such obstructions at any of the outlets or valves of the fuel tanks. All the oil is cleaned or filtered as it enters the tanks, not as it leaves them. Fig. 7 gives details of strainers employed at the manholes.



Outer Strainer. Inner Strainer.

Fig. 7.

The "snapping out," as it is termed, can clearly be really dangerous only when it occurs on a large boiler or furnace with a large cubical capacity; and to further eliminate all risk from this, it has been the writer's practice, and that of his agents, in fitting the hundreds of installations at work, to so arrange the position of the burners that any explosion should be harmless. Figs. 1 and 2 represent a large furnace having four burners, and it will be seen that the area of the grate is divided by two walls of fire-brick. In either of the portions thus partitioned off, careless management would have no serious results.

It is in the lighting up of oil fires that care is desirable, and even then it is only necessary to introduce some waste or wood in flames before commencing to spray the oil fuel in order to ensure absolute freedom from risk of mishap. A little oil, allowed to run into the furnace over some lighted waste, will immediately provide a good flame, over which the fuel may be sprayed and ignited; but after allowing this portion of oil to enter the furnace it is always advisable to commence by admitting steam first and then gradually open the oil valves until the desired intensity of fire is obtained.

The complete substitution of oil fuel for coal on any boiler is a radical change to make, and it would appear that a gradual transfer from one fuel to the other would be desirable; hence the provision in the writer's apparatus for the retention of the fire-grate available for coal while the oil fuel is being inaugurated. It has been found in practice that this is a good procedure, allowing the men to get accustomed to all the little peculiarities of the newer, cleaner, and more efficient fuel.

On the Great Eastern railway forty-seven locomotives have been in regular service for some years past on the main and suburban lines, hauling both passenger and goods trains, and not a single mishap has so far been recorded against their working with the oil fuel. Among the passenger trains, the fast special Cromer expresses should be mentioned; the long run of 130½ miles from London to North Walsham is made by these trains without stopping, maintaining a high rate of speed throughout the two hours and forty-two minutes occupied by the journey.

Inspectors' Report.

JULY, 1899.

During this month our inspectors made 9,225 inspection trips, visited 17,922 boilers, inspected 9,492 both internally and externally, and subjected 855 to hydrostatic pressure. The whole number of defects reported reached 17,668, of which 1,380 were considered dangerous; 98 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,221	78
Cases of incrustation and scale,	3,212	93
Cases of internal grooving,	175	19
Cases of internal corrosion,	1,218	46
Cases of external corrosion,	813	45
Broken and loose braces and stays,	128	26
Settings defective,	418	11
Furnaces out of shape,	510	23
Fractured plates,	341	47
Burned plates,	342	46
Blistered plates,	290	18
Cases of defective riveting,	3,590	271
Defective heads,	215	33
Serious leakage around tube ends,	3,372	329
Serious leakage at seams,	419	23
Defective water-gauges,	326	45
Defective blow-offs,	163	40

Nature of Defects.	Whole Number.	Dangerous.
Cases of deficiency of water,	8	3
Safety-valves overloaded,	113	76
Safety-valves defective in construction,	99	38
Pressure-gauges defective,	518	35
Boilers without pressure-gauges,	34	34
Unclassified defects,	113	1
Total,	17,668	1,380

Boiler Explosions.

June, 1899.

(164.) — On June 3d a boiler exploded in the East Weymouth Wool Scouring Company's plant, at East Weymouth, Mass. Portions of the mill, the boiler-room, and a storehouse, were wrecked. A brick chimney, 75 feet high, was thrown down, and fell through the roof of the boiler and engine-house, carrying a portion of the main mill with it. Bricks flew in all directions, and one struck Mrs. Frank McGuire, who lives quite a distance from the mill, injuring her severely. There were no other personal injuries, as no one happened to be in the boiler-house at the time. The plant is owned by Mr. John E. Mann.

(165.) — Reuben Fulk, a miller, was scalded to death, on June 4th, by the explosion of a boiler at Servia, near Sutton, W. Va.

(166.) — On June 6th a boiler exploded at Frederick, near Aberdeen, S. D. It was in use for drilling an artesian well, under the direction of its owner, Mr. Philip Eyer. Charles Rake was acting as engineer, and Peter Schnorr was tending the drill. Engineer Rake had just stepped away from the boiler when the explosion occurred. The crown sheet blew out, and was carried through the roof of the working shanty, and landed some 1,200 feet away. Mr. Eyers and Mr. Rake each received slight injuries, but nobody was badly hurt.

(167.) — A boiler exploded, on June 9th, in the Spies wagon factory at Abingdon, near Galesburg, Ill. The factory was damaged, but nobody was hurt. The explosion consisted in the blowing-out of one of the heads of the boiler.

(168.) — The torpedo-boat *Talbot*, Lieut. C. A. Gove commanding, bound from Annapolis, Md., to Norfolk, to have an oil-burning apparatus placed in her, blew out a boiler-tube, about twenty-five miles below Annapolis, on June 9th, and had to return to that place for repairs.

(169.) — A boiler exploded, on June 9th, in W. E. Bennett's stone-planing mill at Lanesboro, near Susquehanna, Pa. Only two men were in the vicinity of the boiler at the time. Charles Ranlett, the fireman, was hurled some distance and buried in the ruins. He was quite badly burned by steam, and one of his legs was crushed. Walter Teetsal was injured about the head, but not seriously. The boiler-house was wrecked.

(170.) — A boiler in the factory of John and Charles P. Scott, at Millerton, Duchess County, N. Y., exploded on June 10th. Mr. Charles P. Scott was seriously injured, though it is believed that he will recover. A couple of other men also received minor injuries. The building in which the boiler stood was entirely destroyed, and fragments of it were thrown in all directions.

(171.) — A small boiler exploded, on June 10th, in the canning factory at Delta, near Rome, N. Y. No serious damage was done.

(172.) — On June 15th a boiler exploded at Ontario, N. Y. It was used for operating a steam shovel at the ore beds. The machinery was wrecked, and Roy Eaton, James Watson, George Augustin, and a laborer whose name is not given, were scalded and otherwise injured.

(173.) — A boiler exploded, on June 16th, in Bartlett's sawmill, on King's River, near Forest City, Ark. Gairthair Bartlett and his young son were badly scalded, and it is believed that the boy will die.

(174.) — The city of Muncie, Ind., was left in darkness, on June 17th, by the explosion of a boiler in the city electric light plant. We have not learned full particulars, but our information indicates that "the end of the boiler blew out," and that nobody was injured.

(175.) — Meno Staufer, who lives three miles east of Dallas Center, Iowa, was seriously scalded, on June 19th, by the explosion of a traction engine boiler. The head of the boiler was blown into fragments, and the whole machine was wrecked. Mr. Staufer was scalded over the entire front of his body, from his chin to his knees.

(176.) — A boiler exploded, on June 19th, in the electric power-house at Elmwood Park, Syracuse, N. Y. Engineer Edward Kiddle was severely scalded. The boiler-house was wrecked, the roof being blown off, and the walls badly damaged also. One of our accounts says that "when the proprietor of the place came to look for his roof he decided that it would be just as well to use it for firewood; he has a large variety of splinters and assorted sizes of firewood." The same account adds that "the boiler itself is a magnificent ruin."

(177.) — On June 21st a boiler exploded in the canning factory at Cuba, N. Y. We do not know further particulars.

(178.) — Mr. John S. Veasey of Cool Spring, near Lewes, Del., was badly injured, on June 22d, by the explosion of a threshing-machine boiler. He was struck by flying fragments of machinery and by scalding water from the boiler. His skull was crushed in two places, and he was seriously scalded. At last accounts he was still living, but it is considered certain that he will die.

(179.) — On June 23d a boiler exploded at the United States lock, at the Davis Island dam, on the Ohio River, some six miles below Pittsburgh, Pa. Harry I. Weibush, the lock-tender, was killed, his body being dismembered and thrown some distance. The boiler was used to operate the locks.

(180.) — On June 24th a digester exploded in the Reading Chemical and Fertilizing works, at Reading, Pa. The building was badly wrecked, and the property loss is estimated by various persons at from $1,500 to $35,000. We do not know which of these extremes is the nearer to the actual facts of the case. Nobody was present at the time. The safety-valve on the digester was set to blow off at 20 pounds, but the pressure ran up considerably higher without the valve blowing. Foreman John Lerch, noticing this, went to the boiler-house for the engineer, George Epler. In the boiler-house the gauges read 60 pounds; and the two men were about to proceed to the digester-room to investigate the safety-valve there, when the explosion occurred.

(181.) — On June 24th a boiler exploded in the electric light plant at Fairview, Fulton County, some thirty miles from Peoria, Ill. The building was demolished, and Engineer Frank Stevenson was buried beneath the debris, and fatally injured. Mr. and Mrs. Peter Berger were also badly bruised and otherwise injured, but both will recover. Mr. Berger was the owner of the place, and the explosion crippled him financially as well as physically. The good citizens of Fairview passed around a subscription paper and raised a generous sum for him — enough to give him another good start. A piece of good fortune like this, however, rarely comes to a man. Anyhow, it isn't safe to figure on it. It is a great deal better to pay a small premium to the Hartford Steam Boiler Inspection and Insurance Company, and thus make yourself secure.

(182.) — The tug *Satisfaction* took fire on Lake Michigan, on June 25th, some twelve miles northeast of Sheboygan, Wis. The steamer *Georgia*, of the Goodrich line, tried to reach the burning vessel, but the *Georgia's* boiler exploded as she drew near, and she was badly damaged. The steamer *Olympia*, bound from Erie to Sheboygan with coal, took the dismantled *Georgia* in tow, but she sank when within about five miles of Sheboygan. The crews of the damaged boats escaped in yawls.

(183.) — George Hermsdœffer was fatally scalded, on June 26th, by the blowing out of a manhole-cover in Julian & Kokenge's shoe factory, at Cincinnati, Ohio.

(184.) — On June 28th a flue collapsed in a boiler on the river steamer *St. Paul*, near St. Louis, Mo. John Mack and a man whose name we have not learned were killed, and C. Thompson and two other men were fatally injured.

(185.) — A boiler exploded, on June 30th, in the Crestline boiler shops, at Crestline, near Mansfield, Ohio. Augustus Bieber and Christopher Wynard were badly scalded. The explosion was due to an attempt to repair a boiler while it was in service.

THE following interesting experiment is described in the *Psychological Review* for July, by E. E. Slosson, of the University of Wyoming: "I had prepared a bottle, filled with distilled water, and carefully wrapped in cotton and packed in a box. After some other experiments in the course of a popular lecture, I stated that I wished to see how rapidly an odor would be diffused through the air, and requested that as soon as any one perceived the odor he should raise his hand. I then unpacked the bottle in the front of the hall, poured the water over the cotton, holding my head away during the operation, and started a stop-watch while awaiting results. I explained that I was quite sure no one in the audience had ever smelled the chemical compound which I had poured out, and expressed the hope that while they might find the odor strong and peculiar, it would not be disagreeable to any one. In fifteen seconds most of those in the front row had raised their hands, and in forty seconds the 'odor' had spread to the back of the hall, keeping a pretty regular 'wave front' as it passed on. About three-quarters of the audience claimed to perceive the smell, the obstinate minority including more men than the average of the whole. More would probably have succumbed to the suggestion, but at the end of a minute I was obliged to stop the experiment, for some on the front seats were being unpleasantly affected, and were about to leave the room." — *Popular Science Monthly.*

ON May 26th a steam drying cylinder exploded in James Martin & Co.'s dyeing and finishing mill, at Philadelphia, Pa. Daniel Huston and William Lang were killed, and Michael Carlin and Robert Underworth were injured. The side wall of the building was blown out, and the loss is estimated at $10,000.

The Locomotive.

HARTFORD, NOVEMBER 15, 1899.

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.

IT has been the custom of the publishers of *Cassier's Magazine* to issue, from time to time, "special numbers" of their excellent publication, in which the development along particular lines of mechanical engineering is traced with extraordinary fullness and clearness. We have made previous mention, for example, of their "Marine Number" and their "Niagara Falls Number," both of which we consider to be distinct triumphs in the art of technical editing, as well as in press-work and illustration. The latest issue of this sort is the "Electric Railway Number," in which the rise, development, and present status of the electric railway are set forth admirably, in a long series of articles prepared by men to whose efforts the advance in this department of engineering has been in no small measure due. The issue contains an amazing wealth of information, and it is embellished by over three hundred artistic engravings, a large proportion of which are half-tones, made from photographs. We cannot give it an adequate review, but it affords us pleasure to testify to its marvelous excellence in all respects, and to say that every man who is interested in electric railways will find this special number of *Cassier's Magazine* to be an indispensable possession.

Obituary.

MR. SAMUEL NOTT.

Mr. Samuel Nott, the veteran civil engineer, whom our readers will remember as an occasional contributor to THE LOCOMOTIVE, died, on October 1st, at his home in Hartford, Conn. The *Hartford Times* gives the story of his life in the following words: "At the time Mr. Nott began his life work as a civil engineer there were less than fifty miles of railroad constructed in the United States. The lines in operation at the time comprised the Albany & Schenectady, the Camden & Amboy, a few miles of the Baltimore & Ohio, in Maryland, and a short road in South Carolina. Mr. Nott was born in Bombay, India, being the son of the Rev. Samuel Nott, who was sent to the foreign mission field by the American Board in 1812. He left India in October, 1815. Mr. Nott was educated for a civil engineer, and began practical work as a chainman on the Boston & Worcester Railroad, in 1833. In 1847, he became chief engineer of the Boston & Lawrence road, and ten years afterwards he was made superintendent and engineer of the old Hartford, Providence & Fishkill Railroad. He held this position twenty-one years, most of the time operating under the trustees for the bondholders. The business of the road was quadrupled under his superintendence, and the bonds, which were not marketable in 1859, went up to 118 before Mr. Nott's connection with the road was discontinued. He has not been identified with the road since 1878. Mr. Nott was identified with the Hartford Water Works some years ago. He was an honorary member of the Boston Society of Civil Engineers, and throughout his life he was deeply interested in the history of railroading in this country. He was the author of interesting articles on the subject, which appeared in The Locomotive, published by the Hartford Steam Boiler Inspection and Insurance Company, under the editorship of President J. M. Allen. The highest personal regard was entertained by President Allen for the deceased, whose abilities he fully understood and appreciated."

Mr. W. P. Hoit.

The death of Mr. W. P. Hoit, which occurred at Chicago, on October 17th, has removed a genial, generous man, who will be greatly missed by his associates. His death, although sudden, was not entirely unexpected, as he had a stroke of paralysis about a year ago, and, although he had regained a considerable portion of his wonted activity, his friends realized that his lease of life was, probably, not a long one. Mr. Hoit was born in 1838, and was, therefore, sixty-one years old. He was a special agent for the Hartford Steam Boiler Inspection and Insurance Company, in the earlier years of the Northwestern Department, when Mr. H. D. P. Bigelow was our general agent. He resigned his position in that department in order to follow the fire insurance business, which he did for a number of years. In 1886, however, he resumed his connection with this company, and remained with us until 1890, when, owing to a very generous and tempting offer from a loan association, he was again persuaded to sever his connection with the Hartford company. He was never satisfied with the change, however, and he returned to this company's service again in March, 1891, and remained with us until his death.

Mr. John B. Dumond.

We regret to announce the death of Mr. John B. Dumond, which occurred on October 12th, under peculiarly distressing circumstances. Mr. Dumond, with two other Boston gentlemen, was hunting for deer at Messer Pond, 23 miles from Grindstone station (Maine), on the Bangor & Aroostook railway. On the morning in question the party left camp as usual, Mr. Dumond and one of the men moving away in one direction, while the guide and the remaining member of the party went in another. Not long after leaving the camp the guide saw a deer, but had no chance to shoot at it. A little later he saw the deer again (as he supposed) and fired at it, with the result that he shot Mr. Dumond through the body, injuring him so badly that he died before he could be taken out of the woods, and before medical assistance could be had. He was thoroughly well aware of the circumstances of the accident, and knew that his wound was fatal. He gave one of his friends directions for the settlement of his affairs, and stated earnestly that he desired that no blame should be attached to the guide, whom he knew to be a careful and competent man. Mr. Dumond was born in New York, on December 25, 1862; but for many years past he had resided in Boston, where he was in the employ of the Hartford Steam Boiler Inspection and Insurance Company, at first as an inspector, and afterwards as a draughtsman and mechanical engineer. He was prominent in Boston political circles, and was a member of the Massachusetts legislature, where he has served on several important committees.

The Prevailing Scarcity of Water.

In many parts of the country the rainfall has been unusually light during the past season, and our inspectors report that there has been an uncommon amount of trouble from scale in the regions so affected. The reason for this is not hard to find. After a rain, some of the water soaks into the ground, and, penetrating more or less deeply, it comes in contact with rocks containing lime and magnesia and other soluble substances. These it dissolves, to a certain extent, and when it eventually comes to the surface, somewhere or other, it still holds these minerals in solution. When the ground has soaked up all the water it can hold, the rest of the rain runs off along the surface, and this surface water (as a rule) does not contain much mineral matter in solution, for the very simple reason that it has never been brought in contact with the rocks from which such mineral matter could be obtained. These facts are commonly summed up in the familiar statement that "surface water is *soft*, while well-waters and spring-waters are *hard*."

The actual supply of water that is used in a boiler consists, almost invariably, of what we may call a mixture of surface water and ground water. That is, some portions of it have probably been down to a considerable depth, and have been in contact with lime rocks and magnesia rocks for a considerable time: while other parts have not percolated through the ground very far, or, perhaps, have not been below its surface at all. The degree of "hardness" of a water supply (and hence the amount of scale that it will form) will therefore depend to a large extent upon the *proportion* in which the ground water and the surface water are mingled, and it will vary, for each locality, with the amount of the rainfall during the season. When the rainfall is copious, the ground cannot absorb any considerable proportion of it; most of it, therefore, runs off along the surface, and a water supply that is drawn from any source except the very deepest wells will then be unusually soft and free from scale matter. When, on the other hand, the rainfall is smaller than usual (as has been the case this season in many places), the ground can absorb nearly all of the water that falls, and the conditions are reversed. The surface water is now far less in quantity, and nearly all the water that we get has been in the ground where it can find and dissolve lime and magnesia and other mineral substances. It is therefore distinctly "harder," and it gives much more trouble, in boilers, through the deposit of scale.

Our inspectors report, as we have said, that this phenomenon has been very noticeable, this season, in regions where the water supply is scanty. The quantity of scale deposited in the boilers has been much larger than usual — larger than they have observed it to be, in the same boilers, for some years past.

The lessons to be learned from this are two in number. In the first place, since the formation of scale is going on much more rapidly than usual, it is important to open the boilers and clean them (or at least examine their condition) with a correspondingly greater frequency. It is hard to say just *how much* oftener they should be opened, but judging from our own observations in Connecticut, we should say that it would be well to look after them *twice* as often as usual. If this precaution is not taken, there is great likelihood of scale lodging upon the fire-sheets, and the boiler becoming badly burned or bagged. Such is the first lesson, and the second is like unto it. It is almost impossible to keep a boiler *perfectly* free from scale, when using a hard water; and hence it must be expected that a considerable quantity of scale will remain lodged in the boiler, in spite of the fireman's most conscientious efforts to keep it out, so long as present conditions prevail. When a heavy fall of rain comes, however, so that there is an abundance of surface water once more, the feed water will suddenly become far softer, and it will loosen up the scale that has accumulated in the boiler, and allow it to collect over the fire-sheet, where it may give a great deal of trouble, and cause the sheets to bulge down in a very short time. It is surprising how quickly a soft feed water will sometimes loosen up old scale in this way. "Snow froth," or the water from melting snow, is peculiarly active in this respect, as it has never been in contact with any minerals, and therefore is the softest kind of water that is commonly obtainable in any considerable quantity.

In conclusion, we may summarize the two lessons of this article as follows: (1) In regions where the rainfall has been slight, you must expect that scale will form in your boiler much faster than usual; and you had better open up twice as often as usual, and remove all the scale you can. (2) As soon as a heavy rainfall comes, so that water runs over the surface of the ground very freely, you must expect that the scale that is in your boiler is going to be loosened up, and that you will have to watch your plant carefully if you don't want the loosened scale to lodge over your fire-sheet and burn your boiler. The water from melting snow, in the spring, will do this very quickly.

The Mineral Products of the United States.

Mr. Charles D. Walcott, Director of the United States Geological Survey, has issued a large sheet of statistics, giving the mineral products of the United States in detail for the past ten years, and also a summary of the same since 1880, inclusive. The total quantity of each item is given for the several years, and the estimated value of the output is also included. We reproduce, herewith, some of the more general data, but we have not thought it desirable to print the statistics in full, because the original sheet can doubtless be had by any person who may want it, by applying to Mr. David T. Day, Chief, Division of Mineral Resources, U. S. Geological Survey, Washington, D. C.

Table I.—Metallic Products of the United States for Ten Years Past.

Year.	Pig Iron. (Long tons.)	Silver. (Troy ounces.)	Gold. (Troy ounces.)	Copper. (Pounds.)	Aluminum. (Pounds.)
1889	7,603,642	51,354,851	1,590,869	231,246,214	47,468
1890	9,202,703	54,500,000	1,588,880	265,115,133	61,281
1891	8,279,870	58,330,000	1,604,840	295,812,076	150,000
1892	9,157,000	63,500,000	1,596,375	352,971,744	259,885
1893	7,124,502	60,000,000	1,739,081	339,785,972	339,629
1894	6,657,388	49,501,122	1,910,816	364,866,808	550,000
1895	9,446,308	55,727,000	2,254,760	392,639,964	920,000
1896	8,623,127	58,834,800	2,568,132	460,061,430	1,300,000
1897	9,652,680	53,860,000	2,774,935	494,078,274	4,000,000
1898	11,773,934	54,438,000	3,118,398	526,375,591	5,200,000

In Table I we give the quantities of the more important metallic products that have been mined or produced in this country since 1888. The pig iron is estimated in "long tons" of 2,240 pounds each. The figures given for copper include not only the metal mined in this country, but also the relatively small amount that has been reduced to the metallic form, in this country, from imported pyrites. The most interesting feature of this table is the wonderful growth that it shows in the production of aluminum. This growth is even more remarkable than it appears to be at first sight, because the

Table II.—Total Value of the Mineral Products of the United States since 1880.

Year.	Metallic products.	Non-metallic products.	Unspecified.	Totals.
1880	$190,039,865	$173,279,135	$6,000,000	$369,319,000
1881	192,892,408	206,783,144	6,500,000	406,175,552
1882	219,755,109	231,340,150	6,500,000	457,595,259
1883	203,128,859	243,812,214	6,500,000	453,441,073
1884	186,109,599	221,879,506	5,000,000	412,989,105
1885	181,586,587	241,312,093	5,000,000	427,898,680
1886	214,897,825	230,088,769	800,000	445,786,594
1887	248,925,054	270,989,420	800,000	520,714,474
1888	253,731,822	286,150,114	900,000	540,781,936
1889	267,247,033	282,623,812	1,000,000	550,870,845
1890	305,735,670	312,776,503	1,000,000	619,512,173
1891	300,232,798	321,767,846	1,000,000	623,000,644
1892	307,716,239	339,958,842	1,000,000	648,675,081
1893	249,981,866	323,318,020	1,000,000	574,299,886
1894	218,168,788	307,454,805	1,000,000	526,623,593
1895	281,913,639	338,345,361	1,000,000	621,259,000
1896	287,596,906	333,936,310	1,000,000	622,533,216
1897	302,198,502	327,617,480	1,000,000	630,815,982
1898	344,079,986	352,767,802	1,000,000	697,847,788

figures given for aluminum for the years 1889, 1890, and 1891 include *alloys* of that metal; while for subsequent years, if we understand the case correctly, the data refer simply to the metal itself.

Table II does not call for explanation.

Two Much Whistle.— One of the most important adjuncts of a threshing engine, to others besides the small boy, is the ear-splitting whistle, which is used to call the sleepy farmers' sons from their beds in the dark o' the morning, and to give the welcome toot for quitting time. Besides its legitimate uses, it is also employed on sundry occasions for signaling and hooting defiance to rival outfits in the vicinity. We learn from the thresher whistle, in fact, that childhood's delight in making a noise is not necessarily extinguished by years, but that, on the contrary, the older some men become, the more noise they make, and the greater men they are (in their own estimation). The writer knows of a whistling duel that once occurred between the engineer of a feed mill and the corresponding functionary of a near-by shingle mill, both of which establishments were run by threshing engines. The whistle of one of the mills signaled the end of the noon hour with a long successions of vigorous toots, and then the other took up the refrain with a still longer ear-piercing shriek. The first whistle, not to be outdone, whistled yet more loudly and vigorously, and so it went on as long as the steam in the boiler held out, when a halt was called,— to the great relief of the neighbors. The worst abuse of the whistling habit that ever came to my notice, however, was in the oil fields of western New York, between two rival oil-well drillers. These men had engaged, at various times, in the same childish competitive screeching described above; and one day one of them conceived the fiendish scheme of screwing a large mill whistle on the end of the exhaust pipe of his engine; and he proceeded forthwith to put his idea into execution. What made the scheme doubly seductive to him was the fact that it would also afford him an opportunity to square himself with an irascible farmer near by, who had taken occasion, a short time before, to offer the driller a few well-selected but rather cutting remarks upon some subject or other. The wells in this particular oil field were being drilled as rapidly as possible, so that two gangs were employed, one of which began work at noon, and the other at midnight. The driller in question went to work at midnight, and it was at that hour that his whistle began its jerky wail, which continued through the rest of the night, and well along into the morning hours. It is needless to say that nobody in the vicinity could sleep, as the intermittent screech was much more sleep-destroying than a steady scream would have been. The earnest mob which waited, early in the morning, upon the promoter of the peace-destroying device removed the last doubt from his mind as to the success of his experiment; and although he was clearly a victor in the noise-producing game, it is recorded that he was not particularly pleased with its final outcome, and that he will probably never again attach a whistle to the exhaust-pipe of any engine which may happen to be in his charge.— *Steam Engineering.*

Boiling it Down.— A story is told of the editor of a go-ahead evening newspaper, who, in the eternal rushing to press to get ahead of his rivals, was continually impressing upon his reporters the necessity of condensing all news. On one occasion a terrible boiler explosion had taken place on board a big ship lying at Portsmouth. "Get down there as fast as you can," he said to one of his men; "if you catch the 11:40 you will be there soon after 2, and you can just wire something for the extra special — but boil it down." Soon after 3 o'clock that afternoon they got this telegram from him: "Terrible explosion. *Melpomene.* Boiler empty. Engineer full. Funeral to-morrow. No flowers."— *Exchange.*

Telegraph Line to Dawson City. — Work has been in progress for some time upon a telegraph line from Skagway, on the Alaskan coast, to Dawson City, in the Klondike region. The line has now been completed, and the first message between the two points named was sent on September 28th. The line is a little more than 600 miles long. Forty-one miles of this length is formed by the wire of the White Pass & Yukon railway, which runs from Skagway to Lake Bennett, and the remainder has been built by the Canadian government. It is said that preparations are being made to run a long-distance telephone line from Dawson City to points along the Yukon river, Circle City being one of the places which it is desired to reach, ultimately. The nearest point to Skagway which is reached by the telegraph lines of civilization is Cumberland, or Comax, in British Columbia. It is said that arrangements will be made for steamers to call at Comax, both on their north-bound and south-bound trips, for the purpose of carrying the messages back and forth between Skagway and Comax. When this plan is consummated, Dawson City can be reached by the rest of the world, telegraphically, in two days and a half.— *Railway and Engineering Review.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XX. HARTFORD, CONN., DECEMBER, 1899. No. 12.

A Chimney Freak.

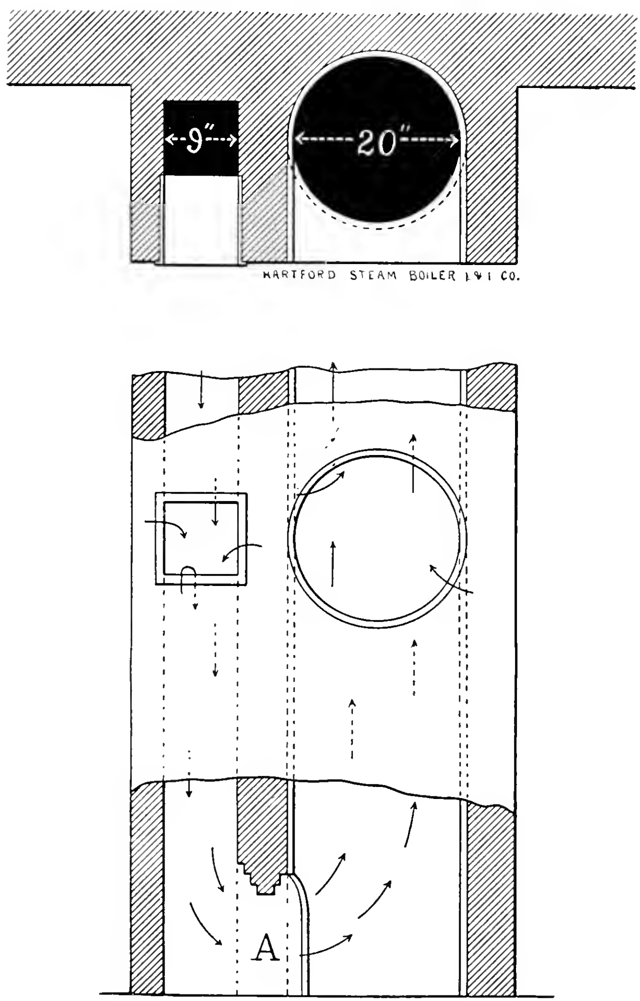


Diagram showing the Chimney and the Course of the Draft.

A Chimney Freak.

There are few mechanical engineers who have not had experiences, in the course of their career, which were exceedingly puzzling at the outset, but which became ludicrously simple upon investigation. An instance of this, from our own practice, forms the subject of the present article. A certain apartment building was to be heated by steam, and our experts were retained to design the plant, and supervise its installation. The contractor appeared to be making an honest effort to do his work right, and we were well satisfied with the general course that things were taking, and anticipated no trouble whatever, as the radiators and the heater were ample in size, the piping was well arranged, and the work, as we have said, was being well done, so far as we could judge, from our periodical visits to the building while the plant was being put in.

It is the unexpected which happens, however, as Professor Sweet has so well said; and when the boiler was fired up for a trial, we were greatly surprised at its misbehavior. In order to make the case intelligible let us first give a few details of the arrangement of the plant. The steam for the system was furnished by a boiler which discharged its products of combustion into a circular flue, 20 inches in diameter, which is shown in the illustration on the first page of this issue of THE LOCOMOTIVE. It was necessary to provide the tenants of the building with hot water as well as steam, and, as the hot water would be required throughout the year, while the steam would be needed only during the winter, a small auxiliary boiler was provided for heating the water, so that it would not be necessary to run the big one through the summer. The small boiler was supposed to discharge its products of combustion into a separate flue, nine inches square, which was built by the side of the big circular one, as indicated in the illustration.

When the preliminary test was made, it was found that the draft was very poor in both flues. The dampers were pulled wide open, and every effort was made to accelerate the combustion in the furnaces, but nothing would induce the fires to brighten up into anything like the condition that we wanted to see. Plainly, the thing wouldn't work; and, as we knew how everything was proportioned and arranged (or *thought* we did), it was hard to understand how the things that were, *could* be. After a good deal of hard but unprofitable thinking, and a few superficial experiments that didn't show anything, we had the nine-inch smoke pipe pulled out of its flue. A candle was then lighted and held up to the opening. It showed that there was a draft into the flue. We then pushed the candle away in, until it entered the vertical part of the flue, and the thing that happened then was so startling and altogether unreasonable that the contractor, who was assisting in the operation, made a few cursory remarks. The flame of the candle was drawn straight *downwards*, and with such violence that the flame burned blue for a second, and then went out. There was good enough draft in the flue, but it went *down*, towards the bowels of the earth.

A section of the front of the flue was then torn out, and it was found that the mason, who seems to have known very little about draft and combustion, had made a large and very neat opening between the two flues at the bottom, as indicated in the sketch by the letter *A*. The steam heater had warmed up the air in the twenty-inch flue, and started an upward current there, and a powerful circulation had then been established, the outside air going down the nine-inch flue, around through the opening at *A*, and up through the twenty-inch flue again.

A supply of bricks and mortar was obtained, the opening at *A* was walled up as shown by the two dotted lines, and the front wall of the flues was replaced; and after this we had all the draft that anyone could wish; and the engineer said that he "had to run with his dampers shut, to keep the safety-valves from scaring the tenants to death."

Boiler Explosions.

July, 1899.

(186.) — On July 1st a boiler exploded in C. E. Wilder's planing-mill, on South Franklin street, Brazil, Ind. There was no one near the boiler at the time, and all the employes escaped injury. It is said that the primary cause of the explosion was the deposit of an excessive amount of scale in the boiler. The walls of the setting were blown down, and considerable damage was done to the building.

(187.) — A locomotive boiler exploded, on July 4th, at Tip Top, a station on the Clinch Valley division of the Norfolk & Western railway, some seven miles from Tazewell Court House, Tazewell county, Va. There is a heavy grade near Tip Top, and engine No. 240, going east, was trying to pull up the grade. Her steam gave out, and she had stopped to run up the pressure, when her boiler exploded. Brakeman Oscar T. Owens, who was on the tender, was killed, and Engineer J. D. McColgan and Fireman E. N. Albert were injured so badly that little hope is entertained for their recovery.

(188.) — Stanton Lowe was fatally injured, on July 5th, by the explosion of a threshing-machine boiler on the farm of Van Buren Lowe, at Masontown, near Uniontown, Pa.

(189.) — On July 5th a boiler exploded in the brickyard at Rudyard, near Sheldon, Iowa. Kinney Bunce, only son of J. D. Bunce, one of the owners of the plant, was instantly killed. This explosion appears to illustrate the danger (to which we have repeatedly called attention) of having a stop valve between the boiler and the safety-valve; for the Sault Ste. Marie *News*, in telling of it, has this to say: "There were two boilers in use, and the young man was making some slight repairs to the smaller one at the time, and had shut off the safety-valve in order to complete the work more expeditiously. At the time of the accident he was standing upon the boiler, busily engaged in the repairs."

(190.) — On July 7th a traction engine boiler exploded on S. J. Mohler's farm at Hays' Grove, near Carlisle, Pa. Engineer John T. Mohler was scalded about the legs, and William Shriver was knocked down by a flying fragment of a flue, and painfully injured.

(191.) — A boiler used in drilling an oil well exploded, on July 8th, on the Moran & Wilson lease, in Oil City, Pa. Leal McCray, the fireman, was instantly killed, and John Turk, a teamster, was painfully injured.

(192.) — On July 11th a boiler exploded in Wesley Smith's mill, in the neighborhood of Woodford, Tenn. The mill was considerably damaged, and Mr. Smith, the proprietor, was badly scalded.

(193.) — On July 13th a threshing-machine boiler exploded on John Herrin's farm, at Wyly, a small place some seven miles south of Big Sandy, Tenn. A. J. Lockhart was instantly killed, and several others were seriously injured.

(194.) — A locomotive boiler exploded, on July 15th, at Hillsville, near Newcastle, Pa., on the Pennsylvania line running up into the Bessemer limestone quarries. The engine was completely demolished. A limestone crusher and several cars were also destroyed. Engineer B. F. Cummings, Fireman Popham, and Brakeman Butterbaugh were painfully scalded and bruised, but it is believed that all three will recover.

(195.) — On July 15th a boiler exploded in E. R. Hibbett's gristmill at Munfordville, Ky. The proprietor and an employe named Parker Bunch were injured so badly that it is likely that they will both die. Three other men also received lesser injuries.

(196.) — A boiler exploded, on July 17th, in Toner & Prescott's mill, at Unionville, near Deckertown, N. J. We have not learned further particulars.

(197.) — The boiler of a portable engine exploded, on July 17th, on Jacob Alter's farm, near Hagerstown, Md. John Alter, who was running the engine at the time, was painfully scalded, Samuel Alter had his hand crushed, and Samuel Stockslager and several other men were scalded and cut.

(198.) — A boiler exploded, on July 18th, in Fishburn & Co's. big sawmill at Fayetteville, Tenn. Tandy Fishburn, one of the owners of the place, was instantly killed, and six of the workmen were badly injured. Three of the injured were hurt so seriously that they cannot recover.

(199.) — Antonio Decesaro and Anedio Decenzo were badly burned about the head and body, on July 20th, by the explosion of a portable boiler which was in use on the railroad in process of construction at Tariffville, Conn. Both men were removed to the hospital at Hartford, Conn.

(200.) — On July 20th a boiler exploded in Zadok Whitehill's sawmill, in Wayne township, near Waynesburg, Pa. Eli Whitehill, a son of the proprietor, was blown to a distance of 200 yards, and killed, and Zadock Whitehill himself was fatally injured. Another son was thrown to a considerable distance, but alighted in a creek, and escaped serious injury.

(201.) — A slight boiler explosion occurred, on July 21st, in the east end plant of the Allegheny light company, at Allegheny, Pa. No person was injured, but several workmen had narrow escapes.

(202.) — The boiler of a traction engine exploded, on July 22d, at Bell's mill, in Buffalo Township, Butler County, Pa. William Watson and his brother, Alonzo Watson, were fearfully scalded, and it is believed that they cannot recover.

(203.) — A tube bursted, on July 23d, in the Morris Station plant of the Camden (N. J.) water works. The damage was small, and we have not learned of any personal injuries.

(204.) — The boiler of a threshing machine blew up, on July 25th, on John Finney's farm, four miles south of Deweese, Neb., seriously injuring four men, one of whom will die.

(205.) — On July 26th a threshing-machine boiler exploded, some seven or eight miles north of Nelson, Neb. Roy Norwood, a young man of about twenty-three, was struck by one of the flues and fatally injured. No other person was injured seriously.

(206.) — On July 27th a flue bursted in one of the boilers at the plant of the Terre Haute (Ind.) Street Car Company. John Comminskie, a fireman, was seriously burned about the head, but it is believed that he will recover.

(207.) — The boiler of locomotive No. 213, on the M., K. & T. railway, exploded, on July 30th, a mile and a half north of Elm Mott Station, near Waco, Tex. Fireman A. J. Hoatson was seriously scalded and bruised, and Engineer L. Fitzpatrick received lesser injuries. The accident consisted in the failure of the crown sheet.

(208.) — On July 31st a boiler exploded in the New Jersey Galvanizing Company's plant, Jersey City, N. J. John Ehard and Theodore Donnelly were seriously injured, and at last accounts it was thought probable that Ehard would die.

(209.)— A boiler exploded, on July 31st, in Lingeman & Adams' big gristmill at Brownsburg, Ind. The building was badly wrecked. Engineer J. T. B. Hollett had just stepped out of the boiler-room when the crash came, thereby escaping injury. Several residences in the immediate neighborhood were damaged by falling debris, and a number of persons had wonderfully narrow escapes from death or serious injury.

(210.)— On July 31st the boiler of a threshing outfit exploded in Big Prairie township, fourteen miles northeast of Newaygo, Mich. Charles Haight, Alvah Haight, Charles Crabtree, Cecil Priest, Raymond Howe, Herbert Salter, and Charles Overly, were instantly killed, and Oscar Evans, George Haight, and several other men were seriously injured. The explosion was unusually horrible in its details, and one of our accounts says that "it took all day to gather up the human fragments from the fields." Three of the dead were married men with families. The others were single.

On the Theory and Practice of Getting Jobs.

By J. W. Alvord, M. Am. Soc. C. E.*

In recently looking over a mass of pamphlets in one of our Society libraries, I became impressed with the lack of attention to the very practical subject which I have chosen as the title of this paper. It is a cause for congratulation to note the completeness and care with which professional brethren have been willing to lay before us, in all possible detail, the methods that they have adopted, the researches that they have made, and the conclusions at which they have arrived after long and laborious study, in the performance of jobs which they have already secured; but when it comes to the important and interesting problem, *how to obtain such jobs*, these writers are usually more than modest, and if perchance they hint at that phase of the subject at all, it is with the lightest and airiest touch, or the breathing of some such unsatisfying and elusive ritual as: "The committee having placed the matter in my charge," or "being consulted by the president of the company," or that still more common and unsatisfactory expression, "The writer being called in at this juncture to undertake the work," etc., etc.

I have enjoyed reading such phrases as these for many years. They appeal to my imagination. In my mind's eye I could see a committee of solid and influential citizens, after long and profound consultation, coming to my professional brother's office in a body, and solemnly — one might almost say reverently — "placing" the matter in his charge, unreservedly and fully and with a simple and childlike confidence that in so doing they had fully insured the brilliant success of the proposed undertaking.

In the course of years of expectancy and yearning for jobs — and more of them — such delightful experiences as these have been somewhat few in my own career, and when

---

*Abstract of a paper read before the fourteenth annual meeting of the Illinois Society of Engineers and Surveyors. While Mr. Alvord treats more particularly of the *civil* engineer, much that he says will be found suggestive to those engaged in other lines of work.

the remotest similarity to the examples given have actually occurred, the experience has left me in a stunned condition of mind. In earlier years I naturally felt with humility that I was only clinging to the outskirts of the profession, hanging on to its extremities, as it were, and when I lost my first important salary and tried to get another, I felt a good deal as a cat does when it is thrown out of an upper window, and goes down with a rush, clawing, yowling, and grabbing at everything in sight, in a vain attempt to ease the situation. My inability, at that time, to get my claws into anything tangible made a serious impression on me, which has only deepened with the lapse of time and the accumulation of experience.

At this particular point I desire to contrast the theory of getting jobs with the practice thereof. You open an office and insert your business card in the technical papers. Then you brace yourself for the flood of business. Your professional rivals drop in one by one to ask "how it comes on," and, incidentally, to see how much your office furniture cost you, and otherwise assure themselves that you are not remotely likely, as yet, to get a job away from them. A few book agents vary the monotony of life, and once in a while a well-dressed life insurauce agent makes your heart jump into your mouth as you lead him into the inner office with every nerve braced to keep the joy out of your face, as you try to assume a bored and indifferent air. I know of few more soul-wrenching moments than the one that comes when the life insurance man discloses his business in that inner sanctum. It is for this, then, that those pumping engine details have been scattered over the table, and books on deep and abstruse subjects placed where they meet his eye! A man who can pass through these experiences without the freshness of his hope being perceptibly withered, has fitted himself for a better land.

But yet the theory seems to be all right. You are a professional man. Your work is such as to require confidence in you on the part of your clients. Consequently it is indelicate on your part to push your claims to their notice. You feel competent to do their work. You have done it before, over and over again, successfully; but you must not intrude this fact upon their notice, but must wait for them to come to you.

These are the conclusions I have been led to, at any rate, after long years of perusal of engineering literature. I take delight in the theory. It accords with my own sensitive nature and my retiring disposition. I always read articles on the "Standing of the Engineer" and "Ethics of the Profession"; I am especially fond, too, of "Presidents' Annual Addresses." I consider them delightful reading. I well remember returning, seven years ago, from a $75 trip to Braceville (where I had been at my own expense, to see another engineer receive a job), being much comforted by reading the annual address of our worthy President. It seemed to relax the strain of the Braceville episode to read of the great achievements of the engineer along the different lines of his profession throughout the world, and to know once more that his was the opportunity to "harness the forces of nature to the uses of man." I have been familiar with that sentiment for many years, but it never seemed to have the same weight and swing as it did on this occasion. It calmed my nerves and filled me with a glow of hopefulness. I felt once more a man. I think we cannot set too great a store on these presidents' addresses.

It may be inferred from my reference to the Braceville episode that I have sometimes gone out after jobs. It is with some reluctance that I am compelled to admit here, confidentially, that once or twice I *have* "run over" to a town or two, to see if there was any interesting and instructive work going on. I very well remember the first time I did this. I thought it a little singular that I should find, near the bait, the plain footprints of several distinguished professional brethren versed in that particular specialty. Some of them, I was told, had "stopped over" on their way to important work at other points further on. Some had been invited by a particular friend, who was extremely anxious to see the important work in the proper hands. Nearly all fortunately happened to have with them some copies of testimonials of former work which they would leave. The engineering of this particular job was finally let on proposals. I remember that at the letting several of us who happened to be in town were interviewed by the council one by one behind closed doors — sized up so to speak. I also remember, while waiting for my turn to trot, being called aside by a mysterious man with a wandering eye and a sinister smile, and being informed in a highly secretive manner that the firm of Tripod & Sight-pole had secured three of the council, and that there would be no show for me unless I would leave the matter with him — that he had a good deal of influence with the council, and wanted to see me get that work. I remember being much touched by his sympathy and solicitude on my behalf, and saying to him earnestly that if awarded the work I would endeavor to do it well and faithfully, together with much more in the same strain, and net results of which, much to my surprise, seemed to cool his interest wonderfully. I noticed afterward that Messrs. Tripod & Sight-pole got the work, and I remember particularly being struck with the fact that there was a difference of some 3,000 per cent. between the highest and lowest bids. It is natural to abuse the wily councilman for his lack of appreciation of engineering ability, but it is hard to see how he can form a very high opinion of a profession whose members have such a variable estimate of themselves.

After my arrival home, I watched eagerly for next week's technical papers. Now, thought I, we will have this disgraceful competition exposed by an able editorial on "the folly of treating brains as merchandise," or "low depths of ignominy to which some town councils are sunk." I was disappointed. After searching vainly all through the news column, I found the following brief item in the next issue: "The services of Messrs. Tripod & Sight-pole, the well-known engineers of Metropolisville, have been secured by the city of," etc., etc.

After this, my confidence in the theory of getting jobs began to wane. I laid the theory on the shelf, as it were, and found myself compelled by urgent necessity to discover the *practice.* In the course of a number of years of heartrending experiences I have, I think, discovered a few simple rules for getting jobs which, after much reluctance, I have concluded to give to the profession in absolute confidence. They have not always worked as well as I would like, but they at least give one a fair chance with other professional brothers, and they are as follows:

1. Find your job. This is quite necessary. I have completely discarded the theory on which I started in, that your job should find you. It may work once in a while, but as a rule a needy engineer out of work is a great deal keener hunter than a lonesome job is. After you have found jobs for a good many years, it is possible that some stray jobs may find you; but I wouldn't count on it.

2. Know a great deal more about how that job ought to be done than anybody else around. There is no doubt at all but that this is a very important requirement indeed, in the practice of getting jobs, but it is one which I feel almost ashamed to mention, and indeed would have foreborne to speak of, had it not been that occasionally I have met enthusiastic and confident engineers eager and willing to lend a hand in the great work of harnessing the forces of nature, but a little uncertain as to the difference between the breeching and bellyband. This delightful trait of ambition in our profession should be commended, could it only be turned into proper channels.

3. KNOW THE MEN WHO HAVE THE JOBS TO GIVE. This last rule seems also to be one of those delightfully simple propositions, in theory, which are found so difficult in practice. The theory of the thing is that an engineer's reputation ought to precede him everywhere. In practice he is usually exceedingly glad if it will only *follow* him at a respectable distance.

People with jobs to give want to see you, poke your ribs, and put you through your paces, as I have elsewhere intimated. And if you would like to be their "hired man," it is best for you to go and submit yourself to the process as gracefully as you can. I believe, however, that it is quite possible to do all this and still be modest. There is no money in being *bashful*, but to be suitably *modest*, at the proper time and in the proper amount, is an art whose worth to the fortunate possessor cannot be overestimated. Long years of harrowing experiences have frayed the edges and removed the bloom from my own early attempts to be modest. Yet I cannot refrain from referring with pride to one attempt which may prove instructive. In the first year of my apprenticeship the city directory man called at the office in which I was engaged and asked for my name and designation. Naturally I did not feel at that time that I stood more than upon the threshold of our great and noble profession, so I informed him simply that I thought I might be entitled to be called an "engineer's assistant." I am at a loss to determine even to this day whether this was an act of true modesty or mere bashfulness, but the classifier at the central office of that directory had evidently no difficulty whatever in placing me. He had met pretentious people before, in his line of business, and when the directory was duly printed and issued I was dumfounded to observe the appellation of "fireman" following my name and address.

It is pretty evident that the business world makes but little allowance for ordinary modesty, but it doubtless has distinct difficulty of its own in designating and classifying a profession which expects a man to drive stakes in a sewer, or paint landscapes in the office, or corner the elusive bacillus in the laboratory, or throw off a literary gem in the shape of a financial prospectus between meals. — *Railroad Gazette.*

Inspectors' Reports.

AUGUST, 1899.

During this month our inspectors made 9,116 inspection trips, visited 17,400 boilers, inspected 7,016 both internally and externally, and subjected 898 to hydrostatic pressure. The whole number of defects reported reached 10,839, of which 810 were considered dangerous; 57 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	890	72
Cases of incrustation and scale,	2,263	71
Cases of internal grooving,	167	5
Cases of internal corrosion,	729	41
Cases of external corrosion,	635	47
Broken and loose braces and stays,	157	29
Settings defective,	408	25
Furnaces out of shape,	397	18
Fractured plates,	216	42
Burned plates,	209	25

Nature of Defects.	Whole Number.	Dangerous.
Blistered plates,	122	4
Cases of defective riveting,	1,439	46
Defective heads,	95	27
Serious leakage around tube ends,	1,495	109
Serious leakage at seams,	385	26
Defective water-gauges,	278	49
Defective blow-offs,	162	40
Cases of deficiency of water,	10	5
Safety-valves overloaded,	75	35
Safety-valves defective in construction,	80	20
Pressure-gauges defective,	398	33
Boilers without pressure-gauges,	41	41
Unclassified defects,	188	0
Total,	10,839	810

September, 1899.

During this month our inspectors made 9,238 inspection trips, visited 17,865 boilers, inspected 7,374 both internally and externally, and subjected 925 to hydrostatic pressure. The whole number of defects reported reached 12,170, of which 966 were considered dangerous; 57 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	999	42
Cases of incrustation and scale,	2,178	50
Cases of internal grooving,	112	19
Cases of internal corrosion,	621	30
Cases of external corrosion,	504	35
Broken and loose braces and stays,	178	63
Settings defective,	326	21
Furnaces out of shape,	392	24
Fractured plates,	278	36
Burned plates,	248	27
Blistered plates,	138	4
Cases of defective riveting,	1,589	56
Defective heads,	78	6
Serious leakage around tube ends,	2,343	254
Serious leakage at seams,	412	13
Defective water-gauges,	351	69
Defective blow-offs,	168	66
Cases of deficiency of water,	33	22
Safety-valves overloaded,	81	47
Safety-valves defective in construction,	113	32
Pressure-gauges defective,	424	22
Boilers without pressure-gauges,	28	28
Unclassified defects,	576	0
Total,	12,170	966

The Locomotive.

HARTFORD, DECEMBER 15, 1899.

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

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

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

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

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

THE index and title page of THE LOCOMOTIVE for the year 1899 are in preparation, and will be ready by January 1st. Copies will be sent free, upon application by mail, to those who preserve their LOCOMOTIVES for binding. Bound volumes for the year 1899 will be ready in a short time, and may be had at the usual price of one dollar each, post-paid.

THE *Annual Report* for 1899, of the Chief of the Bureau of Steam Engineering in the United States Navy, is at hand. During and since the war with Spain the public has taken a deeper interest in the affairs of the navy than it had, previously, for many years. The present report is destined, therefore, to receive an unusual amount of attention.

WE have received a copy of the *Transactions* of the third annual meeting of the National Fire Protective Association, held at Boston last June. The objects of the association are "to promote the science and improve the methods of fire protection, to obtain and circulate information on this subject, and to secure co-operation in matters of common interest." The reports of the committees on fire-doors and shutters, and on automatic sprinklers, which we find among the diversified contents of the present volume, are especially worthy of attention.

IN the October issue of *Steam Engineering* we find an illustrated letter from a Mr. D. S. Terry, entitled "Home-made Smoke Consumers," and referring to an article on the same subject, which was written by Mr. A. H. Strong, and printed in the issue of *Live Steam* for March, 1899. We trust that these gentlemen do not conceive that the devices they describe are new. We printed, in THE LOCOMOTIVE for December, 1892, a description of an apparatus practically identical with these, which was invented and used with success, many years before, by Mr. J. M. Allen, president of this company.

WE desire to acknowledge a copy of Fox and Thomas's *Practical Course in Mechanical Drawing*, which we have received with Professor Thomas's compliments. We have examined it with a good deal of interest, and it gives us pleasure to certify that it is a book after our own heart. It departs from most of the conventional notions that writers on this subject are apt to hold, and goes about its business in a straightforward and simple manner of its own. We wish especially to commend the half-tone engravings, showing the beginner how to hold the instruments and how to use them. Of course nobody can learn to draw by simply reading a book, but the tyro can get a good many valuable suggestions from this particular book, and he will find it well worth its price. (The D. Van Nostrand Company, 23 Murray street, New York. Price, $1.25.)

Obituary.

Mr. Harry F. Keller.

We regret to announce that Mr. Harry F. Keller, a special agent in the Northwestern department of the Hartford Steam Boiler Inspection and Insurance Company, died, on November 13th, at Monroe, Wis. Mr. Keller was born at Carlinville, Ill., on Nov. 5th, 1858. In his early life he was engaged in the grocery business, but about 1881 he became a partner in a hardware firm of which his father, Ezra Keller, was also a member. In 1883, he married Miss Jennie M. Carle, of Janesville, Wis., and a few years later he became a traveling salesman for Burley & Tyrell, of Chicago. He resigned this position in the spring of 1892, to accept an offer made to him by the Hartford Steam Boiler Inspection and Insurance Company, in whose service he has since continued. He was a man of genial nature and great kindness of heart.

Sir William Dawson.

Sir John William Dawson, the well-known educator and geologist, died in Montreal, on November 19th, at the age of 79. Few men have shown such activity and such devotion to the advancement of learning as he exhibited throughout his long and useful career. A full list of his contributions to science and education would be voluminous indeed. He is most widely known, perhaps, for his connection with McGill University, in Montreal, which, as the corporation of that institution has well said, "he raised from small beginnings to the honored place it holds to-day among the universities of the world." He was principal of McGill University in 1855, and held that position continuously until 1893; and it is on account of his long term of active service in this capacity that he was popularly known as "Principal Dawson." He will be remembered personally, by many citizens of Hartford, as the lecturer in the Carew Course at the Hartford Theological Seminary, several years ago.

We desire to acknowledge the receipt of a little book entitled *The Use of The Slide Rule*, which was written by Mr. F. A. Halsey, Associate Editor of the *American Machinist*. In noticing this book we wish to draw a careful distinction between our opinion of the slide rule itself, and our opinion of Mr. Halsey's treatment of his subject. The slide rule, as doubtless our readers know, is an instrument for facilitating approximate calculations. It is much in favor in some parts of Europe, especially in England. Our own experience with it, however, has been rather disappointing. We have had a good deal of computing to do — computing that would appear to be well adapted for slide rule treatment — but after serving what we considered to be a fair apprenticeship at it, we abandoned it, preferring to make use either of four-figure logarithmic tables or of Crelle's multiplication tables, according to which appeared to be the better adapted to the particular work in hand. So much for our opinion of the slide rule itself. If we now leave this opinion on one side and consider Mr. Halsey's little book strictly on its merits, as a treatise adapted for self-instruction in the *use* of the slide rule, we shall have nothing but praise for it. The treatment is intelligible, and probably as simple as the nature of the subject admits. It almost tempts us to reverse our previous verdict upon the instrument, and go back to it again. (The D. Van Nostrand Company, 23 Murray St., New York. Price, 50 cents.)

MR. Jared Day, who has been an inspector in our New York department for a quarter of a century, has retired from this company and from the business of steam boiler inspection, after rounding out his twenty-five years of continuous and faithful service. Mr. Day first took up the duties that he has now laid down, on October 16, 1874. He was formerly chief engineer for the Oriental Steamship Company, making runs to China and Japan. He was also employed in the same capacity on ocean-going coasting steamers, and on the Fall River line steamers, plying between New York and Boston. He was chief engineer on the steamship *Providence* of that line, immediately before entering the employ of the Hartford company. Mr. Day takes with him our sincerest wishes for a long and prosperous career in whatever line of business he undertakes.

A Coal-mine Experience.

[For THE LOCOMOTIVE.]

In May, 1894, the wholesale and retail coal dealers of New York city made their annual excursion to the coal regions, visiting, among other places of interest, Colliery No. 3, of the Lehigh & Wilkesbarre Coal Co., at South Wilkesbarre, Pa. This mine is an unusually deep one, the bottom of the main shaft being 1,078 feet below the surface. It is quite dry, and for that reason was selected for our inspection; but it is one of the most gaseous mines in the country, and according to the gas-testing machine, its atmosphere is almost at the explosive point, even when the ventilating fans are in motion.

A party of eight or ten of us had been sent down the shaft, and the carriage containing as many more had descended about half way, when one of the boilers which supply the steam for operating the fan and the engines at the shafts burst with tremendous force, blowing away the roof and one side of the boiler-house, and hurling a mass of iron over the hill to the Lehigh Valley Railroad, 300 yards distant. The tracks were cut through as if they had been made of cheese, and traffic was delayed for two hours. Several loaded coal-cars near the boiler-house were blown from the tracks and overturned, and several of the excursionists were knocked down by the force of the explosion, some of them having extremely narrow escapes from flying iron and timbers. The boiler-room contained twelve horizontal tubular, four National, and two Pollett boilers, in nests. It was one of the former that burst, and things were so thoroughly wrecked that the shaft carriage could be neither hoisted nor lowered, and, worse still, the fan which supplies the mine with fresh air, was stopped. The visitors who had gone down the shaft, and the 450 miners scattered through the workings, were unquestionably in a bad fix.

I was among the first that had gone down, and we had reached the bottom and started with the foreman to examine the mine when the explosion occurred. We had heard nothing at that depth, of course; but a miner came running after us, and I heard him say hurriedly in low tones to the foreman, "We've got to get out of this mighty quick!" In response to the foreman's question as to what the trouble was, he replied, "Come to the telephone and you'll find out." We went back with them to the foot of the shaft, where the telephone box was located, and the conversation we heard at that end of the line was not very reassuring. "How am I to get these men out? . . . There isn't time to take them to the other shaft. The gas will get there before we do."

Finally he shut off the telephone and explained the situation, after which he opened a small door near by and said, "There is the emergency shaft, built for just such times as this, with ladders leading up to daylight. It's the only way to get out. Keep cool, but climb for all you're worth!" He called an intelligent looking miner to him and said, "Lead these men, and do the best you can for them." The miner nodded, instructed us to put out our lamps, and to light no matches, whatever happened; and then he sprang through the door into the pitch-dark shaft.

It is always interesting to see what men will do in times of danger, and I couldn't help noting the effect upon those with me when this startling condition confronted us. There was a grand rush for the door, and half a dozen men tried to crowd through it at the same time. Some cursed, some prayed, some raved, and a few set coolly about the job of climbing 1,078 feet of ladders in the black, narrow shaft. I went back to the foreman and found him sending some miners off on the run to notify their fellow-workman in the distant tunnels. "What are *you* going to do?" I asked. "I am the foreman here," said he, "and I stay till the last man is out." I thought, as I looked at the cool, serious man, that there are many, many heroes that we know nothing of. I blew out my lamp and put it in my pocket; then I went into the shaft, and the foreman closed the door behind me. I knew full well the danger of the situation; for in case of a mine explosion everything in the shaft goes up,— ladders, platforms, miners,— all in one grand volcanic outburst, borne along by the irresistible expansion of the exploding gases below, as a projectile is blown from a cannon. I say I knew all this, yet somehow it never occurred to me to be frightened. The all-absorbing idea of how to get out in the quickest possible time took entire possession of me, and there wasn't room for anything else. I studied the structure of the shaft, and I found that ladders about 30 feet long reached from each platform up through a narrow manhole to the next; that there were 28 rungs in every ladder; and that by counting 25 of these rungs I could step on to the next platform above without wasting time to feel my way. I also discovered that while each ladder was set to one side of the shaft to allow room to pass around to the foot of it, there was sufficient space between it and the wall on the other side to allow a small man to squeeze through, and thus pass those who stopped to rest. Some of the men developed the bad habit of stopping to rest on the ladders, and in such cases it was necessary to crawl up the under side of the ladder until I had passed them, and then get on again over their heads. By taking advantage of these little things I soon passed those who had started ahead of me. Then I ran into another lot of men, who proved to be the party that had been stuck part way down the shaft. They had pried a board off and gotten from the carriage into the ladder shaft. I finally got past these men also, and was very glad to, because I expected some one would slip or faint and fall on me. I could still hear above me on the ladders the quick pat, pat, pat, of someone who evidently knew how to climb, and was making the most of this knowledge. Throwing away my hat, which had begun to feel like a red-hot band around my head, I set out to overtake him if possible, going as fast as I could without absolutely suffering, and making my arms do as much work in pulling as my legs did in lifting. Suddenly the sound of his footsteps ceased, and I ran into him on one of the platforms where he had stopped to rest. I asked who he was, and learned that he was the miner who started at the bottom to lead us up. He was a born leader at that business, I can assure you. "Are we pretty near the top?" I asked. "We are pretty near half way up," said he. It seemed as if we had already climbed a mile. "Is it necessary to keep up this gait, or can we afford to go a bit slower?" "Well," said he, "every minute in this hole is worth a year of our lives. The good air ought to be going *down*, but it isn't; on the contrary, you can feel it rushing *up*. The gas is behind it, and when that gets here we'll go off these ladders as though we were shot." "Do you think we shall get out alive?" I asked. "I hope so," he answered, "but I doubt it." "Then, good-bye," I said, and started up the ladder ahead of him, resolved to make a more desperate effort than ever. I remember exulting in the thought that I was light and strong, and that if anybody could get out, I ought to be able to. I also remembered — but *without* exultation — that I had recently allowed an accident policy to lapse. If I had overtaken an insurance man in that last 500 feet, he would not have had to argue with me one second on the merits of his company.

The air was growing worse in the shaft, and to pump enough of it into the lungs to keep up the physical effort was agonizing work. My tongue became parched, and I would have given a year of my life for a drink of water. Suddenly the water came — a deluge of it! It washed down the accumulated coal-dust of years, into my face, up my sleeves, and down my neck. But O, how good it felt! It put new life into the air, and cooled the blood and brain. And it kept coming until I was washed comparatively clean again. I learned, later, that two big streams from 4-inch hose were turned down the main shaft, and much of the water found its way between the boards into the side-shaft. It carried much good air with it, and it also helped to stop the rush of air up the shaft.

At last I saw above me a thin streak of light, and I put out a fresh effort to reach it. The shaft grew lighter, so that I could see the rungs of the ladder. Finally I reached it, and found that it came though a crack in a trap-door that was shut down and locked fast! I pounded on it with my bare hands; I yelled like a Comanche Indian; but no one came to open it. For a moment things turned blacker than ever, and I wondered if I had had that climb for nothing, only to be "blown from the cannon's mouth" after all. Then I examined the door. It was made of inch boards, with a brace across each end, and a transverse brace diagonally between the two, like a letter Z. I crawled up under it as far as I could go, with my head down and shoulders against it; then I spread my feet as far apart as the ladder allowed, grasped the top rung with my hands, and decided to burst either that door or a blood vessel. It was the only time in my life that I ever put into one effort every ounce of power I could possibly exert. The door creaked, — cracked — split in the middle, — and my head and shoulders came up through it into the light of day! I had nearly sawed one ear off, but that didn't count.

It was a strange sight that met my eyes. There wasn't a soul near me, but 40 feet away, on all sides, was a dense wall of people — several thousand of them. In anticipation of an explosion, no one was allowed near the mouth of the shaft. In the crowd were hundreds of women, wives of the miners, many with children in their arms, moaning and shrieking over the men down below. There were grimy miners from other collieries near by, and crowds of people from town who had heard of the accident and hurried to the spot. Suddenly a man, who proved to one of our party who had remained above ground, rushed forward as I emerged from the shaft, and threw his arms around my neck. Others followed, and I had more questions fired at me in a minute than I could have answered in a week. They had given us up for lost, it seems, because within a few minutes from the time of the explosion they could get no response through the telephone at the foot of the shaft. The telephone wire ran down the shaft we were in, and some one had probably run afoul of it and broken the connection. My appearance, therefore, was the first evidence they had had for more than half an hour that we were not suffocated. In fact, the excursion committee had already begun to discuss plans as to how they would get our bodies home. It was forty minutes from the time of the explosion up to the time I got out, and as the depth of the shaft is more than twice the height of the Washington monument, I was reasonably well satisfied with the time I had made. But the danger was by no means over for the others, and as it was nearly fifteen minutes before any one else came up, it was an anxious time. At last a dust-begrimed face appeared at the manhole, and one man after another wearily climbed out. Several were in a state of collapse, and fainted when they got to the surface; but physicians were there, and restoratives were successfully applied. It was more than three hours before the last man in our party was safely out. Meanwhile the miners had overtaken and passed them, and came out of the shaft like ants out of a hole; but they behaved splendidly, stopping to help the exhausted men, and even going back into the shaft to carry stimulants to those who had fainted.

I am convinced that the water that was turned into the mine was what saved us, as the upward rush of air gradually lessened until the fan was repaired and set in motion, and ventilation was restored. There was jubilation among the mine officials when all were out, and it was the consensus of opinion that we had had a very close shave. The next day, at Scranton, we visited collieries, but I noticed that some of the party had lost all their curiosity concerning the interior of coal mines, and contented themselves with superficial observations.

ARTHUR F. RICE.

[The boiler explosion to which this article refers occurred on May 24, 1894, and was briefly described in the issue of THE LOCOMOTIVE for July, 1894, it being No. 114 in the list of May explosions, there printed.— ED.]

A Miraculous Boiler.

"Whenever I think of a boiler I saw over in Texas the other day," said an insurance inspector just back from a trip through the Lone Star State, "I feel an icy creeping about the roots of my hair. I found it on a hillside in a country town, but I am by no means certain it is still there. In fact, I wouldn't even bet on the hill being in the same place. The boiler was extremely old. It looked as if it might belong to the glacial period, and was totally devoid of indicators, gauges, or anything else to show the head of steam or quantity of water. The proprietor was a placid German, who told me he filled it every morning with a bucket. I asked him how he estimated the pressure, and he replied that he occasionally let off a little steam, and if it 'looked blue' he ceased to poke the fire. After I heard that explanation I hastily retired to the other side of the town, and didn't breathe easy until the train pulled out. The old boiler has been rocking along for the last ten years, and its presence on earth each consecutive day of that period is a full-blown, 18-karat miracle. It is a capital illustration of the deep depravity of inanimate things. If it was located in the heart of the city, where it could blow up a hundred or so human beings at one fell swoop, it would explode in less than five minutes by the watch. Out there, where the best it can do would be to mix up the Dutchman and the hill, it evidently doesn't consider the results worth the exertion. I think it must be waiting for a Sunday-school picnic."— *New Orleans Picayune.*

Incorporated 1866.

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

Charter Perpetual.

Issues Policies of Insurance after a Careful Inspection of the Boilers,

COVERING ALL LOSS OR DAMAGE TO

BOILERS, BUILDINGS, AND MACHINERY,

AND DAMAGE RESULTING FROM

LOSS OF LIFE AND PERSONAL INJURIES,

CAUSED BY

Steam Boiler Explosions.

Full information concerning the plan of the Company's operations can be obtained at the

COMPANY'S OFFICE, HARTFORD, CONN.,

Or at any Agency.

J. M. ALLEN, President.
W. B. FRANKLIN, Vice-Prest.
FRANCIS B. ALLEN, 2d Vice-Prest.
J. B. PIERCE, Secretary.
L. B. BRAINERD, Treasurer.
L. F. MIDDLEBROOK, Asst. Sec.
E. J. MURPHY, M. E., Consulting Engineer.

Board of Directors.

J. M. ALLEN, President.
FRANK W. CHENEY, Treas. Cheney Brothers Silk Manufacturing Co.
CHARLES M. BEACH, of Beach & Co.
DANIEL PHILLIPS, of Adams Express Co.
RICHARD W. H. JARVIS, Prest. Colt's Fire Arms Manufacturing Co.
LEVERETT BRAINARD, of The Case, Lockwood & Brainard Co.
GEN. WM. B. FRANKLIN, late U. S. Commissioner to the Paris Exposition.
HON. HENRY C. ROBINSON, Attorney-at-Law, Hartford, Conn.
HON. FRANCIS B. COOLEY, of the National Exchange Bank, Hartford, Conn.
GEORGE BURNHAM, Baldwin Locomotive Works, Philadelphia.
HON. NATHANIEL SHIPMAN, Judge United States Circuit Court.
C. C. KIMBALL, President Smyth Manufacturing Co., Hartford, Conn.
PHILIP CORBIN, of P. & F. Corbin, New Britain, Conn.
GEORGE A. FAIRFIELD, Prest. Hartford Machine Screw Company.

GENERAL AGENTS.	CHIEF INSPECTORS.		OFFICES.
THEO. H. BABCOCK.	R. K. McMURRAY.	NEW YORK CITY.	Office, 160 Broadway.
CORBIN & GOODRICH.	WM. J. FARRAN.	PHILADELPHIA, PA.	" 432 Walnut St.
LAWFORD & McKIM.	R. E. MUNRO.	BALTIMORE, MD.	" Chamber Commerce.
		WASHINGTON, D. C.	" 511 Eleventh St., N.W.
C. E. ROBERTS.	F. S. ALLEN.	BOSTON, MASS.	" 125 Milk St.
		PROVIDENCE, R. I.	" 29 Weybosset St.
H. M. LEMON.	JAMES L. FOORD.	CHICAGO, ILL.	" 169 Jackson St.
C. C. GARDINER.	A. B. ECOFF.	ST. LOUIS, MO.	" 319 North Fourth St.
S. R. BENJAMIN.	F. S. ALLEN.	HARTFORD, CONN.	" 650 Main Street.
W. G. LINEBURGH & SON.	J. H. RANDALL.	BRIDGEPORT, CONN.	" 1 Sanford Building.
BURWELL & BRIGGS.	C. A. BURWELL.	CLEVELAND, OHIO.	" 208 Superior St.
JAMES W. ARROTT, LTD.	BENJAMIN FORD,	PITTSBURGH, PA.	" 401 Wood St.
MANN & WILSON.	J. B. WARNER.	SAN FRANCISCO, CAL.	" 306 Sansome St.
THOS. F. DALY.	T. E. SHEARS.	DENVER, COL.	" Ernest-Cranmer Bldg.
LOUIS V. CLARK & CO.,	B. F. JOHNSON.	BIRMINGHAM, ALA.	" 2021 First Ave.
W. S. HASTIE & SON.		CHARLESTON, S. C.	" 44 Broad St.
PETER F. PESCUD.	F. C. BITGOOD.	NEW ORLEANS, LA.	" 818 Gravier St.

INDEX TO VOL. XX. — 1899.

ARTICLES MARKED WITH A STAR (*) ARE ILLUSTRATED.