HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

HARTFORD, CONN.

The Locomotive.

PUBLISHED BY THE

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

NEW SERIES.

Vol. III.

HARTFORD, CONN.

1882.

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NEW SERIES—VOL. III. HARTFORD, CONN., JANUARY, 1882. No. 1.

Destructive Explosion of a Battery of Boilers.*

A few minutes before 5 o'clock on Sunday morning, Nov. 13, 1881, ten boilers exploded at the Salt and Lumber Manufactory of Hamilton, McClure & Co., situated on the Saginaw River in the town of Zilwaukee, Mich.

Four men who were on duty in the fire-room at the time were instantly killed, and property variously estimated from $20,000 to $25,000 damaged or destroyed.

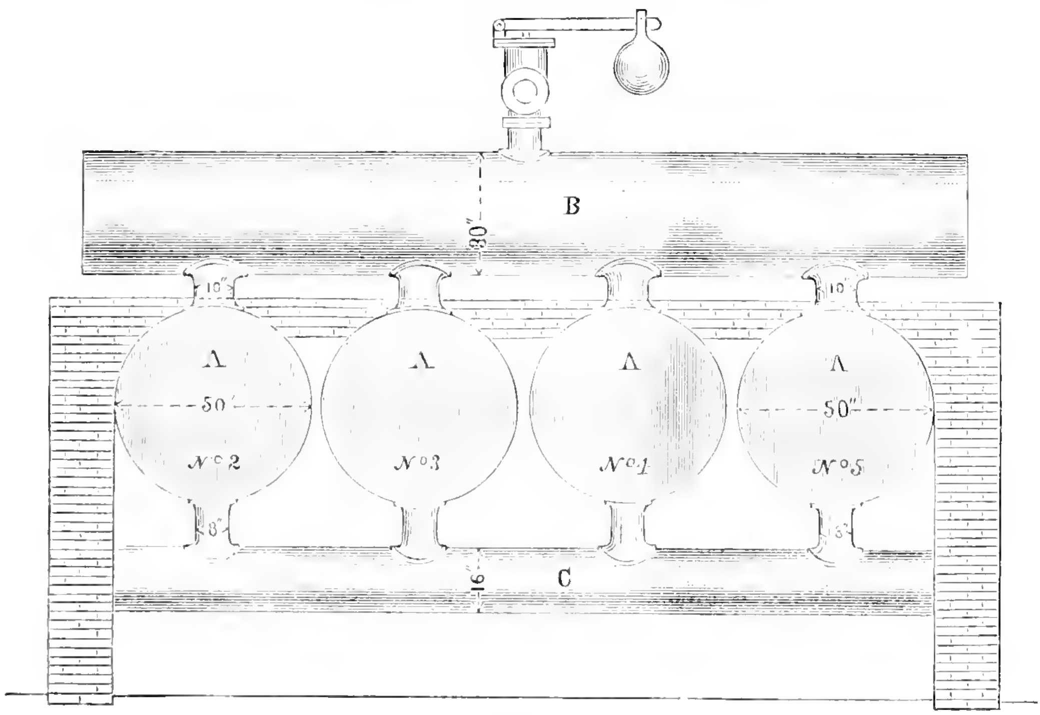


FIG. 1.

The ten boilers were of the horizontal tubular pattern, in a one-story boiler-house, apart from the other buildings. No. 1 boiler was set singly, next to that a battery of four, Nos. 2, 3, 4, and 5; a second battery contained five, Nos. 6, 7, 8, 9, and 10; each battery having but one furnace for all, with suitable fire doors for each boiler. Each of these boilers were 50 inches in diameter by 24 feet long, of $\frac{5}{16}$ iron originally, but since considerably thinned in places, single riveted. The single boiler was 56 inches in diameter by 13 feet long—$\frac{5}{16}$ iron.

These boilers were arranged to feed in each battery through a 2½ inch feed-pipe, which delivered its water into two 16-inch heaters, set in the upper part of the back connection, extending transversely across the boilers, and supported at the ends by the outside walls of each battery. From the heaters, the feed passed into the mud-drum, situated beneath the boilers in the usual way, and connected to them by ample-sized nozzles.

* The above report was prepared by Mr. F. B. Allen, special agent of the N. Y. Department of this Co.

When under steam, the feed-water after its passage through the heaters and mud-drum, entered the boilers at a high temperature. Both an injector and pump were used for the purpose, and the feed supply seemed abundant. Above the boilers there was a steam-drum with ten-inch nozzles connecting each boiler of the battery; on this drum there was one common lever safety-valve. See Figs. 1 and 2.

The boilers were run day and night under a steam pressure of from 50 to 90 lbs.; at night they were under the charge of a head fireman, with instructions to call the engineer who lived conveniently by, if his presence was needed. He was believed to be a very trustworthy man, of whom his employers and associates spoke in the highest terms. There was a steam-gauge, also a water-gauge glass on each battery; the intermediate boilers had one gauge-cock which seemed to have been from one inch below, to three inches above the tubes on different boilers. It did not appear to me the fireman could rely on the gauge-cocks, but would depend on the glass water-gauge; an excellent auxiliary in the hands of a capable engineer, who verifies its indications by trying the cocks. It may be a source of danger to others if too implicity relied upon.

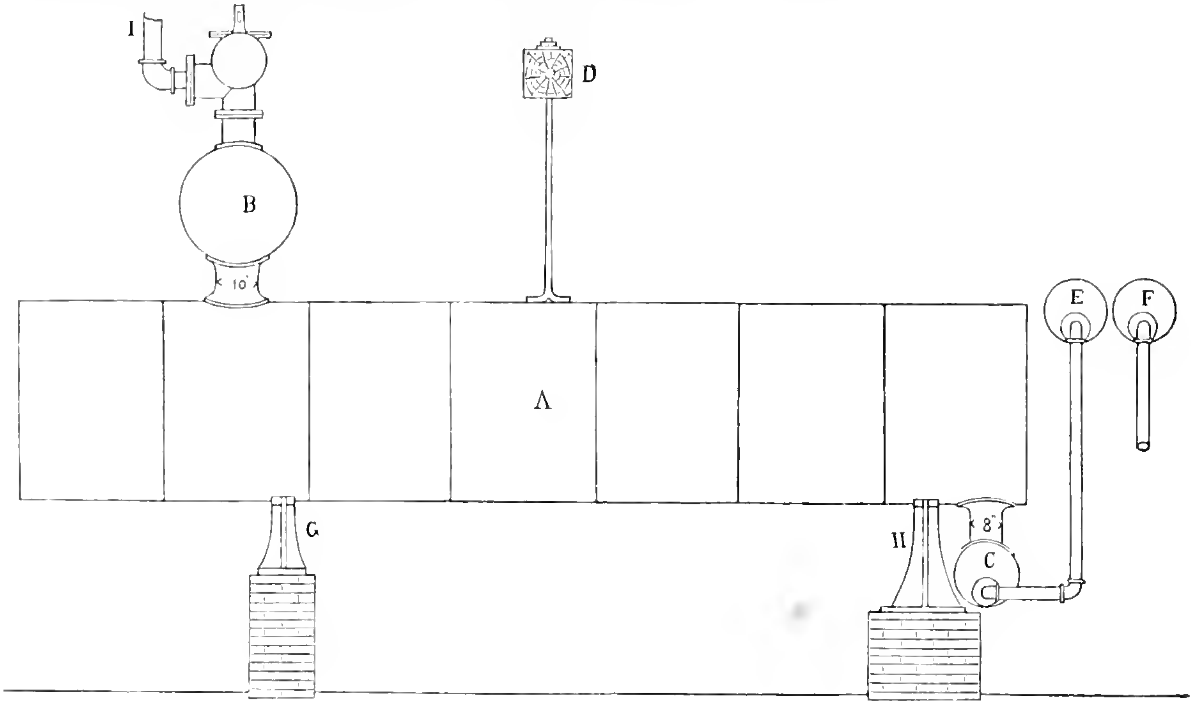


FIG. 2.

A majority of these boilers were originally of the two-flue variety, with 30-inch domes. The flues were cut out and tubes put in some years ago by former owners. Present owners had some additional tubes put in certain boilers, and supposed all were put in thorough repair at that time, some 18 months before the explosion. With perhaps two exceptions, these boilers were 15 or 16 years old, covered by numerous patches, thinned down in spots by corrosion, and badly crystallized as shown by the granular edges of the ruptured plate.

I was informed by the management there was a standing order, that all boilers should be thoroughly cleaned out once a month. Besides that, they were filled up and blown down (part way) under pressure several times every Sunday. The river water used for feeding the boilers was very muddy and formed a troublesome deposit of sediment on the shells and tubes, if these precautions were not observed. The addition of the upper row of tubes considerably lessened the steam room, thereby increasing the danger from foaming, while the neglect to change the gauge-cocks, in all cases to conform to the altered tube level, made their indications deceptive as in Fig. 3 — and the use of such boilers attended with great danger.

With our present knowledge of boiler construction, sheets of $\frac{5}{16}$ inch iron, single riveted for a boiler 50 inches in diameter with the pressure required, and for the service intended, would be considered rather light. The shells, too, were dangerously cut away in putting in the man-hole mouthpieces, the longitudinal openings of which were 18 inches across the grain, instead of girthwise. Among the wrecked fragments of the seven badly shattered boilers, I counted several that ruptured through the line of the weak man-hole opening. After the lapse of so many years, with the usage to which these boilers had been subjected, we may prudently assume that the tensile strength of the iron did not exceed 42,000 lbs., and I believe it would have been considerably less than that, remembering that parts of the shell had been reduced by corrosion, and other

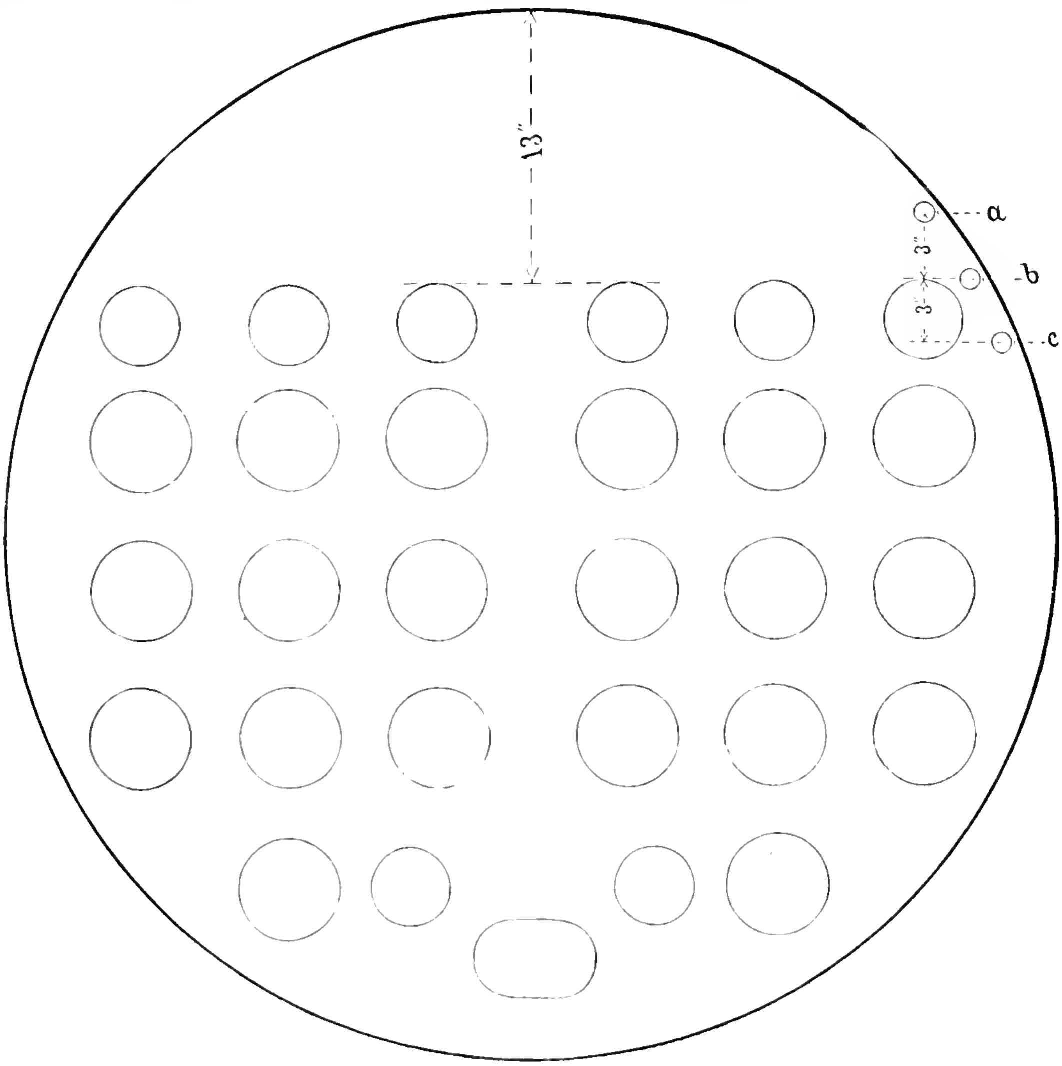


FIG. 3.

causes incidental to their use, so that it callipered but $\frac{1}{4}$ inch. We have approximately $\frac{42000 \times .25}{25} = \frac{420}{6} = 70$ lbs. steam as their safe working pressure, while the actual working pressure as testified by the engineer before the "Coroner's Inquest" was, "They carried from 40 to 80 lbs. steam during the season, and sometimes when the mill shut down it would run up to 90 lbs. before it could be controlled."

With the exception of No. 1 boiler, these boilers were suspended by a $1\frac{1}{8}$ inch hanger bolted to a cross-beam above in the usual way, and also by stands under the shell at the front and back ends. See Fig. 2. It is not known what condition those supports were in, nor whether the load was properly distributed; the enormous weight of the boilers, steam-drum, pipe attachments and fittings, brick covering, mud-drums, etc., with the contained water, must in the aggregate have exceeded 52 tons in the battery of four boilers, Fig. 1, and would, if not properly distributed, have seriously endangered their safety. Many explosions of late years have been attributed to that cause. All the suspended weight on the cross-beam was sustained by the two side walls, the condition of which could not be determined at the time of my visit, after the wreck had been cleared up, and the work of rebuilding commenced.

There were three safety valves for the ten boilers; No. 1 had a separate valve on top of steam dome, with a free escape into fire-room. The battery composed of Nos. 2, 3, 4, and 5, had one 7-inch valve on top of steam-drum; the escape from this valve was through a 3½ *inch pipe to the Salt block.* Figs. 1 and 2.

According to the regulation of the U. S. Steamboat Inspection Service, which bases the safety-valve area upon the heating surface of the boiler, this, though not absolutely correct, is with the data available to an inspector, a very handy method for obtaining approximately the required area. Assuming two-thirds of the shell and three-fourths of the tubes as effective heating surface, gives 972.29 sq. ft. in each boiler, using the rule quoted $\frac{H. S.}{25}$ we have $\frac{972.29}{25} = 38.88$ sq. in. area, or about 7 inches diameter of safety valve. How nearly they complied with this rule will be apparent in the fact as demonstrated, that the battery of four boilers were dependent on a safety-valve, having an outlet of but 9.62 sq. in. It may be doubted, however, if the use of a 7-inch safety-valve would have been advisable in this case, particularly in view of the limited steam space and tendency to foam. Good authorities favor the application of two smaller valves to obtain the requisite area as affording greater security than one valve of large diameter. (Loc., New Series, vol. 1, p. 131, 148.) The other battery of five boilers, Nos. 6, 7, 8, 9, and 10 had a 6 inch safety-valve for all, connected to the steam-drum, same as the battery shown in Fig. 1, but it was better connected, the escape pipe to the salt block being the same size. It was the custom, I was informed, to have two weights on safety-valve lever during the day, one of which *should have been removed at night and the remaining weights shifted in,* so as to blow off at about 40 lbs. The fireman had been detected in moving out the weights during the night, so they might accumulate pressure, while the fires were at their best. The watchman saw 65 lbs. on the steam-gauge an hour before the explosion, which would indicate they were violating orders, when they met their deaths. The fuel used, wood slabs, when dry, makes an intense heat; the habit of the fireman is to fill up the furnaces from grate to boiler bottom, and rest as long as possible between times. The watchman on his last visit to the fire-room, but ten minutes before the explosion, noticed the men at their work; he engaged in conversation with them; everything so far as he could see and judge from their actions was about as usual; they had just put in their last fire, and as he expressed it, "It was a big one."

The immediate cause of explosion, and point of inital rupture, I find myself unable to decide. It may have been due, I think, to any one of several causes which I find existed, and from which these boilers were liable to explode at any moment, or possibly a combination of these several predisposing causes, namely: —

1. Weakness of the boilers. Primarily that of construction, but increased by long service under the unfavorable conditions of high pressure, bad water, and lack of skillful supervision.

2. Insufficient number and arrangement of safety-valves, to permit the free discharge of steam generated in the boilers, which, should the steam outlets be suddenly closed, would permit a dangerous accumulation of pressure until explosion occurred, which pressure, in all probability, would not greatly have exceeded the working pressure.

3. Danger from over-heating and rupture of the exposed shell along fire line, owing to the false position of the gauge-cocks.

4. Danger from foaming, through lack of necessary steam space, consequent upon the addition of the top row of tubes. This danger was further increased by the unavoidable use of muddy feed-water.

5. Possibility that the boilers might have been strained on the girth and horizontal seams, by the shifting of the supports (assuming they were properly placed at first) and unequal distribution of the load, in which case they (boilers) might break in two. This would be most likely to occur when they were pumped up to an unusual height, as they are believed to have been on the morning of the explosion, preparatory to blowing down when the engineer came on duty.

Could I have reached the scene of the disaster immediately after the explosion, or even before the wreck had been cleared up, important corroborative evidence might have been obtained, that would have assisted in solving the problem.

I think the explosion occurred in the battery of four boilers (Fig. 1), for the destruction was the most complete there; absence of water and red-hot boilers was the cause assigned by the "coroner's inquest," but unprejudiced men, if they have experience in such matters, will look long and, if I mistake not, fruitlessly for indications of low water in this explosion. One of the gentlemen who testified at the inquest and attributed low water as the cause, when requested to point to some evidence of it very frankly said his only reason for thinking low water the cause was because he had always heard that given as the cause of explosion, and knew of no other. A casual inspection of the arrangement of heaters and mud-drums will show that when the boilers were fired up, as they were at the time, it would be impossible to feed cold water, for the feed would have to traverse two heaters, each about 20 ft. long, and thence into the mud-drum, before it entered the boilers at a temperature nearly as high as the steam.

That ten boilers should have exploded simultaneously seemed an unfathomable mystery. Really but nine exploded, for No. 10 boiler was only thrown out by the force of the explosion. We do not know that nine boilers exploded simultaneously, for it was testified before the inquest by one of the workmen that two detonations occurred in rapid succession. In that case the second explosion would be due to the concussive jar of the first. The setting of these boilers and size of the steam and water connections *made each battery practically one boiler* with an enormous destructive energy in the event of explosion.

In conclusion, I attribute the violence of this explosion to the liberation at time of rupture of the mechanical energy of a large mass of water at a high pressure, and its instantaneous vaporization at atmospheric pressure.

Inspectors' Reports.

NOVEMBER, 1881.

The absence of returns from some of the larger offices prevents our giving the complete summary for the month of November. The returns as far as received show 1,394 visits of inspection, and 2,823 boilers examined, 1,217 of which were internal inspections, and 348 others were subjected to hydrostatic pressure.

The number of defects found so far as reported foots up 1,479, of which number 352 were regarded as dangerous, as per the following detailed summary:

	Whole number.	Dangerous.
Furnaces out of shape, - - - - -	103	12
Fractures, - - - - - - -	176	101
Burned plates, - - - - -	97	28
Blistered plates, - - -	171	24
Cases of deposit of sediment, - - - -	218	21
Cases of incrustation and scale, - - - -	312	24
Cases of external corrosion, - - - -	97	27
Cases of internal corrosion, - - -	69	17
Cases of internal grooving, - - - -	14	8
Water gauges defective, - - - - -	18	4
Blow-out defective, - - - - - -	15	9
Safety valves overloaded, - - - - -	15	8
Pressure-gauges defective, - - - - -	101	17
Boilers without gauges, - - - - -	38	38
Cases of deficiency of water, - - - - -	3	1
Broken braces and stays, - - - - -	26	13
Necks leaking, - - - - - -	5	
Seams leaking, - - - - - -	1	
	1,479	352

The instructions to boiler attendants issued by the *Manchester Steam Users' Association*, after giving directions what to do in cases of low water, closes with the following sensible words: "The best advice the Manchester Steam Users' Association can give to boiler attendants with regard to shortness of water is,—do not let it occur. Keep a sharp lookout on the water-gauge."

The above is the only sure way that has yet been discovered to guard against low water. There have undoubtedly been many excellent devices invented and put to use, to give warning to the attendant when the water gets dangerously low, but none of them are infallible. The tendency is to rely too much upon them, and under such circumstances, when they *do* become imperative, they are worse than useless; they become a very dangerous thing. This is especially apt to be the case where the water is not of the very best quality, and the apparatus consists of anything of the nature of a whistle, connected to the boiler with small pipe connections. Such apparatus is almost sure to be neglected, so that the pipes become filled with sediment or scale, and then low water is tolerably certain to be the result. We could mention a case now, which occurred within a few miles of here not long ago, where implicit reliance was placed upon a contrivance of this sort, and with the fireman in constant attendance the water got low, and the first indications of it that were noticed were the buckling of the plates of the shell and the tube-sheets, whereby the seams were started, allowing the steam and water to escape. When this occurred the fireman became frightened and incontinently fled, no doubt expecting every instant to have his flight accelerated by the explosion of the boiler. Fortunately this did not occur, as the boiler was well made, of excellent material, and hung together, to use a homely phrase, until the water had all escaped, but of course the boiler was totally ruined.

The common glass gauge is also a very dangerous thing in the hands of a fireman or engineer who neglects to blow it out thoroughly every three or four hours at least. (And it will *not* do to merely open the blow-off cock for a few moments. The proper way to blow out the glass water-gauge is as follows: shut the *upper* or steam valve first, then blow through the *lower* valve until everything is free and the water *comes out clear;* then shut the *lower* valve and blow through the *upper* one in the same manner. If the valves are not closed and blown separately, it is impossible sometimes to tell whether one of them may not be tightly stopped up. After the blowing out is done *be sure* you open *both* valves again.)

We have had many cases in our own experience, where such neglect has produced very serious consequences. This will become very apparent, when we state that the chemical analyses of samples of water sent to us from different localities, show that the amount of insoluble matter contained in the feed water, is in some cases as great as 155 parts, by weight, in 100,000 parts of water, or nearly 91 grains per gallon of water. Suppose, then, that we have a boiler evaporating, as many do, 25,000 pounds of water daily; if none of the sediment is blown off, there will be nearly 39 pounds *daily* deposited in the boiler. With such an amount of sediment in an ordinary sixty-inch boiler, it will require very little argument to convince any one of the absolute necessity of paying the closest attention to all pipe connections upon which in any way depends the quantity of water in the boiler.

There is a vast difference between firemen in the matter of keeping things about the boilers in good order. Some take especial pride in keeping their gauge-cocks always clean both externally and, what is of far more importance, internally. Others don't seem to care whether they are plugged up or not; in fact rather seem to prefer the latter state of things, for then they know that it is of no sort of use to ever try them, and thus they are saved the trouble of doing so.

But they are not *always* to blame. In many cases we are acquainted with, gauge-cocks are so completely worn out with long and faithful service, that they leak upon the slightest provocation; and the mere matter of trying the height of the water involves so much work in trying to stop the leaking of the cocks afterwards, that the fireman hates, and justly too, to go through the operation. In addition to this, gauges which leak, and thus have constantly a current of water flowing through them, are much more liable to get choked up. Leaky gauges should always be attended to at once.

We have thus alluded to the item of deficiency of water at some length, because it is always not only dangerous in the extreme, but a very costly one generally, to the owner of the boiler when it occurs.

BOILER EXPLOSIONS.

DECEMBER, 1881.

OIL WORKS (150). — A boiler in the Yazoo Oil Works exploded Dec. 1st, with terrific force, tearing away the boiler-house and end of the main building. Seven colored men were wounded, four fatally. The boiler was an old one, with five flues, 40 inches in diameter, 30 feet long, and was blown across the street under a house opposite, tearing away the support to the house.

COAL MINE (151). — A boiler exploded at midnight, Dec. 1st, in the Wadsworth Coal Company's mine, near Doylestown, Wayne county, Ohio. John Steinlein was fatally injured, and another man was seriously hurt. The explosion occurred in the mine, and the wounded men crawled half a mile to get to the surface.

SOAP WORKS (152). — The boiler of the Mission Soap and Candle Works, Sixteenth, between Folsom and Harrison streets, San Francisco, Cal., blew up about four o'clock in the morning of Dec. 7th. The night watchman and engineer were the only persons on the premises at the time, and escaped unhurt. The building was demolished. A squatter shanty and Chinese wash-house adjoining were slightly damaged. The building, worth $3,000, is a total loss. Machinery, valued at $50,000, is more or less damaged. The boiler was high pressure, 18 feet long and two feet in diameter. A piece weighing a ton was thrown over a two-story building, landing in a gravel pit a thousand yards distant. Other heavy pieces were blown through the walls of the warehouse, shattering the adjoining buildings, and bricks, timber, grease, and candles were distributed over the neighborhood. That no lives were lost is almost miraculous.

COTTON GIN (153). — A terrible boiler explosion occurred at Jones's gin house, near Elberton, Ga., at one o'clock, Dec. 8th. Clifford, the eight-year-old son of W. B. Jones, had his head blown off; Joseph, a four-year old son of the same man, was badly cut about the head; Harvey Morrison, colored, had both his legs and one arm broken and will die, and another negro was severely hurt.

ROLLING MILL (154). — Dec. 9th, about five o'clock P. M., a boiler burst in the Keystone Rolling Mill, in the fourteenth ward, Pittsburgh, Pa., completely demolishing the boiler-house, scattering the debris in every direction, and killing one man and seriously injuring ten more. At the hour mentioned people living in that portion of the city were startled by a terrific explosion, and hurrying to the mill found on every side evidence of a terrible disaster. As soon as the debris could be cleared away the work of hunting for bodies began. Fortunately, however, this resulted in finding that but one man had been killed. He was the fireman, John Quinn, and was in the boiler-house when the explosion occurred. He was badly scalded, but death resulted from concussion of the brain. Of those injured only one, Albert Gideon, it is thought will die. He is seriously burned, besides having a compound fracture of the right ankle. Upon investigation it was found that one boiler of the battery of five had exploded. The engineer, Charles Bennett, had gone into the engine-room a few minutes before, and thus escaped injury. He says he was carrying 100 pounds of steam, and that the boilers were inspected three months ago, when permission was given to carry 120 pounds. The names of those injured and the nature of their injuries are as follows: John Price, a puddler, injured on the head and side; Andrew Dugolds, a coal-cart driver, struck on the head by a flying piece; George Robinson, bricklayer, cut about the legs; John Thomas and Thomas Thompson, cut about the head and back; John Brislin a heater, scalded; John Jones and Evan Thomas, slightly injured about head and legs.

PLANING MILL (155). — The boiler in Loomis's planing-mill, at Sparta Center, Mich., exploded on Dec. 13th. Cause, low water.

SAW MILL (156). — The boiler in T. J. Sheridan's mill, at Solon Center, Mich., exploded at noon, Dec. 15th, killing the engineer and completely demolishing the mill. The loss is estimated at $7,000.

MINE (157). — A boiler at the Diamond mines of Charles Parish & Co., Wilkesbarre, Pa., exploded Dec. 20th, and demolished the engine and boiler houses. Loss, $6,000.

FLOURING MILL (158). — The boiler of Taylor's Manhattan Mills, located at North Toledo, Ohio, exploded at 2.30 o'clock, Dec. 21st, demolishing the engine-house, damaging the mill badly, and instantly killing the engineer, Louis J. Monnat. The latter was standing at the throttle at the time, and his body was blown into fragments and scattered over the yard. He was about twenty-three years of age, and married. The damage to the building and machinery is estimated at $8,000, on which there was a casualty insurance of $3,000.

POTTERY (159). — The boiler in Risley's pottery, Norwich, Conn., exploded Dec. 24th. George L. Risley, proprietor, was terribly scalded and has since died.

— MILL (160). — Watson's mill, at Gurdon, Ark., was blown up Dec. 26th. The casualties were: Charles Keel killed and Cool French fatally wounded. Allan Creile, R. J. Sappington, and L. McFarland were seriously injured. The mill is a total loss.

CLOTH MILL (161). One of the boilers in the shade cloth factory, owned by Irwin &

Slean, Oswego, N. Y., exploded Dec. 27th. The middle of the building was demolished. Captain William Dorman, fireman and night watchman, is missing. Loss $15,000.

SAW-MILL (162).—The boiler in the saw-mill near Winamac, Ind., exploded Dec. 31st, killing John Helm, fatally injuring Daniel Drit, and severely injuring a third man.

ACCIDENTS OTHER THAN BOILER EXPLOSIONS.

The steamer *Paris C. Brown* bound from New Orleans to Cincinnati, burst her steam-pipe, Dec. 26th, near Catfish Bend, scalding 12 of the crew, three seriously. Three negro roustabouts jumped overboard and have not been seen since.

During the temporary absence of the engineer, Dec. 12th, the piston-rod of the Harris-Corliss engine at the rubber works, Woonsocket, R. I., broke at the cross-head, causing the cylinder-head to blow out with great force, and doing considerable injury to machinery. The damage is estimated at $1,200.

Classified List of Boiler Explosions for the Year 1881.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total per class.
Sawing, planing, and wood-working mills,	2	0	7	3	4	2	2	3	3	4	5	3	38
Portables, hoisters, threshers, pile-drivers, and cotton-gins,	3	1	1	1	0	2	1	3	3	2	0	1	18
Iron works, rolling-mills, furnaces, foundries, machine & boil'r sh'ps,	4	4	2	1	1	2	0	1	1	1	1	1	16
Steamboats, st'm tugs, yachts, st'm barges, dredges, and dry-docks,	3	3	1	0	0	4	0	1	1	0	1	0	14
Locomotives,	0	0	0	2	2	0	2	0	4	2	0	0	12
Paper, flouring, pulp and grist mills, and elevators,	3	1	0	0	0	2	0	1	0	0	0	1	8
Distilleries, breweries, malt and sugar houses, soap and chem w'ks,	1	2	0	0	0	1	1	0	0	0	2	1	8
Bleaching, dyeing, digesting and print works, slaughtering, etc.,	1	0	0	1	0	2	1	0	0	3	0	0	8
Steam heating, drying, dwellings, schools, stores, pub. b'ldings, etc.,	2	3	1	0	0	0	0	0	0	1	0	0	7
Mines, oil wells, and refineries,	1	0	0	0	0	0	0	0	1	0	0	3	5
Cotton and woolen mills, and textile works,	0	1	0	0	0	0	0	2	0	0	0	1	4
Tannery,	0	0	0	0	0	0	0	0	0	0	1	0	1
Miscellaneous works and mills not designated,	2	1	3	0	1	0	1	0	1	3	3	2	20
Total per month,	22	16	15	8	8	15	8	11	14	16	13	13	

SUMMARY OF BOILER EXPLOSIONS AND PERSONS KILLED AND INJURED IN THE YEAR 1881.

	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Explosions,	22	16	15	8	8	15	8	11	14	16	13	13	159
Number of persons killed,	38	18	28	6	11	41	16	19	25	15	18	16	251
Number of persons injured,	35	31	51	11	23	38	19	14	19	32	20	20	313

Explosions Nos. 5, 11, and 41, in the monthly lists, were repeated through our informant's mistakes in locating them in different places. Consequently the total number of explosions is 159, as above, instead of 162, as shown by the monthly enumeration.

WE understand that there is considerable doubt in the minds of many that the cuts of defective rivets shown in our last issue represent "real rivets." We will only say in reply that the cuts in question were made, as accurately as possible, from full-sized photographs of rivets which will be cheerfully shown to any "doubting Thomas" who will take the trouble to call at this office.

The Locomotive.

HARTFORD, JANUARY, 1882.

With this issue commences the third volume of the New Series of THE LOCOMOTIVE. The favorable reception it has met with from engineers and its mechanical readers generally, leads us to believe it to be of some value as a means of disseminating information gained by the company's experience concerning boiler explosions and the safe and economical use of steam, and justifies us in endeavoring to make it as valuable in the future as it has been in the past.

In another column will be found a classified list, as well also as a summary of all the steam boiler explosions occurring in the United States which have come under our notice during the past twelve months. While some of the minor and more unimportant ones may have been overlooked, or have not been reported to us, we are confident that we have secured records of nearly all that have occurred.

A study of the classification of the exploded boilers may possibly be of some interest to our readers. By reference to this list it will be seen that the usual high percentage of explosions occurred in saw-mills and other wood-working establishments—nearly one-fourth of the whole number being in this class. Doubtless the greater number of those reported simply as "mills" would prove, on further inquiry, to be in saw-mills or some allied industry. The question naturally arises: What causes so many destructive explosions in saw-mills and wood-working establishments? While we cannot wholly agree with the opinion expressed by some scientific journals that the greater number of them are caused by the use of light fuels, such as shavings, saw-dust, etc., we will admit that the frequent opening of the fire-doors, which is rendered necessary by the use of such fuels, tends to deteriorate the boiler and shorten its life. It would probably be found, if all the facts could always be obtained, that the frequent explosions among this class of boilers are mainly due to the carelessness and ignorance of those in charge of them. It may fairly be assumed that very few of them are ever inspected by any one who is competent to discover faults and correct abuses in their management. They are neglected, safety-valves are allowed to corrode and stick fast, and they are nearly always run at higher pressures than would be considered safe by careful engineers. The violence which is characteristic of this class of explosions is good evidence that high pressures generally have something to do with them.

The next in order of frequency are portable engines, mainly those used for agricultural purposes; which class of boilers are generally under the same unfavorable conditions of use and management as the majority of saw-mill boilers, and the proportion of those blown up to those in use is probably fully as high as that which obtains in the former case.

The other classes of boilers show about the average number of explosions. One thing we would particularly call attention to is the very small comparative number of explosions which occur in textile manufactories. Among the thousands of them in use in this country, we have but four explosions to chronicle for the past year. This, we think, is strong corroborative evidence of the correctness of the opinion advanced by this company, that good care and management, combined with unceasing vigilance, will prevent most of these destructive accidents. This class of boilers, although probably no better constructed than other kinds, rarely explode. The only reason that can be assigned for this is, that they are in most cases under the direct supervision of a more competent and trustworthy set of engineers and firemen than any other class, and the beneficial results are at once apparent in their comparative immunity from explosion.

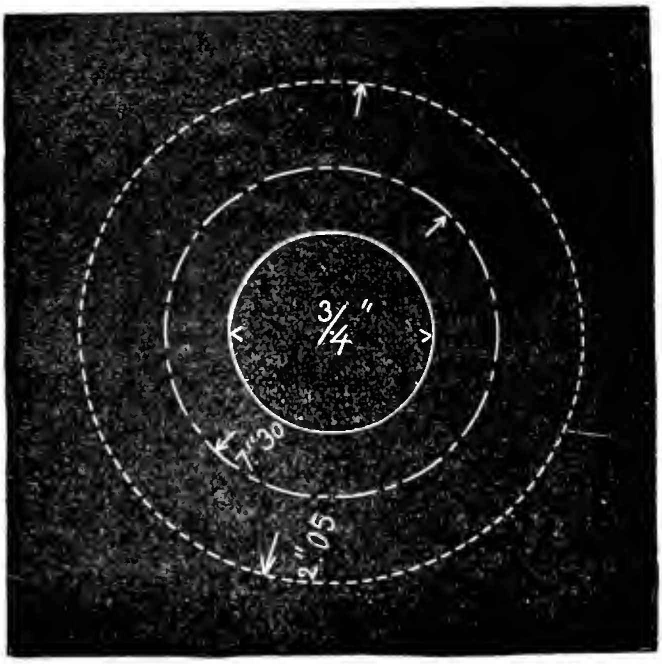
Drifting — Its Effect upon Boiler Plate.

COMPARATIVE RESULTS WITH STEEL AND IRON PLATES.

By James E. Howard.

[Written for the Boston Journal of Commerce.]

The peculiar value of a material for boiler construction depends upon its fitness to resist those strains which are likely to come upon it when it is in the boiler. A metal possessed of high tensile strength, or in other words, which has the greater strength for a direct pull, is not always the best for a boiler. Indeed, it may be quite the contrary, a very unreliable and unsafe material for this purpose. There is no positive injury in having a high tensile strength *per se*, but this quality is not generally accompanied by those others which the necessities of the case demand. When a suitable material has been selected, it should not be subjected to any treatment known to be injurious. It is, however, a strong argument in favor of that metal which permits certain maltreatment, most commonly to be guarded against, with the least comparative injury, a metal having good



qualities in reserve that are not supposed to be called out, but which, nevertheless, may be. Drifting has been very properly condemned, yet, after all that has been said upon the subject, it is doubtful whether the practice will soon be abolished altogether. This fact should be borne in mind when selecting boiler plate.

The results here presented are from some recent English experiments, made by Thomas W. Traill, engineer surveyor-in chief; also, from some experiments by the commissioners of admiralty. In addition to showing the comparative behavior of steel and iron plate, we may observe these tests furnish a very satisfactory indication of the ductility of the metal, and in the absence of a testing machine a few simple tests like these will prove of great value.

The first series of tests were carried out at the works of the Steel Company of Scotland, where the steel plates were manufactured. The wrought-iron plates were of good quality, the manufacturer's name not being mentioned. Square plates were used, having a drilled or punched hole in the middle of each. The drifts employed had a taper of about .05 in. in one inch, they were turned in a lathe, each was driven from one side of the plate a short distance, and then from the other side, enlarging the diameter of the hole about .08 in. before reversing. The drifting was continued till there was complete fracture of the plates.

For our purpose we will compare the results when fractures first appeared, as it seems quite probable that had the plates been under a tensile strain acting on the drift pin, after the manner it acts upon the rivets in a joint, instead of simply resisting the enlargement of the hole, the maximum resistance would have been reached about the time fractures first appeared. From this time onward, the resistance of the plates would gradually diminish till the fractures were fully developed.

TABULATION OF COLD DRIFTING TESTS MADE AT THE WORKS OF THE STEEL COMPANY OF SCOTLAND.

No. of Experiment.	Kind of Plate.	Size of Plate—ins.	Thickness of Plate—inches.	Hole—inches.	Diam. of hole when fracture first appeared—inches.	Diam. of hole elongated—per cent	DESCRIPTION OF FRACTURE.
148	Steel	6½ x 6½	½	¾ drilled	2.05	173	Plate tore at hole.
149	Steel	6½ x 6½	½	¾ drilled	2.05	173	Plate cracked at outside edge.
150	Steel	6½ x 6½	½	¾ punched	2.01	168	Plate cracked at outside edge.
151	Steel	6½ x 6½	½	¾ punched	1.87	150	Plate cracked at outside edge.
152	Steel	6½ x 6½	½	¾ punched, then drilled to 1 in. dia.	1.65	65	Plate cracked at two outside edges.
153	Steel	6½ x 6½	½	¾ punched, then drilled to 1 in.	2.70	170	Plate cracked at outside edge and at hole.
153*a*	Steel	10 x 10	½	¾ drilled	2.80	273	Plate cracked at outside edge.
153*b*	Steel	10 x 9¾	½	⅜ punched	2.50	233	Plate cracked at hole and edge.
154	Iron	6½ x 6½	½	¾ drilled	1.30	73	Fracture began at outer edge.
155	Iron	6½ x 6½	½	¾ punched	1.36	81	Fracture began at outer edge.
156	Iron	6½ x 6½	½	¾ punched, then drilled to 1 in.	1.39	39	Plate cracked suddenly from edge to hole.
157	Iron	6½ x 6½	⅝	¾ drilled	1.13	51	Fracture began at outside edge.
158	Iron	6½ x 6½	⅝	¾ punched	1.20	60	Fractured at hole and at edge.
159	Iron	6½ x 6½	⅝	¾ punched, then drilled to 1 in.	1.36	36	Fractured at hole and at edge.

An examination of the above table shows very little difference in the behavior of the plates, whether the holes were drilled or punched.

In the steel plates the elongation of the drilled holes was 173 per cent., while for the punched holes the elongation averaged 159 per cent. We should not be misled by this, however, to assume that, practically, it doesn't matter whether the holes are drilled or punched. A great many tests have demonstrated the superiority of joints made with drilled holes. Fractures occurred with both punched plates at the outside edges of the plates, in the same manner as one of the drilled specimens failed, which would appear to indicate that the size of the plates was not sufficient to develop the difference between drilling and punching. The same remarks would also apply to the iron plates, although there is a slight apparent advantage in favor of the punched holes.

The plates with inch holes failed when about the same enlarged diameters had been reached as with ¾-in. holes, the percentage of elongation being less correspondingly, again showing the plates failed at the outside edges first, or else simultaneous with fracture at the holes. As between the steel and the iron, a most surprising difference is found to exist. The iron plate elongated only 73 per cent. where the steel elongated 173 per cent., or, comparing the areas of the enlarged holes, there was a displacement of .88 square inch of metal in the one case, and 2.86 square inches of metal in the other, more than three times the displacement of steel than of iron. The preceding sketch shows the relative sizes of the enlarged holes in iron and steel plates.

The inside full circle represents the original hole, the first dotted circle the enlarged hole in iron plate, the second dotted circle the enlarged hole in steel plate, each measured when fracture began. The superiority of the steel is here well illustrated. We should have confidence that if the drift-pin was used upon this metal its effects would be far less serious than upon iron plate. A distinguished steel-maker of this country remarks: "It is a fact that good steel will endure more pounding than any iron."

The preceding experiments were made upon boiler-plate metal, those following refer to some cold drifting tests made upon steel of higher temper.

EXPERIMENTS UPON COLD-DRIFTING IN STEEL PLATE.

Number of the Experiment.	Kind of Plate.	Size of plates—inches.	Thickness—inches.	Hole—Inches.	Diam. of hole where fracture began—ins.	Diam. of hole elongated—per cent.	Description of the fracture.	Tensile strength of the Metal—lbs. per sq. in.	Elongation in 4 inches—per ct.	Contraction of area—per ct.
201	Crucible steel...	3¼x3¼	7-16	⅝ drilled	1.41	126	Began at hole	76,750	13.6	17.5
202	Bessemer steel	3¼x3¼	5-16	⅝ drilled	1.39	106	Began at hole	82,[illegible]60	13.4	19.2
203	Bessemer steel	3¼x3¼	5-16	⅝ drilled	1.39	106	Began at hole	77,870	20.3	38.3
204	Sub carburized steel...	3¼x3¼	7-16	⅝ drilled	1.73	177	Began at hole	65,230	19.5	35.5
205	Whitworth's liquid compressed steel—soft...	3¼x3¼	7-16	⅝ drilled	1.734	177	Began at hole	58,970	31.7	53.2
206	Whitworth's liquid compressed steel—hard......	3¼x3¼	7-16	⅝ drilled	1.39	106	Began at hole	72,880	23.1	43.1
207	Atwood's patent steel—soft	3¼x3¼	7-16	⅝ drilled	2.20	252	Began at hole	53,680	30.5	66.9
208	Atwood's pat. steel hard	3¼x3¼	⅜	⅝ drilled	1.346	115	Began at hole	75,200	21.5	27.

We see from the above experiments that steel having the most ductility, as displayed in the tensile tests by elongation after fracture and contraction of area, is less injured by drifting than the higher grades of steel, the most ductile metal having a tensile strength not far from good wrought iron.

It would have been desirable in connection with these experiments to have ascertained the effect of drifting upon the tensile strength of the plates. That was not done, but reserved for subsequent investigation.

WE learn with pleasure that the Senate Committee on Claims has favorably reported the bill making an appropriation to satisfy the claim of Mr. A. H. Emery of this city, for the design and construction of the great testing machine now at the Watertown Arsenal. An appropriation was made to cover the estimated cost, but the real cost, with attendant expenses to the builder, was much greater than the amount appropriated. Mr. Emery has received $31,500, and has a claim for $129,000 for disbursements and expenses. It is the duty of the Government to recognize and pay for professional work duly ordered, especially when it is honestly and intelligently performed, and the results are entirely satisfactory, as Mr. Emery's testing machine certainly is. The bill reported by the committee appropriates $225,000 as compensation to Mr. Emery for his work. It will be worth this to the country many times over, if the work of testing materials is committed to such a commission as that which began its work by giving Mr. Emery an order for this great machine. As used at present, it is not likely to be of any great value to anybody.—*Iron Age.*

THE Philadelphia *Press* says: "It is alleged by prominent lawyers of this city that, for the last fifteen years, not a single jury has been drawn in which all of the twelve were honest men. Justice has been thwarted over and over again." * * *

We can readily believe the above to be true.

Boiler Explosion under very Remarkable Circumstances.

The mere announcement of a boiler explosion has, perhaps, ceased to create any interest from the frequency of their occurrence; but the explosion of a boiler which took place on Saturday last, in the mill of Schumacher & Co., of Akron, Ohio, was of so unusual a character as to merit more than a passing notice. It was in fact a boiler explosion at a time when there was no steam pressure on, no water in, and no fire under it. The boiler, which is the return flue style, was built at Pittsburgh, and has a shell of about 72 inches diameter. The plates immediately over the furnace, either from excessive pressure of steam alone, or aided by the deposit of scale on their interior surface, which prevented the water from coming in contact with the iron, became considerably bulged outwards, and it was while the workmen were engaged in cutting out these defective plates that the accident occurred. They had chipped an opening of several inches at the forward end of one of the sheets, when suddenly the after end tore apart with a tremendous noise, in fact, so loud was the report that the men engaged in the mill rushed to the door, exclaiming, "There goes another powder-mill" (one having exploded only a few days before in that vicinity), and it was several minutes before it was discovered that the rupture of the boiler had caused it. One of the men, who was in the act of chipping, and had his hand hold of the chisel which was wedged in the boiler, was so completely paralyzed on one side as to be unable to move, and he was conveyed home very ill. The rupture took place in one of the transverse seams of the boiler, tearing the solid iron between the rivets about one-sixteenth of an inch apart and over one foot in length. Philosophers and experts in engineering, who have been puzzling themselves and the public by their various theories of low water and no water, high pressure, super-heated steam, electricity, galvanic action, unknown and combustible gases, etc., may here find a field for further speculation as to the cause of a boiler explosion in which there was neither steam, fire, nor water.

The above account of an accident which happened in 1866 was lately forwarded to us by Chief Inspector A. C. Getchell, of the Cleveland, Ohio, office. At first we thought it somewhat resembled the story about the old lady's gun "without lock, stock, or barrel," which "went off" and killed some one who was fooling with it and "didn't know it was loaded," but the letter sent by Inspector Getchell explained the matter, and showed that it was produced by natural causes, the same as all boiler explosions are. It seems that the boiler had several sheets badly corrugated or buckled on the bottom, which brought a severe compressive strain on the flues, and consequently an equal tensile strain on the shell. The workmen were engaged in cutting out the damaged sheets, and when they had cut around about a foot, the great tensile strain on the shell, concentrated at the edges of the cut, tore the shell apart.

The occurrence affords a good illustration of the fact that the strain caused by steam pressure is not always the greatest that a steam boiler is sometimes subjected to.

It does not appear to be generally known that the value of the mechanical equivalent of heat has within a few years been corrected. It is generally referred to by mechanical writers as 772 foot pounds. Dr. Joule repeated his famous experiments in 1876, nearly six years ago, with extraordinary precautions, and the mean result of sixty experiments gave 774.1 foot pounds, with a possible error of $\frac{1}{400}$, on account of the "thermometric scale error." This value should be used in all calculations relating to the value of heat as a motive power.

Proportions for Chimneys.

The following table, which is taken from Robt. Wilson's *Boiler and Factory Chimneys*, may be of service to engineers who are in doubt in regard to the efficiency of their chimneys. It is calculated on thoroughly sound principles, and may, we think, be relied upon.

Height of Chimney in feet.	Pounds of coal burned per hour per square foot of area at top of chimney.	Height in inches of column of water balanced by the draught pressure.	Horse power of each square foot of chimney assuming 7 lbs. of coal per horse power.	Area of top of chimney in feet per horse power for 1 or 2 boilers.	Area of top of chimney in feet per horse power for several boilers.	Area of flue in feet per horse power.
30	78.24	.218	7.3	.146	.091	.182
40	90.35	.296	8.4	.126	.077	.155
50	101.01	.364	9.4	.113	.070	.140
60	110.65	.437	10.3	.103	.064	.129
70	119.52	.5	11.2	.095	.059	.119
80	127.77	.58	11.9	.089	.055	.111
90	135.52	.656	12.6	.084	.052	.105
100	142.85	.729	13.3	.08	.05	.100
125	159.71	.911	14.9	.071	.044	.089
150	174.96	1.09	16.3	.965	.04	.082
175	188.98	1.26	17.6	.060	.038	.075
200	202.03	1.45	18.8	.056	.035	.07
225	214.28	1.64	20.	.053	.033	.066
250	225.87	1.82	21.	.05	.031	.063
275	236.90	1.99	22.	.048	.03	.06
300	247.43	2.18	23.	.046	.028	.057

Column 2 shows the amount of coal burned per hour per square foot of flue-area at top of chimney, and is calculated by the following formula, $W = \frac{A\sqrt{H}}{.07}$, in which W = weight of coal burned per hour as above; A = area of chimney in square feet; H = height of chimney in feet; and .07 = a constant.

Column 3 shows the height in inches of a column of water balanced by the draught pressure. Apparatus which is necessary to perform this experiment is very simple and will be described in some future number.

Column 4 is calculated by the formula $H. P. = \frac{A\sqrt{H}}{.75}$;

Column 5 is calculated by the formula $A = \frac{.8}{\sqrt{H}}$;

Column 6 is calculated by the formula $A = \frac{.5}{\sqrt{H}}$; and

Column 7 is calculated by the formula $A = \frac{1}{\sqrt{H}}$; in all of which A denotes the area of flue in square feet, and H denotes the height of the chimney in feet. By means of the above formulæ the proportions of chimneys for ordinary cases may be very easily determined.

We would call attention to the article on the effect of drifting upon boiler-plates in this issue. More extended experiments upon this same subject are now being made under the auspices of this company, the results of which, when completed, will be fully detailed in The Locomotive.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. III. HARTFORD, CONN., FEBRUARY, 1882. No. 2.

Explosion at Norwich, Conn.

On Saturday morning Dec. 24, 1881, a small boiler located in the pottery establishment of Mr. Geo. L. Risley, at Norwich, Conn., exploded, demolishing the boiler house, destroying a considerable amount of manufactured goods, and injuring Mr. Risley, who was in the boiler room at the time, so severely that he died a few hours afterward.

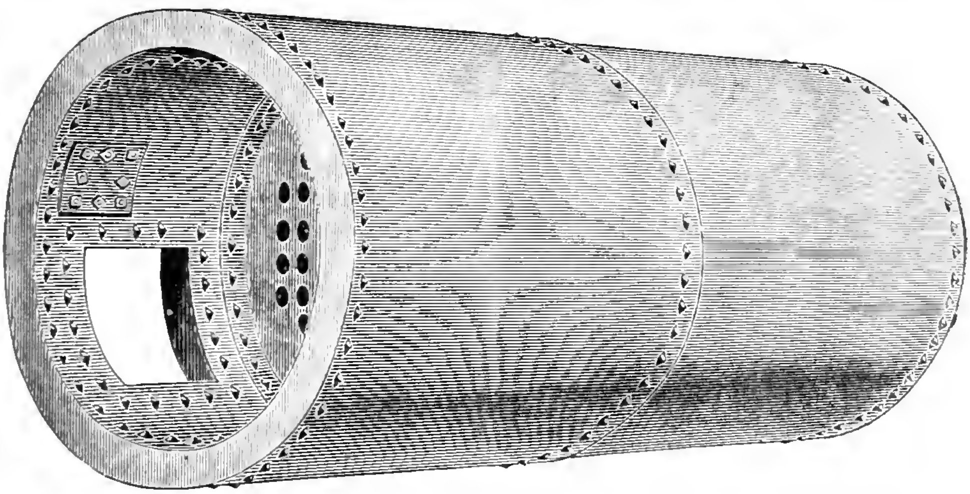


FIG. 1.

The exploded boiler was of the upright tubular type, seven feet long, three feet in diameter, shell about five-sixteenths of an inch thick, single riveted. It had sixty tubes two inches in diameter and five feet long, internal furnace about 30 by 24 inches, and was provided with an ordinary lever safety valve, properly connected and in good order. The boiler was about 15 years old. From the position in which it lay when seen by the writer, the stamp on the plates could not be seen, but the shell-plates had the appearance of being of good quality, and were sound externally. The appearance of the boiler indicated that there was plenty of water at the time of the explosion, there being no evidence of overheating, and this view was borne out by the testimony of one of the employes, as well as by the character of the explosion.

What, then, caused the disaster?

The boiler had evidently been neglected, or rather the precautions necessary to protect this type of boiler from injury from corrosion were not understood, the location of the boiler being low and damp, and from its appearance not in constant use. Under these conditions special care would be required to protect it from corrosion. The furnace plates were badly corroded, a soft or bolted patch had been put on near the fire-door, the plates at this point having evidently been eaten through. The upper tube-sheet and ends of the tubes had suffered severely from the effects of corrosion, four of the tubes having given out, and the holes plugged. The lower tube-sheet, or crown-sheet, and tubes at the fire-box end of the boiler had suffered most severely, the tube-sheet being reduced to about one-half of its original thickness, and the tubes at this end being also badly corroded, so that their holding power was reduced to such an extent that they were unable to sustain the required working pressure which was ordinarily about 60 pounds per square inch. The pressure at the time of the explosion probably did not much exceed this amount. When the head and tubes parted, the lower head bulged downward, and the contained water and steam rushed out through the holes in the tube-sheet, and the reaction lifted the boiler like a sky-rocket, shooting it out through and demolishing, the roof of the boiler-house, and throwing it to a height of 75 or 80 feet at least. It passed completely over a large tree standing near, and came down about a hundred feet from its original position, falling partly upon its side and burying itself about one-third of its diameter into the ground. The force of the explosion shattered the cast iron base upon which the boiler stood into fragments, and scat-

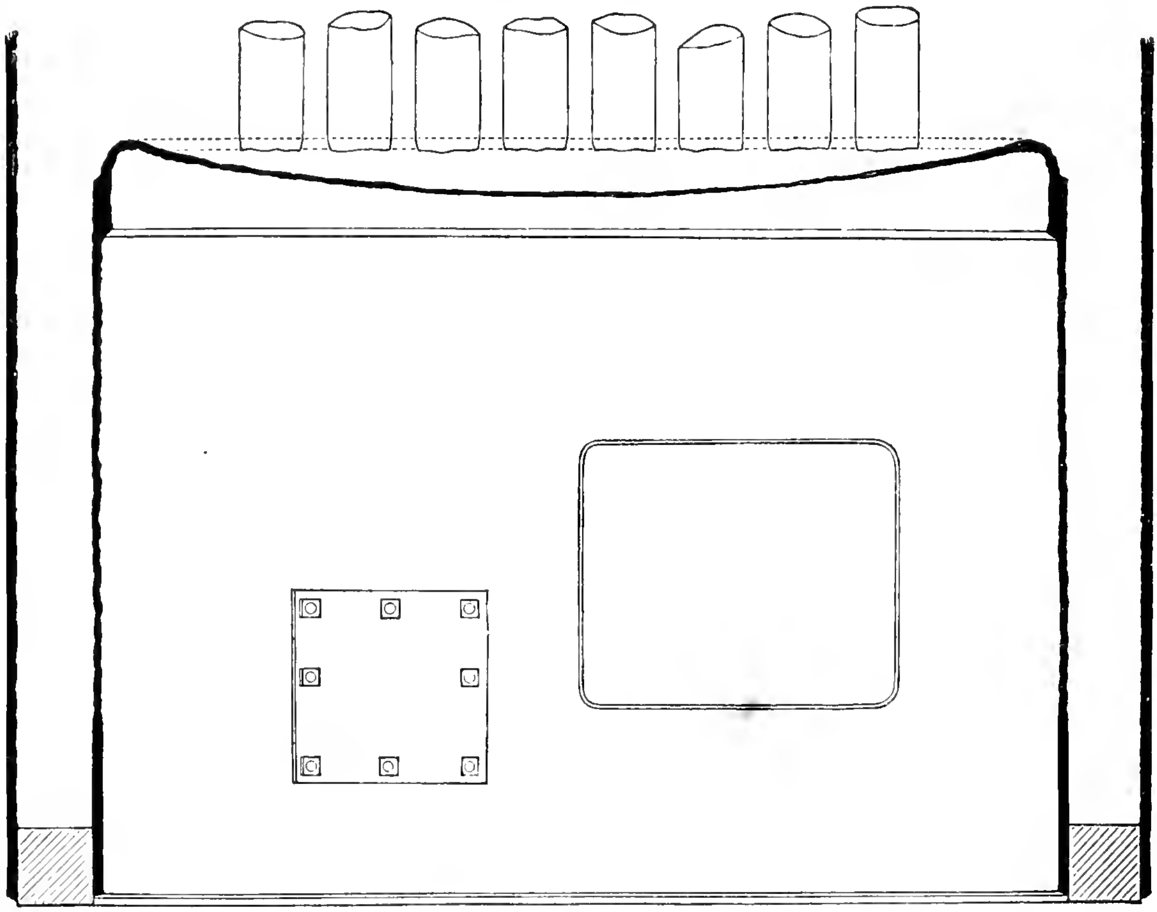


FIG. 2.

tered them in every direction, and blew the unfortunate Mr. Risley who had just entered the room, violently against the wall, where he was found in a half insensible condition, severely scalded, and covered with debris.

Boilers of this class cannot be too carefully looked after, more especially when they are not in constant use and are located in damp places. The furnace plates in particular should receive the closest attention, and should be kept clean and often scraped and painted. Moreover, the shells should always be provided with at least four hand holes placed slightly above the crown-sheet, so they may be removed and the interior of the boiler examined from time to time, and kept free from sediment or anything which would be likely to injure the plates. When no means are provided by which an internal examination of a boiler can be made, defects are very apt to arise which the application of hydrostatic pressure will not reveal, but which are likely to cause the most disastrous explosions.

Inspectors' Reports.

NOVEMBER, AND DECEMBER, 1881.

Below will be found the complete summary of the work of the Inspectors for the month of Nov., 1881, which we were unable to obtain before our last issue went to press, and following it the summary for the month of Dec., and the total for the year 1881.

During the month of Nov., there were made 1,944 visits of inspection, by which 3,924 boilers were examined. Of this number, 1,372 were thoroughly inspected, both externally and internally, and 351 were subjected to hydrostatic pressure. 36 boilers were condemned, being thoroughly worn out and beyond repair.

The number of defects of a serious nature discovered was 1,899, of which number 502 were considered dangerous.

The following table exhibits the defects in detail:—

Nature of defects.	Whole number.	Dangerous.
Furnaces out of shape,	129	26
Fractures,	219	125
Burned plates,	125	40
Blistered plates,	261	34
Cases of deposit of sediment,	266	44
Cases of incrustation and scale,	361	34
Cases of external corrosion,	129	42
Cases of internal corrosion,	82	26
Cases of internal grooving,	19	13
Water-gauges defective,	28	6
Blow-out defective,	19	11
Safety-valves overloaded,	36	19
Pressure gauges defective,	134	23
Boilers without gauges,	38	38
Cases of deficiency of water,	6	2
Broken braces and stays,	46	19
Seams leaking,	1	
Total,	1,899	502

SUMMARY FOR DECEMBER.

During the month of December there were made 1,929 visits of inspection. The number of boilers examined was 3,979, of which number 1,711 were annual internal inspections.

The hydrostatic test was applied in 345 cases. 44 boilers were condemned.

The number of defects found foots up 2,226, 635 of which were considered of so serious a nature as to impair the safety of the boiler.

The defects in detail are as follows:—

Nature of defects.	Whole number.	Dangerous.
Furnaces out of shape,	89	35
Fractures,	267	138
Burned plates,	119	39
Blistered plates,	353	63
Cases of deposit of sediment,	306	65
Cases of incrustation and scale,	486	55
Cases of external corrosion,	160	45
Cases of internal corrosion,	94	35

Cases of internal grooving,	32	21
Water-gauges defective,	43	15
Blow-out defective,	32	20
Safety-valves overloaded,	27	21
Pressure gauges defective,	129	28
Boilers without gauges,	10	3
Cases of deficiency of water,	24	20
Broken braces and stays,	53	32
Seams leaking,	2	
Total,	2,226	635

SUMMARY OF THE INSPECTORS' REPORT FOR THE YEAR 1881.

During the year 1881 there were made 22,412 visits of inspection, being an increase of 1,473 over the number made in 1880; the number of boilers inspected was 47,245, an increase of 2,079 over the number inspected the previous year, while the number of complete internal inspections foots up 17,590, an increase of 1,580 over the number made in 1880. The hydrostatic test was applied in 4,286 cases, the majority of which were new boilers. This is an increase of 796 over the business of the preceding year.

The total number of defects found which were considered serious enough to be reported was 21,110, of which number 5,801 were of a dangerous nature. This does not include many defects of a less serious character.

The following table shows the defects in detail:—

Nature of defects.	Whole number.	Dangerous.
Furnaces out of shape,	1,164	301
Fractures,	2,417	1,414
Burned plates,	1,180	426
Blistered plates,	3,260	468
Cases of deposit of sediment,	2,752	532
Cases of incrustation and scale,	4,082	494
Cases of external corrosion,	1,346	450
Cases of internal corrosion,	899	266
Cases of internal grooving,	225	128
Water-gauges defective,	401	157
Blow-out defective,	255	132
Safety-valves overloaded,	296	169
Pressure gauges defective,	1,647	375
Boilers without gauges,	552	51
Cases of deficiency of water,	128	101
Braces and stays broken,	478	313
Seams leaking,	8	3
Defective heads,	13	13
Loose tubes,	4	
Mud-drums defective,	3	3
Dangerous defects unclassified,	-	5
Total defects,	21,110	5,801

Boilers condemned,	363
Heads condemned,	13
Mud-drums condemned,	3

The grand total of the work of the inspectors since the organization of the company is as follows:—

Visits of inspection made,	186,109
Boilers inspected,	378,463
Internal inspections,	125,750
Boilers tested by hydrostatic pressure,	29,139
Total number of defects discovered,	184,175
Total number of dangerous defects,	42,428
Boilers condemned,	2,200

We would call attention to the above record of defects discovered, and then most respectfully ask: Is not the periodical inspection of steam boilers of some slight value? There can be but one answer to the above question, and that must be in the affirmative. It is impossible that a system of inspection which brings to light a total of nearly *six thousand* dangerous defects in one year, can fail of accomplishing an incalculable service to the steam users of this country.

Of the 17,590 different boilers which were internally examined by the inspectors of this company during the past year, we find that 1,164 had *defective furnaces;* this is one in every fifteen on an average. This may not seem to be a very serious thing at first sight, but when we stop to think what it means, the whole aspect of the question changes.

Furnaces may be defective in various ways. In internally fired boilers they may be too small and cramped, and as a rule, this is nearly always the case. This is probably one of the most important defects to which this class of boilers is subject; but it is a structural defect of such a character that it is not included in the above list of defects. The defects there classified refer more particularly to the matter of blisters, bulged plates, burned plates, fractured plates, and grooved or broken flanges. *Blisters* are one of the most common defects met with, and one of the most difficult to guard against in the selection of boiler plates.

A very careful inspection of the plates will sometimes discover imperfect welding between the different laminæ of a plate, which would almost certainly develop into a blister under the influence of the intense heat to which it is subjected in the furnace of a steam boiler. The most common way to search for such defective places, is to tap the sheet lightly all over with a small hammer. This must be done on both sides of the plate, for sometimes the defect lies so near the surface that an examination of one side of the plate will fail to reveal it. Sometimes when there is doubt in regard to the quality of a plate and the preceding test fails to resolve it satisfactorily, the plate may be suspended by the corners by means of cords, and the upper side evenly sprinkled with sand, and then the under side being tapped lightly with the hammer, the movement of the sand will reveal the presence and locality of the defect.

In many cases however, in spite of all precautions, defective sheets will be put into boiler shells, and when they are exposed to the action of the furnace heat, blisters are sure to result. In many cases blisters never become serious; after attaining a certain size they cease to enlarge, and remain so for years. In other cases, however, they continue to enlarge rapidly, and unless their progress is arrested, serious trouble may result. When a blister appears on a boiler-plate it should be carefully examined at once, by some one who is competent to judge of its probable thickness, and form an opinion as to whether it may be likely to lead to serious consequences or not. If it is of a serious nature, it should be at once smoothly trimmed off with a chisel. This will generally, but not always, prevent further spreading and mischief. Sometimes they will continue to spread after they are trimmed, and penetrate the plate so deeply that they have to be cut out, and a patch put on the plate in their place. Cases have been known where even after these extreme measures have been resorted to, the blistering has continued beyond the edge of the patch to such an extent as to necessitate the removal of the entire sheet. Blisters are liable to occur on any part of a boiler-shell which is exposed to the action of the heated products of combustion, but the furnace plates are oftener affected than any other part, for there the heat is greatest.

Bulged plates may result from various causes. Insufficient bracing is a very common cause of bulged plates, as well also as broken braces and stays. The writer knows of a case where the braces of a $\frac{3}{8}''$ thick crown-sheet, intended to carry a pressure of from 60 to 80 pounds per square inch, were pitched 12″ apart. The result may be imagined. A very few days' service sufficed to bulge the plate between each and every brace, to the extent of about 2″, and then it was thought best to remove the plate, and substitute another and better braced one. Cases of this kind are quite common.

Broken braces, unless the defect is soon discovered and repaired, are almost certain to result in serious consequences. If the braces of a crown-sheet are unskillfully put in, so that one brace has an undue strain brought upon it, the *sudden* breakage, and the consequent shock, may bring such an intense strain upon the surrounding braces, as to fracture them in turn, and the entire crown-sheet may collapse. In this connection it may be well to remember that a stress suddenly applied, produces a *strain* just *twice* as great as it would if applied gradually.

But the most fruitful source of bulged plates, as well, also, as *burned plates*, is shortness of water. This may be brought about by various causes. Sometimes the fireman has such a multiplicity of duties to perform, that, through no fault of his own, he neglects his boiler, and before he is aware of it, the crown-sheet is bare. In many cases, especially where the water is bad, and too much reliance is placed upon the glass water gauge, the pipes connecting the gauge with the boiler become filled with sediment to such an extent that all communication with the boiler is shut off: in that case, while the glass gauge may show abundance of water, there may not be a drop in the boiler itself, and the inevitable result is a burned and collapsed furnace.

In many cases where explosions have occurred, and the engineer and firemen have sworn there was plenty of water, they may have based their opinion on the reading of the glass gauge, and while they honestly enough believed there was plenty of water, there might have been a great deficiency of it.

Burned and bulged plates are also caused by accumulation of scale or sediment on them, which prevent contact of water, but as this matter is fully discussed in another part of the issue, we will pass over it here.

Grooving of the flanges of the flues, and fracture of the furnace plates, are very common defects, and cannot be too carefully guarded against. Defective construction has much to do with this class of defects, as for instance when flues are made either too long or too short, and undue strains are brought upon the plates and flanges when the boiler is put together. In this case the strains are greatly exaggerated by the expansion and contraction produced by the heat, and the opening of furnace doors, and in some cases, there is no doubt that such strains have been so great as to cause sudden rupture of some part of the boiler, which has resulted in explosion. Of course, such strains are further aggravated by any buckling or distortion of the shell-plates.

In externally fired boilers, one of the most common defects met with is at the front end of the furnace. The bricks over the furnace door are continually falling down, and where the ends of boilers are set "flush" with the masonry, the extension of the shell forming the smoke-box is very apt to be burned, and permanently injured. Overheating of this portion of the shell causes leakage around the tube-sheet, which ultimately does much damage if neglected. A very much better way is to let that part of the shell beyond the front tube-sheet, project beyond the masonry of the setting, and then no damage can possibly result to it from the tumbling down of the fire-bricks at front of furnace. By this means, also, a much thinner wall may be used, and the mouth-pieces correspondingly reduced in thickness, whereby the labor in firing is very greatly reduced.

But the limits of our space forbid further comment. A volume might be written devoted entirely to the consideration of the steam boiler furnace, and the defects which make themselves manifest therein. We will add a few words however, in regard to the proportions of furnaces of internally fired boilers. These are invariably made too small to secure economical combustion. And there is no good reason why they should be either. If the form of any boiler necessitates a cramped furnace, then that particular style of boiler should be abandoned, or so modified as to admit a furnace of proper size. With large roomy furnaces, thin fires, and a due allowance of air both below and above the grate bars, all kinds of fuel may be burned without any trouble.

Relative non-conductivity of different substances.

Mr. Chas. E. Emery, of New York, recently made some experiments upon the relative non-conductivity of various materials with reference to the needs of the New York Steam Company. His apparatus consisted of a boiler 12 feet long and 4 feet in diameter, with 3 ten-inch flues passing through it. Inside these flues were smaller tubes through which the steam passed; the non-conductors surrounded the inner tubes, and water was kept circulating around the flues in the outer shell. A layer of hair felt 2 inches thick gave the best result, and using equal thicknesses of the other materials the following results were obtained:—

Material.	Non-conductivity. Per cent.
Hair felt,	100.
Mineral wool, No. 2,	83.2
Mineral wool, No. 2 and tar,	71.5
Saw-dust,	68.
Mineral wool, No. 1,	67.6
Charcoal,	63.2
Pine wood across the grain,	55.3
Loam,	55.
Gas work's lime, slaked,	48.
Asbestos,	36.3
Coal ashes,	34.5
Fuel coke,	27.7
Air space, 2 inches deep,	13.6

The low result from air space no doubt is due to the unimpeded circulation of the currents. *The Iron Age.*

Owing to the fact that certain scientific journals have made use of our monthly list of boiler explosions, for the purpose of making up a summary and classification of the explosions during the year, without giving us due credit, we have resolved to discontinue publishing it monthly hereafter. We shall keep our record as usual, however, and at the end of the year issue a special number of the *Locomotive* devoted entirely to explosions, which will contain a detailed list of the entire number, with a summary and classification, with illustrations of some of the more destructive ones, and a discussion of heir probable causes.

The Locomotive.

HARTFORD, FEBRUARY, 1882.

MANY of the difficulties which arise in connection with steam boilers in use are not understood by engineers in general, and, in fact, some phenomena cannot be accounted for, even by experts.

The conditions under which a boiler is used have much to do with its behavior. First, is it properly constructed, and are the parts so adapted to each other that there is no undue or unequal strain brought to bear on any particular part? This may arise from improper bracing—having a greater tension on one brace than there is on its neighbor. Joints may be so constructed that there is constant distress over their entire length. If the holes for the rivets are not fair and the *drift pin* is used to bring them fair, there is an unnatural strain brought to bear that is no part of its legitimate burden, and is not provided for in the formulae used for estimating safe working pressures. These abnormal strains are very much exaggerated when the boiler is under pressure and the load is not evenly distributed. Hence, the portion bearing the excessive load becomes a point of weakness, and how weak can never be known until leaks, ruptures, or worse consequences follow. Many boiler explosions are no doubt attributable to carelessness in construction. The responsibility, therefore, resting upon boiler-makers is a very grave one.

It is not always easy or possible to detect defects in workmanship when a boiler is finished and painted over with a coating of gas-tar, or some similar material. Another difficulty is the water used. In many cases, no trouble arises from this source, while in some sections of the country there is constant and serious trouble from water carrying more or less lime or magnesia in solution, or from a combination of both with iron and other ingredients. Hard scale or crust is formed on the fire-sheets, tubes, and flues, and the efficiency of the boiler is greatly impaired, besides the damage from burning the iron—thus destroying its strength. Carbonate-of-lime deposits as a fine powder under about 180° of heat. In some sections it is so abundant that the water becomes quite sensibly thickened by it, and it interferes with the free escape of steam. Allusion is made to this trouble in an article on another page, to which attention is called.

The sulphate-of-lime is a more serious difficulty, and not so easily overcome. It makes a very hard scale, and, when once formed, can only be removed by hammer and chisel. How to overcome this difficulty is a question not so easily answered, and we would not venture to give a solution without knowing something of the circumstances in each case. There is no universal "grand panacea"—different waters require as different treatment as different diseases. As it is well to pay due regard to the laws of health to prevent disease, and the more unfavorable the surroundings the more is care and caution required, so in this matter of bad water. Constant vigilance is necessary. A bottom blow and a surface blow may be found of great service. Use them freely and frequently. A solvent of tannate-of-soda, or some similar preparation that would not affect the iron unfavorably, may be found serviceable. But this should be used intelligently. The engineer should know what is being put into his boilers, and not take the opinion of every vender of boiler compounds.

The fuel used is another subject for consideration, but as our space is limited we will leave that for next month.

Obituary.

The death of Alexander Lyman Holly, the eminent civil and mechanical engineer, has caused a world-wide sorrow. He died in Brooklyn, N. Y., January 29, 1882. He was the son of Ex-Governor A. H. Holly of Connecticut. By his death the state loses one of her most brilliant sons. He was a man that did things. He was not merely a theorizer and dreamer, but he bent his energies to the accomplishments of great ends; not merely for personal fame, but that he might do something of benefit to his country and to the world. His sphere was a wide one. A new country with vast undeveloped resources. He grappled with these problems and with what success, those know who are familiar with his career. His works on *American and European Railway Practice, and Ordnance and Armor*, are familiar to those who are interested in such matters. But his great work was the introduction and development of the manufacture of Bessemer steel in this country. Much that is unwritten, and never will be written, was accomplished here. But the record is before us in the results. Every Bessemer Plant is a monument to him—and every steel rail over which the flying train passes, rings out its tribute to his memory. The noble sentiments which dwelt in his heart cannot be so well expressed, as in his own words; the closing words of that memorable *extempore* speech which he made in Pittsburg, in response to the presentation of a handsome testimonial from his friends.

"Among us all who are working hard in our noble profession and keeping the fires of metallurgy aglow, such occasions as this should also kindle a flame of good fellowship and affection which will burn to the end. Burn to the end—perhaps some of us should think of that, who are burning the candle at both ends. Ah! well, may it so happen to us that when at last this vital spark is oxidized, when this combustible has put on incombustion, when this living fire flutters thin and pale at the lips, some kindly hand may turn us down, not underblown—by all means not overblown—some loving hand may turn us down, that we may perhaps be cast in a better mold."

The funeral services were held on February 1st, at Plymouth Church, Brooklyn. The Rev. Henry Ward Beecher conducted the services, assisted by Rev. J. H. Twichell, of Hartford, Ct.

A Case of Bagging Resulting from the Use of an Open Heater.

Editor Locomotive:

The article in September issue of the Locomotive, entitled a peculiar case of "bagging," recalls a similiar case that came under the writer's observation some nine months ago. I was sent for to examine a case of "bagging" in a boiler fifty-four inches in diameter and twelve feet long, with a man-head plate under the tubes. The number of tubes I do not remember, but the boiler was a new one, and when run one month the sheet bagged, and the seams over the fire began to leak. The parties who built the boilers re-riveted and calked them. The difficulty was not overcome, and a new half sheet was put into the boiler. This very soon behaved in the same manner as the original sheet had done. (The iron was Bailey's best Flange-iron, and no fault could be found with it.)

The builder now concluded that the boiler was not kept clean, and requested that when further trouble occurred the man-head be left in for him to remove, so that he could see the inside of the boiler before any washing out or removing of sediment was done. He was called when trouble again occurred, and upon opening the boiler found it very clean, but it had "bagged" down and was leaking, nevertheless. He gave up the solution of the difficulty in disgust or despair. We were sent for to contract for a new boiler, but before doing so thought it best to make a careful examination of the case. I found the water which was used impregnated with lime, and it was passed through an open heater and lime extractor before going to the boiler. The parties assured us that lime had never been deposited on the sheets of the boiler. We had suspected that this was the cause of the trouble. The boiler was constructed in the usual manner, the tubes being put in "staggered" rows, the nearest approach to shell being about two and one-fourth inches, which, while nearer than we would recommend, did not,—considering the large water-space underneath,—appear to hinder circulation. We refused to contract for a new boiler until we found out what was the cause of the trouble. With a most diligent and careful examination we could not assign a good reason for the trouble. But being prejudiced against open heaters, we allowed ourselves to be guided in a measure by our prejudices. Our prejudices were based on the fact that tallow and grease from the engine go freely into the open heater and mingle with the feed-water.

We recommended that the rivets be cut out from the leaky seam, and the "bagged" portion set back as well as it could be, and then re-riveted. This was done. We also recommended the open heater be disconnected and the boiler be fed with an inspirator which we loaned them for the purpose of ascertaining if the changes would work any improvement. Everything being ready, the boiler was started up and has been running every day since without leaking or "bagging." Now, what in your opinion was the trouble? * * * *

The remedy applied seems to have been, the removal of the open heater. We have often shown the troubles arising from the use of open heaters. particularly in portions of the country where the formation was limestone. The writer of the above article says that the boiler was clean and free from deposit or scale. If this was strictly so then the trouble must have arisen from grease that found its way into the heater with the exhaust steam, and thence into the boiler. We suspect, however, that when it is stated that the boiler was clean, we are to understand that there was no hard scale on the sheets. *Carbonate of Lime*, often deposits as a loose, fine powder, which when dried appears very much like magnesia. This is sometimes of a light color, but more frequently by mixing with the grease imparted to the water by the exhaust steam into the heater, it assumes a darkish color. This settles down upon the bottom of the boiler, lies along the seams and keeps the water from contact with the iron. Hence, very troublesome leaks and "bagging" often occur from overheating. If the boiler is blown down hot this slush or sludge will bake on to the hot sheets and form a scale. But if the fires are drawn, and fire-sheets allowed to cool off, the sludge does not bake or burn on, and in drawing off the water it will appear muddy. Boilers in limestone districts are often found with this sludge or mud on the bottom inside, and if such was the case in the boiler above described it accounts for the whole difficulty.

It is generally supposed that a deposit in a soft state causes little or no injury. This impalpable powder, however, is long held in suspension on account of its lightness, but finally settles down on to the fire-sheets, and then trouble begins, especially if an open heater is used. Many cases similar to the one reported above have come under our notice, and in all cases the engineer has declared that there was no scale in the boiler, and an examination has usually proved that there was no *hard scale*. But the sludge was there, and the boilers were in almost all cases fed through open heaters. It will therefore be seen that a hard lime scale (sulphate of lime) is not necessary to produce serious results. But the light, almost impalpable powder of carbonate of lime is capable, under some circumstances, of doing immense mischief. Frequent blowing,—an inch or two at a time,—will generally overcome the whole difficulty. We recommend a heater always, for we believe the working age of a boiler is increased by a good heater. But an open heater in carbonate of lime districts is almost sure to give trouble.

Still another "Prolific source of Boiler Explosions."

The periodical "explosion idiot" has again put in an appearance, hugging his little theory and then letting it loose upon a defenceless community. This time he "bobs up serenely" through the columns of the *Manufacturer's Gazette*, and signs himself X. At first we thought the signature was the usual symbol for John Smith $\overset{\text{his}}{\underset{\text{mark}}{\times}}$, but on second thought concluded that he had selected X because it was universally used to denote an unknown quantity, and he thought the value of his ideas could best be represented in that manner. Let us hope that this is the case, and also hope that X will resolve itself into either $\frac{0}{0}$ or 0, for we have now altogether too many mysterious and peculiar theories to account for steam boiler explosions. What we are sorely in need of is, less theory *after* boilers have exploded, and more right practice in their care and management *before* they explode. This will obviate, in a great measure, the need of any theory to account for explosions, for the reason that there will be few explosions to account for. We think it is decidedly better to look out for thieves, in order to prevent their depredations, than it is to lock the stable-door after the horse has been stolen.

The brilliant theorist in question leads off with the assertion that "many steam boilers explode from no apparent cause, and become the subject of various speculative theories." We must beg leave to differ with the gentleman in regard to the first part of the above quotation, for the records of the investigation of explosions flatly contradict it; but with respect to the last part of his statement, that "they become the subject of various speculative theories" we heartily and entirely agree with him. If there *was* any doubt on the subject, a perusal of his own article would instantly dispel it. His next statement is: "The fault is generally ascribed to some imperceptible defect in the boiler." Of course. That is an easy way to account for a boiler explosion. The mental strain involved in ascribing "some imperceptible defect" to the boiler, is far less than that involved in an examination of the fragments to discover the true cause, or even in inventing a new "theory" to account for it. Therefore, it is very often done. And besides defects are always "imperceptible" until they are discovered. Therefore it is sometimes an advantage *not* to discover them. So it will be seen that the "imperceptible defect" theory is very convenient sometimes.

Continuing he says: "In order to ascertain what I regard as a prolific source of boiler explosions we must first consider the nature of steam. This we learn from the way it is produced. I contend that the principle underlying the whole matter is the peculiar affinity which the water possesses for heat at 212°. The unit of heat, rising from the boiler fire, is incased by a thin shell of water. On reaching the top of the water and encountering colder air, the shell breaks and the heat escapes."

We will give a chromo to any one who will satisfactorily explain the third and fourth sentences of the above quotation. We confess our entire inability to penetrate the deep and awful mystery hidden beneath the above apparently simple words.

If the affinity of water for "heat at 212°" is as "peculiar" as the above language, then it must be a very surprising thing indeed. And the writer's conception of the nature of the "unit of heat" is so marvelous in its simplicity, and so sublime in its ridiculousness, and is so "utterly" different from our own conception of it, that we are almost led to believe that Dr. Joule is a mythical personage, and the published results of his investigations some horrible fiction invented by evil disposed persons for the purpose of deluding poor humanity into a belief which shall eventually lead to their utter destruction.

Further on he says: "As we increase the pressure, the heat increases in definite ratio, and as the pressure increases, the steam-globules are compressed. This action goes on until the pressure of the globules in the steam space becomes equal to the pressure exerted by the fire, when steam ceases to form."

This is really something new in the manner of generating steam. Alas for the fondly cherished traditions of our childhood! We had always been led to believe that as we increased the heat, the pressure increased; but now we are forced to admit that we have all along had "the cart before the horse;" the laws of nature all work backward, and "the heat increases as the pressure is increased." And the idea that steam pressure is produced by the *pressure* of the fire is decidedly novel and refreshing. We shall never dare to open a furnace-door again for fear that the immense *pressure*, exerted by the fire, will blow us into "kingdom come" heels over head, which would be very awkward to say the least.

But here perhaps we have a hint for a method of making boilers perfectly safe, regardless of such trifling things as inoperative safety-valves, fractured plates, broken braces and all such defects which are generally supposed to lead to the failure of boilers. Our plan is this: Let the boilers be set so that they are entirely surrounded by the fire, then the "pressure" of the fire on the outside, will just equal the pressure of the steam on the inside, and so of course there will be no tendency for the boiler to explode. We furnish this hint gratuitously for the benefit of a suffering community.

He continues: "Now, here we have a boiler, capable, we will suppose, of withstanding 500 pounds pressure to the square inch. In the furnace the fire is equal to the maintenance of 200 pounds pressure in the boiler. (That is, we suppose he means that the "pressure" of the fire is 200 pounds to the square inch.) Everything is working smoothly; the engine taking a regular amount of steam and leaving 200 pounds pressure in the boiler."

"Now let the steam be cut off from the engine. What is the result? The steam keeps on forming, and the globules will accumulate until the pressure they exert is equal to the "pressure" of the fire. The two forces being equal, action ceases. The boiler, however, will bear a pressure of 500 pounds, and the steam gauge does not register anywhere near that amount. Therefore it may be said that no danger is to be apprehended. But there is a subtle force at work all this while. It is true that steam is not being formed *actively;* but the heat is entering the water and is absorbed by it. It cannot convert it at once into steam, for its force is balanced by the force of the compressed steam globules above. But suppose that steam is now let into the engine. The pressure is suddenly relieved. The steam at the top rushes out and the "latent steam," as we may call it, rises from the water, asserts its real character, and more than fills the room which has been made for it. * * * * The result is an explosion."

Funny, isn't it, how very easy it is to "bust a biler" on paper, with the aid of one of these little 4 by 6 double-ended, patent back action, muchly hypothecated theories. According to this noble theorist, we have only to stop an engine and start it up again after a few moments, to infallibly produce an explosion. This we are deliberately asked to believe in the face of the fact that tens of thousands of engines are daily and hourly shut down, and started up again all over the world without "starting a hair." We have heard of many wild and startling theories to account for boiler explosions, but the above is about the most jumbled up and asinine production that ever came under our observation. Observe the colossal calmness with which he makes the contradictory statements that, "the two forces being equal, action ceases * * * * but the heat is entering the water and is absorbed by it." We always supposed that as long as heat continued to enter the water, the pressure would continue to rise; but such it seems is not the case, especially, where the above theory is applied. After the pressure of the steam is equal to the "pressure" of the fire, we may super-heat our water as much as we please. This discounts the Donny theory, and then comes in a long way ahead.

But what is now to become of the "rival" theory, that shutting down the engine causes the boiler to explode? Engines are stopped, as often as they are started, and the boilers seem to be as apt to explode in one case as in the other, so that the two theories seem to be about equal as regards efficiency. This being the case we suggest that the rival theorists hire a hall and be left to themselves to settle the question of merit. We are confident that this is all they are good for. H. F. S.

Reversing Filters.

It is by no means clear that the reversing process somewhat used in filtering apparatus, or even blowing back through them with steam under pressure, is really effective in the cleansing of the filtering medium which is employed. This method, with various modifications, has been practiced for many years; but when large masses must be treated, or the finest grade, as it may be termed, of filtering is to be provided for, then recourse is had to the old-time open sand bed, or to the vessel filled with animal charcoal—that *ne plus ultra* for the manufacturer or painstaking housekeeper.

In the large majority of cases the sifting out from the water of the sediment mechanically suspended in it, is all that is or can be attempted, and hence the material of which the filter bed is made up is selected and laid into the filter with this particular object in view. The process of filtration is thus the lodgment, in or upon the fragments or particles of this filling material, of the fine silt or sediment borne by the water as it passes very slowly through. The cleansing process aimed at, or proposed, in the reversing movement is the dislodgment, or washing off and bearing away out of the filter, of this sediment; but as this washing off and away necessarily implies or involves a rapid movement of the washing current. it is quite obvious that in the reversing filters a self-contradiction is often attempted. The upturning or disarrangement of the closely-packed filtering material, which to act perfectly needs to be undisturbed, is the last thing that should be attempted in an apparatus which is expected to be durable and permanent in its action. The fact that this cleansing movement of the reverse flow to be useful must be rapid, is shown by the method so often practiced in the management of open filter beds in regions where this sand or gravel material is scanty, and that which has become foul in use must be washed and repacked in the filter. In such cases the vigorous stirring up or agitation of the silt-covered sand particles in a flow of water alone suffices to restore their efficiency, the cleansing thus accomplished being clearly impracticable in the very slow current which alone is possible in any reversing device.

In reference to the use of filtering apparatus in general, it may be said that it is far too little valued and employed. Men take great pains, or some men do, to secure coal or coke for their work which shall be as free from ash as possible, while in the same immediate connection a water supply is employed, which, though it may be cleansed from serious or even dangerous impurity by simple and inexpensive means, is nevertheless accepted and used as if the art of filtering had never been practiced, or, indeed, had never been heard of.—*The Iron Age.*

Mr. James Emerson of Holyoke, Mass., has prepared a Treatise, relative to the *Testing of water-wheels and machinery.* It has the records of experiments made at several of the large water-powers in the country. It also describes the various water-wheels in use, and the attachments and appliances used in connection with them. Altogether it is a valuble Compendium of Hydrodynamics, and should be in the hands of every person interested in the subject.

Getting up Steam.

The records of boiler explosions demonstrate unmistakably the importance to the steam user of the most careful supervision over boilers at the time of getting up steam. Some of the most destructive explosions of which I have any knowledge, occurred either on Monday morning, or at the time of getting up steam after the boilers had been out of service, while cases in which plates are bulged, furnaces distorted, and flues and tubes badly injured, are of quite frequent occurrence, all due to ignorance or carelessness, or both, in getting up steam, or neglect of necessary precautions in filling boilers, or having filled them, a failure to detect leaky gaskets, imperfectly closed blow off valves, or cocks that had permitted the escape of the water before fires were lighted.

An old shipmate now chief engineer of one of our largest steamship lines, of extended experience among engineers and thoroughly practical in every department of the steam engineering service, used to say there were few among our best engineers who properly understood how to charge a furnace and get up steam. All things considered, he regarded that job when well done, as one of the most important duties in the business, and of sufficient importance to be done by the engineer, or at least immediately under his direction, and not as is commonly the case intrusted to a fireman.

Filling boilers, charging furnaces, and getting up steam, are considered very ordinary duties by most engineers, who would smile derisively, if it were intimated that they did not understand those duties; perhaps they do, if so, it must be confessed many of them have a queer way of showing it.

In filling boilers, I have found it a good plan to raise the safety-valve and block it open; this will permit the escape of air, besides indicating the time boilers begin to steam, after which the valve may be lowered. I have observed most stationary engineers in charging furnaces, put the kindling wood on the grate bars; another and I think a better plan is to first scatter a thin layer of coal all over the bars, atop that the wood is placed; the latter plan if tried, will be found a more economical and expeditious way in obtaining a good bright steaming fire.

The masonry or setting of externally fired boilers now almost universally employed in our larger cities where aqueduct water is used, is frequently ruined by heavy forced firing, when steam is first got up—the cement and mortar instead of being allowed to set properly as they would do if slowly and judiciously heated, speedily crumble away, losing the strength of the joint, the brick-wall cracks open, the draft is impaired, heat lost, and perhaps the girth seams of the boilers strained by the unequal settling of the walls. In a few months it is necessary to reset the boilers again, for which the innocent mason may be cursed loud and deep, the engineer in all probability being his chief accuser.

Forced firing is not only injurious to the setting, but to the boiler as well; this is most apparent in the use of the common upright or vertical tubular boiler, in which the water is carried some distance below top of tubes; the tube-heads soon begin to leak and require frequent expanding in order to keep them tight; it will be found a good plan when troubled in this way to have defective tubes ferruled. Horizontal tubular boilers are often set to return heat over the top of shell; the disadvantage of this plan of setting is the danger of the exposed shell above water line, being injured in getting up steam from cold water; the shorter the boiler the greater the danger of injury, the lower part of boiler being at a temperature due to that of the contained water, while the upper part is exposed to that of the escaping products of combustion. A recent experience was that of three boilers 42″ × 10′ used for heating purposes only, at a pressure never exceeding 25 lbs. Yet under these favorable circumstances they were ruined in about five years. More or less trouble had been experienced during the preceding season from leaks above the water line. On examination it was found that the upper half of shell was badly cracked in several places, and when it was attempted to cut out the defective sheets, the surrounding metal was found so brittle and badly crystallized, the boilers were condemned. The shells below water line had never given any trouble and appeared to have suffered no injury during their brief service. There can be no doubt, I think, their failure was due to the plan of setting, for they were built by one of our best boiler-makers, of selected iron, and while in service were under the care of a first-class engineer; under less favorable circumstances their failure would have occurred sooner. Fractures in the sheets of boilers set in this way are of common occurrence, the danger increasing with the frequency of getting up steam.

In some parts of the country local ordinances for smoke prevention are now in force. and many worthless smoke-burning appliances (so called) have been sold to steam users in those localities. A roomy furnace, ample combustion chamber, and a clean bright even fire not exceeding eight inches thick, with systematic firing will be found helpful in lessening the smoke nuisance. When there is more than one furnace, the firing and cleaning must be alternated, the fireman having his fire tools within reaching distance, and damper closed before he opens furnace door, which must be closed again as quick as possible.

There are two principal methods of firing known to the initiated, as "spread firing" and "side firing." Each has its advocates, who are convinced their's is the only plan. I have practised both, and so far as I could tell with about equal results; am inclined to attach greater importance to having an experienced fireman, careful attention, regularity of firing and rapidity of movement, than to any prescribed form of covering the fire, which must of necessity vary in different localities according to the quality of the fuel. But a careful attention to the details enumerated, will result in economical consumption of fuel, lessening of smoke, and greatly increased efficiency of the boilers whenever practised.

F. B. Allen.

In our last issue, page 3, second line below cut, in the calculation of the working pressure of the boiler the expression "$\frac{42000 \times .25}{25} = \frac{420}{6} = 70$," would perhaps have been less liable to be misunderstood by those unfamiliar with the calculation of the strength of steam boilers, if it had been written "$\frac{42000 \times .25}{25} = 420$, and this divided by 6 = 70 lbs." &c., where 6 is the factor of safety.

The Association of Proprietors of Steam Engines in the North of France, have made numerous experiments which show that many of the bricks that are employed in building furnaces are so porous as to allow an easy passage for air. In consequence of these experiments, they advise that no bricks should be employed for the purpose which are not very compact and refractory, and that they should be either glazed upon the outside, or covered with an impenetrable varnish. *The Iron Age.*

Mechanics is the name of a new publication issued by David Williams, the well known publisher of the *Iron Age*, *Carpentry and Building*, and the *Metal Worker*. The opening numbers are full of choice reading, and we predict for it a brilliant and successful career.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. III. HARTFORD, CONN., MARCH, 1882. No. 3.

Boiler Construction and Setting.

We present below, Fig. 1, a drawing of a Horizontal Tubular boiler with attachments and setting, which was designed by THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

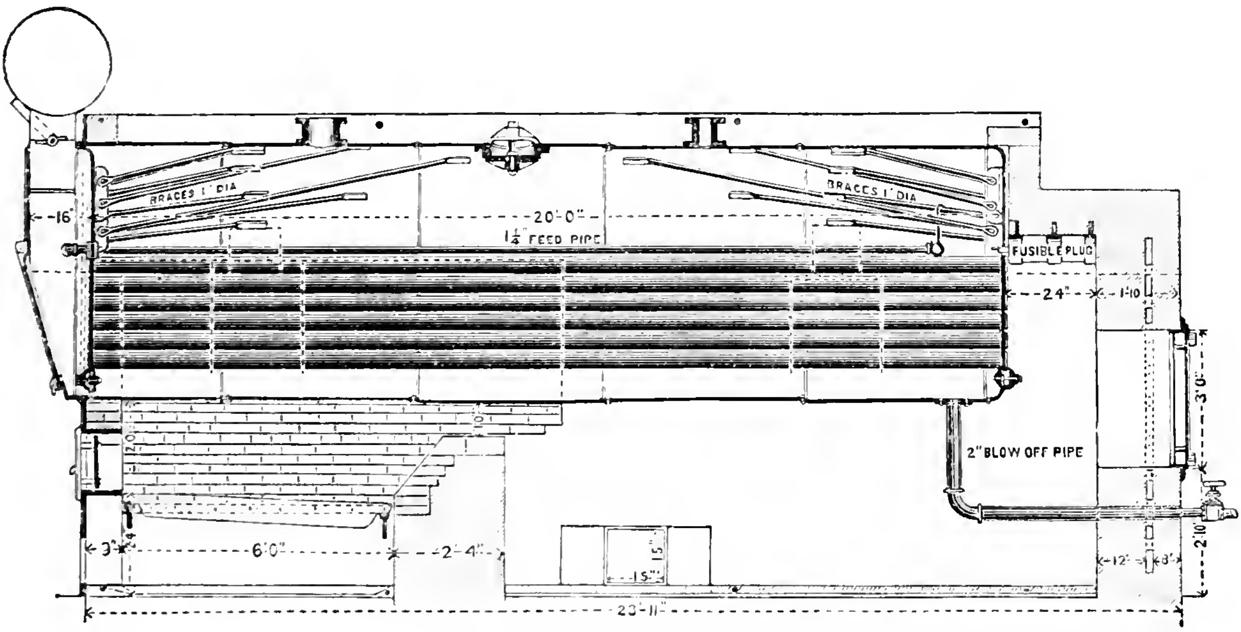


FIG. 1.

The proportions of this boiler are somewhat at variance with the present practice among boiler-makers, and we would not recommend its adoption except after careful examination of all the surroundings. The quality of water and fuel used are important considerations—also the draft. The dimensions of the boiler are as follows: 21 feet 4 inches long outside, 66 inches in diameter. Tube-heads 20 feet apart. 54 tubes, each 4 inches in diameter. The front is known as the "cutaway" projecting front. The braces are attached to pieces of T iron arranged radially on each head, as shown in Fig. 2. The heads above tubes are stiffened by these pieces of T iron. There are two nozzles, one for safety-valve, and one for steam.

The boilers are constructed of steel plates $\frac{3}{8}$ inch thick. Heads, steel $\frac{1}{2}$ inch thick. Horizontal seams double-staggered riveted.

The setting is so planned, as to secure the best effect of the radiant heat, at the same time there is ample provision for a proper mingling of the gases with atmospheric air. The ash-pit bottom is a water basin, in which four or five inches of water are constantly kept. No ashes or cinders should be allowed to accumulate there, but should be raked out as often as the fire is cleaned and replenished. The boiler is supported on lugs, so as to leave the bottom free from any obstructions, and to give the inspector ample room and opportunity to thoroughly examine the fire-sheets.

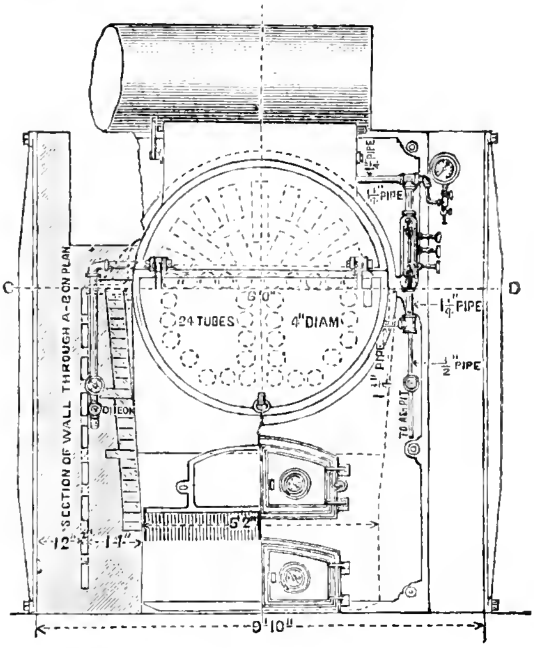


FIG. 2.

These boilers are working fully up to our expectations. The gases are well-consumed, and with soft coal, very little smoke is ever detected issuing from the chimney. Properly constructed, and properly set, we regard it as one of the most economical, and easily-managed boilers in use.

Inspectors' Reports.

JANUARY, 1882.

The following summary shows the work of the inspectors of this Company for the initial month of the year. It compares very favorably with the corresponding month of last year. From it we learn that the number of visits of inspection was 2,001, by which 4,292 boilers were inspected. The number of boilers thoroughly examined both internally and externally was 1,303, and the number subjected to hydrostatic pressure was 312. The number of boilers condemned was 17.

The number of defects found was 1,550, of which number 409 were considered dangerous. The following statement shows the defects in detail:—

Nature of defects.	Whole number.	Dangerous.
Furnaces out of shape,	72	19
Fractures,	209	138
Burned plates,	68	23
Blistered plates,	240	38
Cases of deposit of sediment,	188	23
Cases of incrustation and scale,	330	31
Cases of external corrosion,	94	24
Cases of internal corrosion,	68	14
Cases of internal grooving,	9	6
Water-gauges defective,	41	10
Blow-out defective,	18	11
Safety-valves overloaded,	23	9

Safety-valves defective.	2	1
Pressure gauges defective,	131	33
Boilers without pressure gauges,	5	3
Cases of deficiency of water,	14	9
Broken braces and stays,	30	17
Cases of serious leakage,	7	0
Heads defective,	1	0
Total,	1,550	409

Fractured plates are very common, much more so than is generally supposed to be the case. In the above list, only those of a serious character are reported. Fractures are found in all parts of boilers, and their location and appearance will generally be sufficient to indicate their probable cause to an experienced inspector.

The nature of the iron of which plates are composed, of course influences very much the liability to fracture, as does, also, the treatment which the iron receives at the hands of the boiler-maker, and the after treatment which it receives when the boiler is in use.

One prolific source of fracture in boiler-plates lies in the pernicious habit of leaving the damper wide open while slicing the fire, or adding fresh coal. A current of cold air is drawn into the furnace, and impinges on the under and highly-heated side of the boiler shell, causing sudden and violent local contraction, which is sure to strain the girth-seams, and in many cases rupture the shell. Cases have occurred in the experience of this company where boilers have been exploded in this manner with disastrous results, when there was no fire at all under them. This may seem strange, but it is nevertheless true. In one case which occurred in 1879, a battery of boilers were in use, and were all connected to one steam-pipe. Some of the boilers were heated by the waste gases from puddling-furnaces, and when the furnaces were stopped, and fire out for a night, it was customary to leave the stop-valve open, so that steam from the other boilers might keep the water warm. In this case there was steam at a pressure of 70 pounds per square inch, the temperature of which would be about 316 degrees Fahr., acting on the upper half of the boiler, while the lower half was exposed to the current of cold air drawn through by the draft of the chimney. It may easily be seen that the contraction thus caused would be quite severe. It was so great in this instance that it caused the boiler to leak badly, and the water tender, an ignorant fellow, pumped in a lot of cold water. This was the straw that broke the camel's back, and away the boiler went—a genuine explosion where there had been no fire for several hours. It will readily be seen from this, how important it is to avoid sudden cooling of any part of a boiler-shell.

The practice of feeding cold water into a boiler and delivering it near the shell, cannot be too strongly condemned. Boilers fed in this manner invariably leak at the seams near where the water is delivered, and show other unmistakable signs of distress. If the use of cold water is unavoidable, a "circulating" feed-pipe should always be used. This is a pipe entering horizontally through the front head, near one side, a few inches below the water-level, thence running back to within one or two feet of the back head, then crossing over to the other side of the boiler and projecting downward between the tubes and side of the shell. The water is thus caused to traverse the entire length, and nearly the whole width of the boiler, and is finally delivered downward into the coolest part of the water. By this means it is heated nearly or quite to the temperature of the main body of water in the boiler, before it can possibly come in contact with any part of the shell, and so the evils of violent contraction are entirely obviated. Of course where an injector or feed-water heater are used all the time, this is not so essential.

Fractures frequently occur at the girth-seams of long boilers such as are found in iron works. These are frequently made as much as 30 feet long, and not over 3 feet in diameter, with supports at the ends only. It will readily be seen that under such circumstances the strain on the girth-seams near the center of the boiler must be very great, when they are full of water. Boilers of the above proportions should always have more than two supports, and those near the center should be so constructed as to always bear their due share of the weight of the boiler, as its position varies from the effects of expansion. This subject, however, has been fully discussed and illustrated in preceding numbers of THE LOCOMOTIVE, so we need say nothing more about it here.

One of the most frequent causes of fractures at the seams of boilers is the use of the drift-pin. Where the rivet-holes in a seam fail to match in a direction parallel to the length of the seam, and the drift-pin is used recklessly, we frequently find the plate cracked from a dozen rivet-holes consecutively, running from the side of the hole to the edge of the plate. Sometimes the cracks will never extend beyond the rivet-holes; in this case they may give comparatively little trouble if the seam does not leak, if it causes leakages at the seam, or if any of the cracks extend *beyond* the rivet-hole into the plate, then the matter may become serious.

When the rivet-holes fail to come fair in a direction at right angles to the length of the seam, and the drift-pin is used, then the fracture runs from one rivet-hole to another, and thus forms practically one fracture. This is always a serious matter, and should always be attended to at once.

Sometimes the location of boilers is such, that the upper side comes on a level with some floor where it is convenient to stow articles in process of manufacture. We know of places now where flag-stones have been laid over the tops of some large boilers, and several tons of goods are piled up on the place every night. The inevitable result has been to fracture each one of the boilers in its turn, as well as to keep the girth-seams in a chronic state of leakage.

Mechanics says: "Mr. D. T. Lawson, whom our readers will remember in connection with experiments made some time since in boiler explosions at Pittsburg, has recently been doing something further in the same line. The present series of experiments are made to show that a boiler fitted with his patent explosion preventer cannot be burst. We believe there are two boilers precisely alike, save that one has the patented device, and the other is without it. One of the experimental boilers is to be exploded, and the other is expected to resist all efforts to do so. The latest experiments show that both of the boilers stood the tests remarkably well, the gauges showing about 275 pounds, but as a gasket blew out soon after this pressure was reached, the experiments were pronounced undecisive. Mr. Lawson might conduct his experiments in a much more conclusive manner if he would use smaller pressures and larger boilers. If he will get an old pair of condemned marine boilers capable of holding a large quantity of water, even though they would not stand more than twelve or fourteen pounds of steam, he could get up an explosion that would astonish all concerned, and demonstrate conclusively whether his apparatus had any value."

And we are of the opinion that if he will get an ordinary boiler in good condition, and use the ordinary working pressure, he will find it utterly impossible to explode it in the manner in which he is now experimenting. Furthermore, if he will get an old, badly-used, muchly worn out boiler, with safety-valve stuck tight, braces broken, and all steam outlets closed, and fire it up, he will find it entirely unnecessary to open his steam-valve suddenly to produce an explosion.

The Locomotive.

HARTFORD, MARCH, 1882.

The Brooklyn Boiler Explosion.

On the 16th day of February, 1882, about half-past eleven o'clock, two of the boilers of the Jewell Milling Company of Brooklyn exploded with terrific force, doing great damage to the building, and killing the engineer. These boilers were insured by The Hartford Steam Boiler Inspection and Insurance Company, and had been, since June, 1880. The boilers were made by the Woodruff & Beach Co., of Hartford, Conn., whose reputation for first-class work is well-known.

The boilers were of the type known as "Drop Flue," 21 feet long, 7 feet in diameter, thickness of plates $\frac{5}{16}$-inch originally. Internally fired. There were 17 flues; 4 were 13 feet long and 16 inches in diameter, and 13 were 9 feet long and $9\frac{1}{2}$ inches in diameter. The boilers were built in 1861, and had been used since that time under the care of a competent engineer. They were internally and externally inspected in June, 1880, when they first came under the care of this company, and were found in bad condition. Previous to this time they had been under the care of the city official, whose inspection consisted mainly of the hydrostatic test. It was the careful internal and external inspection of this company that discovered the defects, and repairs were ordered. These repairs consisted of new furnace-sheets, extra and renewed bracing. The owners applied for 90 lbs. of steam, but that of course could not be allowed. When the repairs were completed the boilers were again examined, and it was decided that 45 lbs. might be safely carried. The safety-valve was loaded at 50 lbs. to prevent steam constantly blowing off, if the pressure reached 45 lbs. The safety-valve commenced to blow at 48 lbs. by the gauge. Quarterly visits of inspection were made while the boilers were in use to see if everything was in good condition, safety-valve free, and steam-guage correct. In June, 1881, another internal and external inspection was made,—thorough and complete,—and no change material to the risk was discovered.

In examining the parts of the exploded boilers, it was evident that the incipient rupture was not at the theoretical weakest point. It did not commence at or along the longitudinal seam, but began at the drop connection, and followed along at the girth or "roundabout" seam. The boilers were supported from a girder in the rear, and rested on a wall or foundation in front. The peculiarity of the fracture indicated the presence of some strain other than that caused by internal pressure. The settling of the foundations has been suggested, and in studying the locations and surroundings there appears to be good ground for such an opinion. The buildings are located on a dock of "made ground," driven thick with piles so as to secure a foundation.

The chimney settled some time ago, and it became necessary to fasten it to the walls of the building by iron rods or straps, to hold it in position. The foundations of the engine have settled once or more, and it has been necessary to relay or readjust them. The boilers were located outside the main building, and nearer the water's edge than either the chimney or engine. Now a slight settlement of the foundations of the support at either end would cause a strain that might ultimately result in fracture, and the rupture once started, the rest is easily accounted for. It might be said that the settling of chimney and engine foundations should have called the inspector's attention to the boiler-foundations. But those familiar with the business can readily see that it would be no easy defect to discover, and the influence of heavy rains, and high tides, may have been an element in the problem. The public can rest assured that this company does not, nor can it afford to, make careless inspection of the boilers under its care. It has every incentive to be especially particular and careful in its inspections. It has been doing business in the *Metropolitan Department* for fifteen years, and this is the first explosion of any boiler there under its care during that time. During this period there have been some ten or twelve explosions in the Department, all of which we believe were under official inspection, and it is proper to state here, that in the year 1881, the company insured some 15,000 boilers, only two (2) of which exploded. If any other system can show a better record, we should be glad to hear of it. It must not be forgotten that manufactories of all kinds in the country are being driven to their utmost capacity at the present time, and in this case it appears that there was a constant demand on the engineer for more steam. Many people have the impression that so long as the pressure of steam is not increased the "wear and tear" of the boiler is not increased. This is erroneous. The wear and tear is mainly dependent upon the amount of water evaporated. If the demand for steam is such that the fires must be constantly forced, the boiler will feel the effects in every fiber. To illustrate: A horse may be able to draw a ton or more on a good road with ease for hours, but if you urge him and make him trot, or run, he will soon give out. A man may be loaded up to his full capacity with work, and he will do it easily, but if you drive and fret him, he will soon fail and break down.

The report of this explosion was spread far and wide through the public press, and no opportunity was lost to cast odium upon this company.

We do not lay this up against the press. For it is their business to get all the items of news they can, and the more sensational, the more attractive with the reading public. But it is not perhaps generally known that the office of Thos. F. Powers, Boiler Inspector for Brooklyn, is in the same building as that of the associated press. Nor is it perhaps known that his animus has been anything but friendly towards the company for some time.

Under these circumstances it will require no severe stretch of the imagination to account for the statements sent out over the country. It was stated that Powers had condemned the boilers; that he had said they were not safe for 30 lbs., that there were many boilers in his department insured by the company which he would condemn, etc., etc. The facts are, that the boilers were placed under the company's care by the Jewell Milling Co. because "they did not consider the local inspection a safe one, that is, the mode of inspection." This is Mr. Jewell's testimony before the coroner's jury. When the boilers first came under the company's care it would not insure them at any pressure, but after thorough repairs were made they were willing to insure them. When Powers examined the boilers only 30 lbs. pressure were wanted. He testified thus: "We examined these boilers in question on June 22, 1879, and made the test by means of *hydrostatic pressure;* the result of my examination was that *they were in good condition.*" Further on in his testimony he says: "*In order for me to give my opinion whether* 50 *pounds of steam would be safe, I would again have to test the boilers.*" This don't read much like the stuff sent out over the country as Mr. Powers' statements mentioned above. The testimony of Chief Engineer Sewell, of the U. S. Navy, was emphatically in favor of the *hammer test* as against the *hydraulic test.* He also stated that he had figured up the pressure, and did not regard that used at the time of the explosion as excessive. The inspectors of the company who made the inspection gave a clear and intelligent account of the process in detail, and Chief Inspector McMurray presented specimens of the iron which had been cut from the plates of the boiler at the fractured edge. These were tested by the Colt's Arms Manufacturing Company, and showed a clean fibrous fracture with a tensile strength varying from 46,400 lbs. to 48,940 lbs. Four tests were made. There was no evidence whatever given to warrant the verdict rendered.

This opinion has been repeatedly expressed to us, and it is characterized by those who have good reason to know as a "put up job" to influence legislation against the company. We are informed by an eye witness that when the evidence was all in, coroner Keller proceeded to sum it up and charge the jury by *taking from his pocket a document all prepared*, and which, from the difficulty that he had in reading it, was evidently written by some other person, and before the evidence had been given. It is said that all through the investigation there was unmistakable evidence that the coroner and jury had prejudged the case from the start.

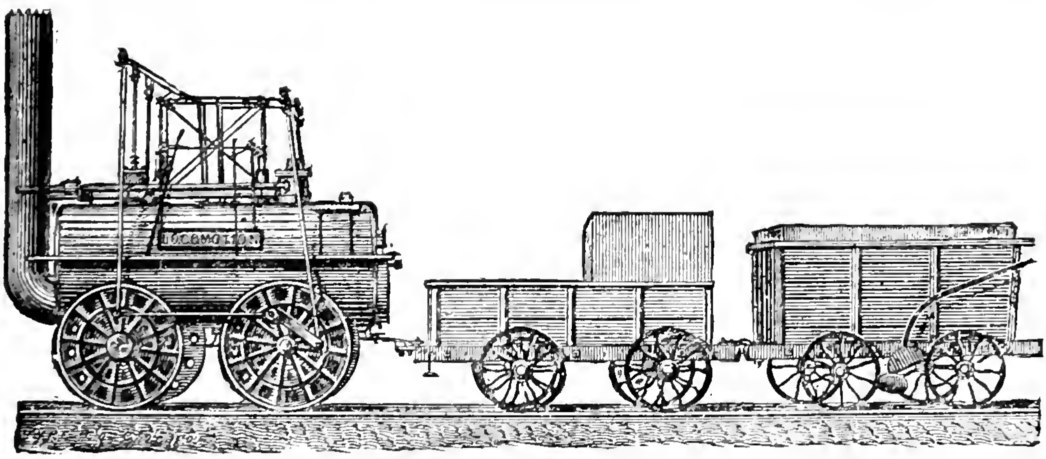
The Emery Testing Machine at the Watertown Arsenal.

We have read with no little interest the letter of Col. T. T. S. Laidley, U. S. A. Commandant at Watertown, to the *Iron Age*, giving an account of the work being done on the Emery Testing Machine. It has been our privilege to spend some time with Mr. James E. Howard, the operator, and to witness some very important tests which were made on boiler plate and riveted joints. We believe that these tests, when published, will have a very important bearing on boiler construction. We regret that they cannot be published as they are made. The deep interest which Col. Laidley and his assistants have taken in these experiments is worthy of all commendation, and engineers will find in the reports when published much valuable information that cannot be gained from any other source. If any plan can be adopted by which engineers can be put in possession of the results as they are made, it would be a great improvement. But we doubt if men could be found who would show more interest in the work than those now in charge.

Through the courtesy of the editors of the *Industrial World*, we are able to reprint the following interesting article which appeared in a late issue of their paper.

The First Locomotive Engine.

The accompanying engraving is a correct representation of the first engine ever employed on a railroad, and is copied from a photograph taken by Mr. Peter Rhodes, of Darlington, England. The engine itself is now to be seen standing opposite the depot building in that city. It was built by George Stephenson, the celebrated engineer, in



THE FIRST LOCOMOTIVE ENGINE.

1825, and is the identical engine that pulled the first train of passenger coaches ever drawn by steam, a mention of which was made by a correspondent of the *Industrial World*, of November 24, 1881. This engine was in continuous service on the Darlington & Stockton railway, from 1825 to 1858, when it was relieved from duty, and has since been on exhibition, as above stated.

It may be imagined, from the peculiar construction of the working gear of this engine, with its upright cylinders, massive cross-beams, and long connecting rods, that it was a cumbersome affair and, being painted black, it had an awe inspiring appearance.

The wooden tender had a box on top of the water tank, into which, at each depot, a supply of coal was passed out of the freight car, sufficient to run the engine to the next station.

The first style of brake ever used on railroads is also shown in the illustration. It consisted simply of a huge block of hard wood fixed on an iron pin, and having attached to it an iron lever. When applied, the brakeman placed the weight of his body upon the upper end of the lever, thus pressing the block of wood against the face of the two wheels. Placed side by side with the elegantly perfected locomotive of the present day, this engine, tender and freight car are quite suggestive of the marvelous progress made in railroading machinery, within the memory of men still living, inasmuch as the foregoing facts were furnished to us by a person residing in Iowa, who saw this engine make its first trip. We may further remark in this connection, that there were three persons who shared the honor of constructing and operating the Stockton & Darlington railway. One was George Stephenson, whose action in this regard we have already referred to, and whose subsequent history is known to the world. Another was Hon. Edward Pease, of Darlington, who is entitled to the honor of having been the first treasurer of any public railroad corporation. Mr. Pease was a highly esteemed and wealthy Quaker, and, being elected a member of Parliament, was the first of his denomination allowed to be enrolled as a member of that body without taking the usual oath of office. The other person was Richard Otley, Esq., who may be truthfully claimed as the first chief executive official connected with any railway corporation. In addition to being the secretary of the company, Mr. Otley was superintendent, manager, director and engineer. His son, J. W. Otley, Esq., now resides at Perry, Iowa, and, like his father, is distinguished as a railroad engineer and surveyor, having practiced his profession for about twenty-five years, a portion of the time as chief engineer of the old Des Moines Valley railroad, from Keokuk to Fort Dodge. Mr. Otley made a visit to Darlington a few years ago, and, on his return to the United States, brought with him the photograph from which our engraving is copied.

Boiler Explosions in England in 1881.

At the last monthly meeting of the Executive Committee of the Manchester Steam Users' Association, on Friday, February 3d, Mr. Lavington E. Fletcher, Chief Engineer, presented his report, from which we learn that during the past year 12,138 boiler examinations had been made. No explosion had arisen from any of the boilers under the inspection of the Association during the year, but twenty-five explosions had occurred throughout the country outside of its ranks, killing 35 persons, and injuring 40 others. These explosions had all arisen from simple causes repeatedly met with, and the greater number, at all events, might have been prevented by competent independent inspection.

Nine explosions, killing 21 persons and injuring 25 others, arose from the defective condition of the boilers; in one case accompanied with excessive pressure.

Seven, killing 4 persons and injuring 12 others, arose from malconstruction, coupled in three cases with defective condition, and in another, with caulking under steam pressure.

Five, killing 4 persons, and injuring 3 others, arose from excessive pressure.

Three, killing six persons, arose from overheating through shortness of water. As to the remaining one, no particulars had been obtained.

In addition to these twenty-five steam-boiler explosions, forty-one explosions, killing 8 persons, and injuring 11 others, had arisen from kitchen-boilers during the frost at the beginning of the past year. These explosions were due to an accumulation of pressure caused by the choking of the outlets with ice, and might have been prevented by the adoption of a small reliable safety-valve.

The report attributed the recent locomotive boiler explosion on the Northeastern Railway at Stockton, by which five persons were killed, to overheating of the furnace-crown through shortness of water. The boiler was lifted from the ground, turned bottom upwards, and thrown on to a truck in a goods-train standing in advance. The Association had recorded sixty-six locomotive boiler explosions since the year 1861, a large proportion of which arose from internal grooving at the longitudinal seams of rivets in the barrel. This source of danger, however, was now guarded against by more frequent internal examinations, and in many cases by the adoption of double butt-strips at these seams, one inside, and the other out, the object of which was to prevent the buckling action which gave rise to internal grooving. An internal examination of a locomotive boiler involved taking out the tubes, but this it was thought was an expense that ought to be faced in the interest of the public safety, at least once every three years.

The average working results of 33 economizers, or feed-water heaters under inspection were as follows: Temperature of gases on entering the economizer, 584 degrees; on leaving, 392 degrees; fall, 192 degrees. Temperature of the feed on entering the economizer, 95 degrees; on leaving, 217 degrees; rise, 122 degrees.

The Manchester Steam Users' Association is promoting a bill in Parliament for the prevention of steam boiler explosions, the scope of the measure being to provide a more searching investigation of boiler explosions than that at present made by the Coroner's court, and also to secure such an investigation, whether the explosion be fatal or not.—*Engineering.*

The Cause of Boiler Explosions.

Gas caused by the decomposition of water and ignorance in the person using the boiler at the time of the explosion. There is not a particle of steam in the boiler, and it does not matter as to the amount of pressure in the boiler whether it is one pound or 100 pounds to the square inch, if it takes fire it must go. It does not matter whether the boiler is new or old, weak or strong, or how many safety-valves there are on it, or where the water is, gas is liable to occur at all stages of water—more liable when the water is low. Now, what is wanted to prevent boilers from exploding is for all men firing under boilers to know when gas occurs, and what to do. A sickish sweet smell, and the absence of steam is a sure indication of gas. Wet out your fire immediately, and let the fire door be open. Let on a full supply of water. No steam will evaporate as long as gas has the ascendency. If there is any wood-work near the safety-valve, do not let off the gas, or it will fire the wood. The price of safety is eternal vigilance. Nine-tenths of all the explosions may be prevented by the proper information being acquired by persons using steam boilers. The Portland explosion was gas and ignorance combined.

JAS. CARPENTER, *Forty years an engineer.*

The above is copied *verbatim* from the *Louisville Courier-Journal*, and taken altogether is about as laughable a piece of nonsense as we have seen for some time. The ideas advanced completely destroy all chance of safety in the use of steam. We infer from his opening statement, that explosions arise from "gas caused by the decomposition of water and ignorance" in the fireman. We must confess to our utter ignorance of the nature and properties of gas generated by "the decomposition of water and ignorance," but presume it must be something terrible. Some of our chemists should study this wonderful chemical compound, and enlighten an anxious community on the subject.

Now it is evident to the ordinary unbiased observer, that the persons of all firemen are either liable to be afflicted by gas caused by the "decomposition of water and ignorance" or else they are *not* liable to be so afflicted. This we hold to be self-evident. Now in his first sentence he says explosions are caused by the *decomposition* of water and ignorance, and in his last paragraph he says, the Portland explosion was gas and ignorance *combined*. Now if the *decomposition*, or *combination* of these strange chemical substances are equally dangerous and destructive, what are we poor mortals to do? Every avenue leading to safety seems to be completely closed. We confess our inability to see any very close connection between any gas which may be generated *in* the person using the boiler, and the safety of the boiler, but then we haven't been "Forty years an engineer," and don't claim to know everything. Perhaps we will grow wiser as we grow older. At any rate we don't propose to allow any more firemen to have anything to do with water in any form. This will prevent any further trouble from that source, at all events.

But we must forbear to comment further, as we feel that any efforts we can make to say funny things, will be completely overshadowed by the sublime humor displayed by the article in question.

Webb's Compound Locomotive.

To Mr. Webb, locomotive superintendent of the London & Northwestern railway, is due the credit of being the first English engineer who has in recent years produced a startling novelty in locomotive engines. In France, Belgium, and Austria remarkable specimens of locomotive construction are turned out every now and then; and America has recently come to the front with the Fontaine locomotive. But in England we have preferred to follow the even tenor of our way simplifying details, adopting better methods of putting work together, and rendering engines more substantial and more serviceable, refraining from making excursions into unknown regions of invention; and it can hardly be disputed that the result of this policy has been on the whole satisfactory. This, however, is no reason why departures should not be made now and then from the beaten path of locomotive construction, and to condemn Mr. Webb's design hastily or without due thought would be rather worse than foolish. For the present Mr. Webb is reticent about the engine, and naturally so. It will be time enough to bring it prominently before the world when it has done some work. It will then form the subject, no doubt, of a paper to be read before the Institution of Mechanical Engineers. Meanwhile, we can at least satisfy the curiosity of our readers concerning its prominent peculiarities, though we can do little more.

The new engine has been constructed at Crewe, and is similar as regards boiler, wheels and so on, to the four-coupled express engines of the London & Northwestern railway, with which all English engineers, at least, are tolerably familiar. The trailing-drivers are driven by a pair of outside cylinders, 11½-inch diameter and 24-inch stroke, secured to the side frames at a point just in advance of the leading driving-wheels. The piston-rod heads are guided by two flat bars, one at each side, instead of four, as usually employed, the crosshead being channelled to slide on the bars. The slide valves are worked by Joy's patent gear, and the connecting rods lay hold of pins in the wheel-bosses. So far we have a complete engine with outside cylinders and a pair of driving-wheels behind the fire-box, the whole closely resembling Crampton's patent engines, of happy memory. In the smoke-box, right beneath the funnel, is fixed a third cylinder, 26-inch diameter and 24-inch stroke, the connecting rod of which lays hold of the pin of a single crank in the middle of the length of the leading driving-axle. The exhaust steam from the two small cylinders passes into a kind of gridiron of pipes between the engine frames, which pipes act as an intermediate receiver, and from thence it is led into a copper pipe coiled in the smoke-box, in order that it may be reheated and dried. Thence it goes into the valve-chest of the large cylinder. We have thus a locomotive with a single pair of driving-wheels in advance of the fire-box, driven by a single cylinder. It must be understood that the Crampton engine and this single cylinder engine are quite independent of each other—that is to say, each may run at any pace it can. There are no coupling-rods, nor is there anything to maintain a fixed relative position between the cranks of the single and double cylinder engines, save the rails. The single engine depends for its supply of steam on the double cylinder engine, and should the latter slip, more steam is sent into the receiver than the large cylinder will take, and the back pressure rises, and so tends to check slipping; while for the same reason the pressure on the large piston is augmented, and it may slip its wheels. If, on the contrary, the single engine slips first, it will take more steam away than the other engines can supply, and its own pressure will fall off while the effective pressure in the other cylinders will be augmented. It is found that this controlling action operates very effectually, each engine doing its own share of the work fairly. No inconvenience results from the changing position relations of the crank-pin, the size of the intermediate receiver being sufficient to prevent irregularities in the amount of back pressure of much moment. With a boiler pressure of 120 pounds the pressure in the receiver averages about 50 pounds. Such, then, briefly stated, is Mr. Webb's compound locomotive. It is a handsome engine, and has been run at very high speed with perfect steadiness.

Mr. Webb has not, we need hardly say, adopted so abnormal a design for a whim. On the contrary, he expects to derive important advantages from this system of construction; and it is not too much to say that of the many compound locomotives which have been proposed and patented, this is immeasurably the best. He claims, in the first place, that he gets all the advantages of a coupled engine without its disadvantages. Now, practically, the advantages and disadvantages of coupled and uncoupled engines resolve themselves into a question of coal bills. Mr. Stirling has stated that a coupled engine will burn from 1 pound to 2½ pounds of coal more per mile than an uncoupled engine; but other locomotive superintendents say that on the whole the advantage is with the coupled engines, because they do not slip, and nothing wastes fuel more than slipping, which tears a fire to pieces, besides throwing away steam. In lieu of two coupling rods, with such frictional resistance as they set up, Mr. Webb gets an extra complete engine. It can hardly be possible that the frictional resistance of all kinds caused by coupling an engine can be as great as the resistance of a piston, valve-gear, cross-head and connecting rod. Secondly, Mr. Webb claims that by working his steam through two engines in succession, he will get great economy of fuel. On this point, also, there is much room for doubt. The first cost of the locomotive is, of course, in excess of that of a locomotive of the same power of the ordinary type; and there are three engines to be kept in repair and lubricated instead of two. These points must not be overlooked. Now, the objections to sending an engine into the shops for repairs are so great that all locomotive superintendents are straining every nerve to get the largest possible mileage out of their stock; so that there is reason to conclude that there must be not only a saving in fuel, but a very substantial saving effected by Mr. Webb's engine, before it can be regarded as a success. The locomotive has already done a good deal of hard work in, we understand, a most satisfactory manner, and so far as can be ascertained, there is reason to anticipate that a saving of fuel will be effected; how great no one at present knows. Mr. Webb is very well satisfied with the results he has obtained so far. The experiment will be watched with interest by railway engineers all over the world, and we wish Mr. Webb that success which his skill and inventive talent deserve. —*The Engineer.*

How Long may a Boiler be Used?

There has been considerable discussion lately concerning the life of a steam boiler in active service. Some very remarkable statements have been made, and many absurd reasons advanced for the purpose of making the public believe that after a boiler has been used just ten years, it suddenly becomes dangerous and unfit for further use.

It is an unfortunate fact, that more nonsense has probably been written on the subject of steam and steam boilers, than any other one thing in the world. A great part of this nonsense emanates from those who are interested in the manufacture and sale of patented humbugs; this class of people generally have little or no knowledge of what they are talking about, and no regard whatever for the interests of the steam-users for whom they profess so much solicitude.

There is no more reason why a steam boiler should be condemned at the end of ten years' service, than there is for condemning any other engineering structure at the end of that time. A steam boiler, properly made of good materials, and used with proper care, will run for twenty-five years with perfect safety and economy; on the other hand, the same boiler may be utterly ruined or blown up, inside of twenty-five hours from the time it is first fired up.

A great deal has been said and written about iron losing its strength and becoming crystallized through long use. Cases have occurred where this has apparently been the result of long usage in steam boilers, but if all the facts were known, it would probably transpire that the iron was *originally* defective, or had been repeatedly overheated. For there is abundant proof that long service, *per se*, does not render good iron brittle. The writer knows of a case where the plates of a boiler taken out a few months ago, after twenty-six years of active service, showed no deterioration of quality whatever, and incontestible proof of that is furnished in the fact that the shell-plates were flanged and put into the heads of other boilers, and they stood the test of flanging in the most satisfactory manner. Surely if ten years' service is sufficient to ruin good iron, these shell-plates would not have stood the test of flanging after nearly three times that length of active service.

But the falsity of the position taken by these people who advocate the "ten years' service hit or miss rule," is shown by the fact that no two of them advocate it for the same reason. The originator of the idea based his reasons for it, on the alleged deterioration of iron through long usage. Another later advocate of the same thing, who seems to have no very clear idea of what he is writing about, advocates it because, "when a boiler has been used long enough to need patching, then it is time to throw it into the scrap-heap." His remarks seem intended to convey the notion that when a boiler is just ten years old, it must of necessity be patched. He seems to be totally oblivious of the fact that most patches are put on for entirely different reasons than the one he gives, viz., "when a boiler needs patching, it has been worn down thin." He ought to go out among boilers awhile, and see what is going on, and then, perhaps, he wouldn't display such utter ignorance of his subject.

Looked at in any light, the idea that boilers should be limited by law to ten years' service, is a most pernicious one. The practical working of such a law would have precisely the opposite effect to that intended. Boiler owners, knowing that the use of their boilers was limited to a certain invariable term, would strive, and justly too, to get all the work out of them that they could in the allotted time. The natural consequence would be, to force the boilers beyond their limit, they would not be so particular in regard to their care as they are now, and the inevitable result would be a great increase in the number of explosions. We think any one who denies the force of this reasoning, would be convinced of its truth after a short practical experience under the working of such a law as that proposed.

There are steam boilers under the care of this company which have been in continuous service for upwards of eighteen years, that are as perfect now as they were the day they were put in. Clean, free from scale or sediment, leaks have never occurred, fractures, grooving and corrosion are unknown, and they are apparently good for years more of service. On the other hand, new boilers of the best material and workmanship, have been totally ruined and condemned inside of a year from the day they were first fired up. What would have been the practical working of the ten year rule in such cases as these? In the first, it would have been downright robbery of the owners of the boilers; in the second, it would have been simply the death warrant of any person, who, by an unfortunate chance happened to be within range of the flying fragments when the final catastrophe occurred. H. F. S.

Distance apart of the Supporting Lugs on Boilers.

As there seems to be a wide difference of opinion and practice regarding the proper distance apart of the supporting lugs of steam boilers, perhaps a few words in regard to the matter may not be out of place here.

There is a wide diversity of practice among the different boiler makers on this point, some never putting more than two sets of lugs on all the ordinary proportions of boilers, and others almost invariably putting on three sets. Let us examine the matter briefly, and see if we can arrive at any definite conclusion.

It is evident that an ordinary steam boiler, filled with water and supported by lugs resting on the walls on either side, is in the condition of a beam of an annular cross-section, with the load uniformly distributed. The general formula for the breaking weight of such a beam is as follows:

$$\text{Breaking weight} = \frac{3.1416 \times \text{square of diameter} \times \text{thickness} \times \text{tensile strength},}{\text{length in inches between supports.}}$$

when the load is concentrated at the center; when the load is uniformly distributed it will sustain just *twice* as much.

Let us take for example a boiler 60″ diameter, 15 feet long, shell $\frac{5}{16}$″ thick, 66 three-inch tubes with supports 12 feet apart. Then by the above formula, the uniformly distributed load required to produce failure, would be 2,236,528 pounds. This result we must reduce about four-fifths to allow for the diminished section of the shell at the girth-seams, and this result about one-tenth more to allow for the straining action due to the steam pressure on the heads; this leaves us in round numbers, 1,200,000 pounds as the breaking weight, which divided by a safety factor which should not be less than 10, gives us 120,000 pounds, which may be safely distributed upon the boiler-shell.

The weight of that portion of the boiler-shell between the supporting-lugs would be about 2,500 pounds, and of the water contained therein, about 7,500 pounds. This gives 10,000 pounds as the weight distributed through the boiler, which we have just seen is capable of safely sustaining about 120,000. This shows that for the ordinary sizes and proportions of boilers, two sets of supporting lugs are amply sufficient. This view is also borne out by the behavior of such boilers in daily use, as they never give out by "breaking their backs," as it is called.

With the smaller sizes however, especially when they are of great length, we must deal cautiously. Let us suppose we have a plain cylinder boiler, 36″ in diameter, and 32 feet long, shell $\frac{1}{4}$″ thick, supports 25 feet apart. We shall find in this case by the same process as above, that 8,000 would be the limit of the load, while the weight of the boiler and its contained water, would be about 10,000 pounds as before. In this case our factor of safety would be reduced to eight, which is not sufficient, as is shown by the fact that many iron work boilers of substantially the above proportions, have exploded disastrously by rupturing at their girth-seams.

In the above examples we have neglected the influence of that portion of the boiler-shell which overhangs the supports at each end, not only for the purpose of simplifying the calculation, but because in many cases the supports are placed so near the ends of the shell that it does not materially influence the strains between the supports. In many cases, however, this might be taken advantage of, by riveting on the lugs at such a distance from the ends of the shell, that the strain produced on the top of the shell by the weight of the overhanging part, shall be equal to that on the bottom of the shell by the weight between the supports; by this means, the straining action would be reduced to a minimum, and to a great extent equalized. In many instances this arrangement would undoubtedly be preferable to three sets of lugs, especially where there is no provision made for the middle lug to adjust itself to the varying position of the central portion of the boiler, due to expansion of the under shell of the boiler.

A good "rule of thumb" for placing lugs on boilers is to put them *not over* 4 diameters apart. Thus in the case of the 60-inch boiler in the first example, two sets of lugs will be found sufficient, unless the boiler is above 20 feet long; while in the case of the 36″ boiler, a support would be required every 12 feet. Where only two pairs of lugs are used, a convenient method of locating them will be to divide the distance between the tube-sheets into six equal parts, and place the lugs each one of the parts from the tube-sheet. Thus in the case of a boiler 15 feet between heads, place the center of the rear supports $2\frac{1}{2}$ feet from the end of the boiler, and the center of those at the front end, $2\frac{1}{2}$ feet back of the front tube-sheet. By this means the strains are very evenly distributed.

H. F. S.

At the late fair of the Massachusetts Charitable Mechanic Association, at Boston, examples were shown of tests of materials made by the machine lately erected in the United States Government Arsenal, at Watertown, for the proving of structures of full working dimensions. A steel wire cable, $1\frac{3}{4}$ inches in diameter, was shown, which had withstood a pull of 75 tons, when the fastenings by which it was held gave way, although the cable itself remained sound. A hammered iron bar 6 inches in diameter, was shown to have concealed a crystalline formation of the fibres, and it consequently parted with a loud report under a strain of nearly 723,000 pounds, or 36,900 pounds to the square inch. A smaller wrought-iron bar drew down and broke with a fibrous structure under a pull of 51,240 pounds per square inch. Some pine wood columns were also shown which had been tested by compression. The first of these, originally 12 feet long, yielded at a pressure much below its estimated strength, in consequence of a large knot in the side which acted as a comparatively incompressible wedge. Another column was a spar 12 feet long, $7\frac{3}{4}$-inch butt, and a $6\frac{1}{2}$-inch top. This stick was a perfect sample, and gave way by splintering at its smaller end. A seasoned hard pine girder, 11 inches square and 10 feet long, bore a load of 751,000 pounds.

We are indebted to *The Insurance World*, of Pittsburgh, Pa., for a very neat and comprehensive Fire Insurance Chart. It has the statistics showing the standing of the principal companies doing business in the country, also a list of those which have retired from the field in the past five years. The chart is valuable to insurers. Send for a copy.

Avoid Waste.

Every man in a workshop ought to constitute himself the guardian of his employer's property, and not only should he avoid waste himself, but as far as practicable he should discourage it in others. If this were done, millions of dollars would be saved to the country, a much larger percentage of profits would go into the pockets of the employer, manufacturers would be enriched, and, in the end, the workmen would be proportionately benefited. Strange that these simple facts should have so simple weight, but so it is. Waste by another is cruel to the man who has to pay; it does not, cannot benefit the person guilty of it, and it is a dead loss to the nation; and every scrap of material so destroyed makes the product more costly, and consequently dearer. In the interest of workmen it is important that these facts should be borne in mind. Wages bear a relative proportion to cost of raw materials, and both combined determine the price of commodities: the cheapness of the latter augments their sale, increases their production, enhances the demand for labor, and tends to keep up wages; the reverse is wholly true. If, therefore, an obvious duty is neglected or carelessly performed, the men mainly responsible ultimately suffer, and that suffering will be in an exact ratio to that which produced it.

One great remedy for the losses incurred by waste is a closer supervision of every detail of the undertaking, whatever it may be. This, however, involves extra expense. If the men can contribute to a saving, in this respect, they will indirectly reap the advantage. To overlook this fact shows a lamentable ignorance of the internal economy of a workshop, and of the forces and influences always at work for the purpose of bringing about a given result. The men who complain of strict supervision are just those who need it most, and who, without it, would render large contracts next to impossible, for the simple reason that they would not pay, and therefore could not be executed. Many a builder and contractor has been ruined by the wastefulness of his employees and negligence of his foreman. A careful man is a jewel in a workshop.—*Builder and Woodworker.*

Noises in Steam Pipes.—The primary cause of the loud hammering noises that are often so annoying to occupants of apartments heated by steam pipes, is the condensation of steam in the system of pipes. When the steam is first turned on, it takes some time for the pipes to become thoroughly heated, and the steam in contact with the cold metallic surfaces condenses. This water of condensation is further cooled off by contact with the metal and in turn condenses the steam immediately in its vicinity, with more or less suddenness. The pressure being thus removed from one side of the water column, the body of water is driven by the elastic force of the air behind it, violently into the space occupied by the condensed steam, and, striking against the bends of the coil or the valves, it causes the cracking or hammering noise referred to. The water body is again driven forward by the steam, and it again condenses it, and the knocking is repeated, the blows often succeeding each other with great rapidity. Or some of the steam after admission may become shut off by the condensation between the two bodies of water, and the noise will then be caused by the violent impact of the two bodies of water rushing together to fill the vacuum. The familiar experiment of the "water hammer" will explain how, in the absence of any resisting body like the air or other elastic body, a mass of water will strike a resisting surface with all the effect of a solid body. On account of the inconvenience experienced from this cause, provision is always sought to be made in steam heating apparatus to provide for drawing off the water of condensation in traps, thus removing it from the pipes and coils as rapidly as it accumulates. When the steam is shut off, the condensation of the residual steam in the pipes and coils may produce the same hammering noise, though to a less degree than immediately after its admission.—*Milling World.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

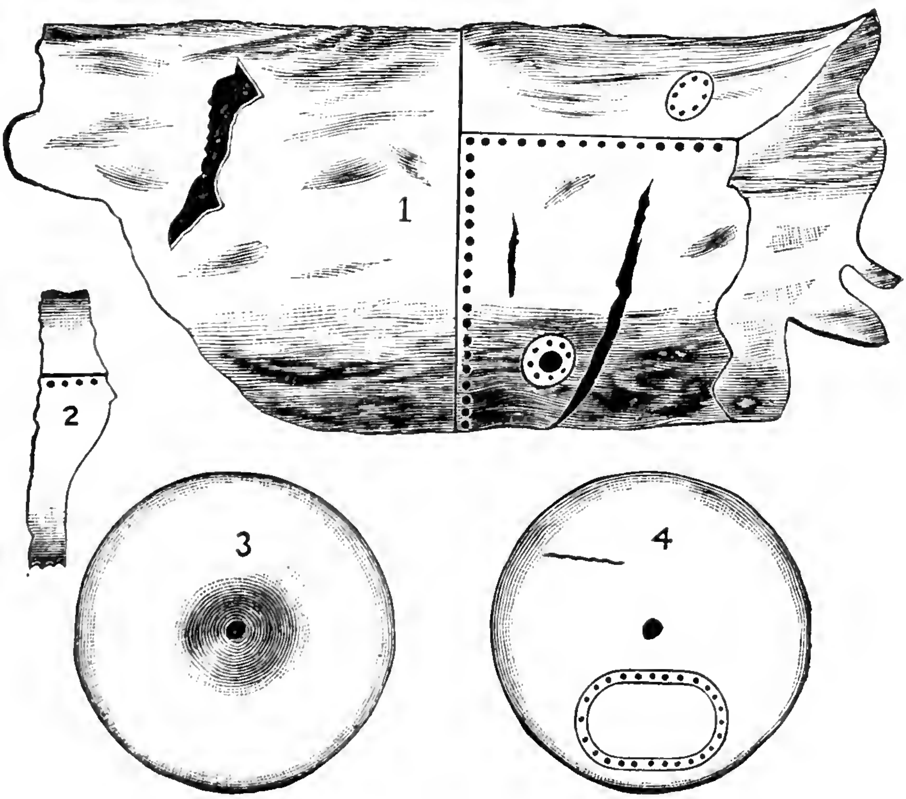
NEW SERIES—VOL. III. HARTFORD, CONN., APRIL, 1882. No. 4.

Report of the Experiments on Boiler Explosions.

MADE BY MR. D. T. LAWSON, AT MUNHALL FARM, NEAR PITTSBURG, PA.

The test made in February last, was a failure. The following are the details of the next attempt, March 7, 1882:

The boiler used was of the plain cylinder type, 5′ 9″ long, 2′ 6″ diam., shell $\frac{3}{16}$″ thick, single riveted; iron branded 56,000 T. S., heads $\frac{3}{8}$″ thick, stayed with one rod running through from head to head, with nuts outside screwed against each head. Height of water at beginning of experiment was 14″, leaving 16″ for steam space. The steam guages used were made by Wm. Kirkup & Son, of Cincinnati, Ohio.



The object of the experiments was to demonstrate the truth of the theory held by Mr. Lawson that boiler explosions are caused by the opening of a valve, whereby the steam escapes, and the highly heated water remaining in the boiler thus relieved from pressure, suddenly flashes into steam, producing a concussion great enough to explode the boiler. The following table shows the results attained:

Time of opening the valve.	Steam pressure.	The pressure fell.	And rose afterward.	Time of opening the valve.	Steam pressure.	The pressure fell.	And rose afterward.
12–00 M.	100	15	5	12–38	180	17	4
12–20 P.M.	115	10	3	12–39½	190	15	11
12–28	130	7	5	12–41	195	15	9
12–31	150	9	7	12–42½	200	15	7
12–34	155	13	5	12–44	205	13	4
12–35	160	13	7	12–46¾	210	15	15
12–36	170	15	5	12–51	215	7	4
12–37	175	14	5				

At this point the front head of the boiler gave out and operations were suspended until it could be repaired. At 4.41 P.M. the experiments began again.

Time of opening the valve.	Steam pressure.	The pressure fell.	And rose afterward.	Time of opening the valve.	Steam pressure.	The pressure fell.	And rose afterward.
4–41 P.M.	70	3	4	5–24 P.M.	215	20	12
4–42	75	7	7	Leaking so	badly that	steam be-	gins to fall.
4–44	80	3	3	5–26	220	12	7
4–48	85	5	5	5–27	215	15	7
4–49	90	5	8	5–28	210	6	10
4–52	100	4	3	5–29	205	8	7
4–54	110	5	5	5–30	195	7	2
4–56	120	8	5	5–31	180	7	2
5–00	150	15	10	5–32	175	7	2
5– 3	165	15	10	5–33	165	5	
5– 6	175	15	7	5–34	155	5	
5– 8	185	15	15	5–35	150	5	
5–14	200	12	12	5–36	145	5	
5–18	210	20	12	5–37	140	5	

At this point the boiler leaked so badly that the experiments were stopped. On examination it was found that Mr. Lawson had been a victim of the drift-pin; the hole in the front head for stay-bolt being drilled too small, the boiler-maker had drifted the hole and fractured the sheet in three places, and when the pressure was up to 220 pounds, the shock the boiler received caused the fractures to extend, so that operations were suspened until the head could be repaired, which was done by bolting on a piece of boiler plate, over and around the hole. Thus ended the first day's experiments.

Second trial, March 8, 1882.

Time of opening the valve.	Steam pressure.	The pressure fell.	And rose afterward.
5–41½ P.M.	100	5	5
5–59½	125	12	5

At three minutes past six the steam pressure had fallen to 120 pounds and the experiments were stopped. This was caused by leakage around the tap bolts that were used to fasten the patch to front head. It now began to look as though it would be with Mr. Lawson as it was with the Government experts when they tried to explode new boilers, and only succeeded in straining them so that they leaked so badly that the leaks became safety-valves.

The third trial, March 10, 1882.

At 11.35 A.M. the steam-gauge registered ten pounds. The pressure gradually increased to 175 pounds at 12.04 P.M. when upon attempting to open the valve it was found to be stuck, and as no one dared to approach the boiler to open it, everyone remained in the bomb-proof and awaited the result. At 12.13 the pressure had reached 275 pounds, when the boiler sprung a leak and the pressure began to fall. It was then decided to abandon that boiler and experiment with the one which was provided with Mr. Lawson's Patent Diaphragm, which is simply a perforated plate running from end to end of the boiler above the water-line.

The fourth trial, March 20, 1882.

Boiler provided with Lawson's Patent Diaphragm.

At the trial of this boiler in February last it was not exploded.

Time of opening the valve.	Steam pressure.	Gauge in steam above plate.		Gauge below plate.		Time of opening the valve.	Steam pressure.	Gauge in steam above plate.		Gauge below plate.	
		Down.	Up.	Down.	Up.			Down.	Up.	Down.	Up.
12–50½ P.M.	50	3	7	0	3	1–15	175	23	15	10	10
12–59	75	7	10	0	4	1–21¼	200	20	20	0	15
1–3½	100	7	12	3	5	1–29¾	225	20	30	0	12
1–8½	125	15	15	4	8	1–38	230	30	40	0	10
1–11½	150	20	20	7	8						

At this point the steam went up so slowly that the experiments were interrupted to build a fresh fire.

Time of opening the valve.	Steam pressure.	Gauge in steam above plate.		Gauge below plate.		Time of opening the valve.	Steam pressure.	Gauge in steam above plate.		Gauge below plate.	
		Down.	Up.	Down.	Up.			Down.	Up.	Down.	Up.
2–43 P.M.	225	20	25	5	10	2–49¾	275	25	30	5	15
2–46½	250	25	30	5	15	2–57½	300	30	40	0	15

After reaching 300 pounds as above it was concluded to stop this trial, remove the diaphragm, and try this boiler without it. On cooling down the boiler was found in good condition, every seam being tight and showing no signs of having been strained.

The fifth trial, March 22, 1882.

Boiler with diaphragm removed.

Time of opening the valve.	Steam pressure.	Upper gauge.		Lower gauge.		Time of opening the valve.	Steam pressure.	Upper gauge.		Lower gauge.	
		Down.	Up.	Down.	Up.			Down.	Up.	Down.	Up.
2–10 P.M.	10					2–31¾	100	3	0	3	0
2–15¾	25					2–35¾	125	3	0	3	0
2–20¾	50					2–38	150	5	0	5	0
2–26	75					2–41	175	4	2	3	2

At this point the steam was blown down to allow the brickwork to dry, the boiler having been re-set; and to replenish the fire.

Time of opening the valve.	Steam pressure.	Upper gauge.		Lower gauge.		Time of opening the valve.	Steam pressure.	Upper gauge.		Lower gauge.	
		Down.	Up.	Down.	Up.			Down.	Up.	Down.	Up.
3–2	175	5	0	5	0	3–7¾	225	5	0	3	0
3–4	200	5	0	5	0	3–8	235	5			
3–5¾	210	3	0	3	0						

At 235 pounds pressure as the valve was opened the boiler violently exploded. The main portion of the shell was thrown a distance of about 1,000 feet, with such force as to cut off the tops of several trees that were in its course.

The sketches on first page show the appearance of the principal fragments into which the boiler was torn. No. 1, is the shell, No. 2, a smaller piece of the shell, No. 3, the front head, and No. 4, the back head in which the manhole was placed; this piece landed on top of the bomb-proof where the observers were posted.

Capt. Fehrenbatch, Supervising Inspector for the Seventh District, and Messrs. Atkinson and Batchellor, Local Inspectors for the government, located at Pittsburg, assisted per order of the government, and Mr. A. C. Getchell, Chief Inspector for the Cleveland, Ohio, Department, represented the Hartford Steam Boiler Inspection and Insurance Company.

Pieces of shell were tested after the explosion by Capt. Fehrenbatch, on a Riehlé testing machine, and found to have a tensile strength of 61,449 pounds per square inch, which is remarkably strong for iron boiler plate. From the foregoing results it is probable that many destructive boiler explosions may be averted by the use of Mr. Lawson's apparatus, still it is evident that it cannot influence the effects of varying expansion, crystallization, corrosion, and other kindred defects, and that boilers must still be very carefully watched and often inspected.

A. C. GETCHELL, *Inspector.*

Inspectors' Reports.

FEBRUARY, 1882.

Below is given the summary of the inspectors' reports for the month of February last. From it we learn that the number of visits made was 1,681; the total number of boilers examined was 3,685; the total number inspected internally was 1,401; the number tested by hydraulic pressure was 349; and the number condemned was 33.

The whole number of defects reported was 1,464, of which number 391 were considered of so serious a nature as to impair the safety of the boiler. A list of the defects in detail follows:—

Nature of defects.	Whole number.	Dangerous.
Cases of deposit of sediment,	208	42
Cases of incrustation and scale,	300	41
Cases of internal grooving,	11	6
Cases of internal corrosion,	68	15
Cases of external corrosion,	101	35
Broken and loose braces and stays,	33	21
Settings defective,	6	0
Furnaces out of shape,	77	17
Fractured plates,	141	81
Burned plates,	76	39
Blistered plates,	191	29
Defective rivets,	2	0
Defective heads,	3	0
Serious leakage at seams,	1	0
Serious leakage around tubes,	6	0
Water-gauges defective,	25	6
Blow-out defective,	22	11
Cases of deficiency of water,	7	5
Safety-valves overloaded,	37	12
Pressure gauges defective,	141	30
Boilers without pressure gauges,	8	1
Total,	1,464	391

The question of the relative value and efficiency of the hydrostatic and hammer tests has been again brought to the notice of the general public, through the medium of the daily press, which has freely discussed the circumstances of the late explosion at Jewell's Mills in Brooklyn, N. Y. As many of the ideas which have been advanced in regard to this subject are well calculated to mislead the general reader, we will endeavor to present the subject in its true light.

The first question that naturally arises in a discussion of the subject is: What is the object of the hydrostatic test? Primarily, to ascertain if the boiler is capable of sustaining some given pressure, somewhat in excess of the required working pressure; if it does satisfactorily sustain this pressure, then it is assumed that the boiler will be safe under the conditions of practical use at the working pressure. Secondly, to test the tightness of the joints and the quality of the work generally.

The next question that arises is:—What is the pressure which is best calculated to fulfill the above requirements without injury to the boiler? In seeking an answer to this question we obtain some idea of the true value of the hydrostatic test.

The following are some of the official rules and regulations regarding the testing of boilers:

The United States laws prescribe that the pressure applied under the hydrostatic test shall be $1\frac{1}{2}$ times the working pressure. Thus, a boiler to be worked under a steam pressure of 80 pounds per square inch would be subjected to a hydrostatic pressure of 120 pounds; when the working pressure is to be 90 lbs., the test pressure would be 135 pounds, and so on.

The French laws require a test pressure double that of the working pressure. This must be applied to merchant vessels at least once a year; in the case of naval vessels, the boiler when new must be tested to twice the working pressure, and annually afterwards to one and one-half times the working pressure.

The English Board of Trade rules prescribe a test pressure double the working pressure.

Various other authorities recommend a test pressure of from $1\frac{1}{2}$ to 3 times the working pressure. Thus it will be seen that there is a wide diversity of opinion on the subject, from which it is fair to infer that its efficiency in some cases may be very doubtful.

Let us consider the matter briefly. It may be considered to be reasonably well settled that iron cannot be strained beyond its elastic limit without serious and permanent injury. Also, it may be considered equally well demonstrated that it may be strained nearly up to its elastic limit without injury. The only doubtful factor in the question is the exact point of the limit of elasticity of any given piece of material. This can only be determined by actual test of the specimen. The elastic limit of *ordinary* iron boiler plate is about 20,000 pounds per square inch of section. We will apply these facts to a case in practice.

Suppose we have a boiler 60″ in diameter, made of $\frac{5}{16}$″ plate, longitudinal seams double riveted. And here we would caution one to beware of the average double riveted seam. It is generally supposed to be 20 per cent. stronger than a single riveted seam, in the same plate; but where the pitch is the same as in the single riveted joint, as most boiler makers make it, it cannot be materially stronger. *We must in every case reckon simply on the amount of plate section left between the rivet holes after they are punched.* Suppose, then, that the plates are stamped 45,000 T. S. The tensile strength is not an accurate measure of the elasticity, but with plates marked as above the elastic limit for practical purposes may be taken at 20,000 pounds. Further, suppose our double riveted seams have rivets pitched 2″ apart from center to center, and that the rivet holes are $\frac{13}{16}$″ diam.; this is a very common proportion for this joint. Then the proportion of plate cut away for the rivets is $\frac{13}{16}$ divided by 2, = .4. This subtracted from 1 leaves us .6 of the area of original plate, which should be taken as the *efficiency* of the joint.

Now then, we shall have for a pressure which will strain the material of the shell to its elastic limit $\frac{20{,}000 \times \frac{5}{16} \times \frac{6}{10}}{30} = 125$ pounds per square inch. But we should never subject a boiler to a strain *quite* as high as the theoretical elastic limit. We must make an allowance for unavoidable imperfections in the workmanship, otherwise we would inevitably strain some part of the boiler a little beyond the limit of elasticity, and thus do it an injury. As we may safely fix the working pressure at one-half of that due to the elastic limit, in this example it would be, say, $62\frac{1}{2}$ pounds; then if we applied a test pressure double the working pressure we would very likely seriously injure some portions of the shell. But if we apply only $1\frac{1}{2}$ times the working pressure, we keep within the safe limit and no harm can possibly be done. So we may conclude that $1\frac{1}{2}$ times the working pressure is about right for the hydrostatic test; *but*, the working pressure should be first calculated from the known strength of the plates and the proportions of the joint.

Of course the inspector or other person making the above test must satisfy himself of the strength of the other parts of the boiler, such as the flat heads, manhole frame, etc., before applying the test pressure. One thing in particular should he examine, and that is the joining of the braces to the crow-feet, or angle-iron on all flat surfaces. This is a part of the structure which is generally made deficient in strength, and should never be neglected or overlooked.

Having once satisfactorily withstood the hydrostatic test, what benefit is to be derived from repeated applications of it afterward at frequent intervals, when the boiler can be examined internally? This is the point on which the dispute in regard to its efficiency is really based, and we shall refer to it at length in some future number.

Plumbago as a Lubricant.

A fly-wheel shaft bearing, eight inches in diameter and ten inches long, carried a load of nearly ten tons. The bearing was supported on a box-girder, and was lined with good brass. The engine could not be run as this bearing invariably got nearly red hot after a few revolutions. Various oils, tallow, sulphur, and gunpowder, were tried with most indifferent success. By using a mixture of tallow and sulphur, the engine could be run half an hour at a time, and once or twice it was run a whole day, the shaft making sixty revolutions per minute. It was decided to have a new crank, and shaft with a longer bearing, but, as at the last moment the use of black-lead and tallow was suggested, a package of the ordinary black-lead used for stoves, was worked up with some tallow, the bearing carefully wiped, and the grease-box on the cap filled with the mixture. The bearing never heated again unless oil was allowed access to it. The success of the plumbago as a lubricant was perfect. It should be added to the foregoing, that, while the principle of lubricating by graphite or plumbago is scientifically correct, and has in thousands of instances been practically illustrated, it has been damaged seriously by the use of impure graphite. For perfect success the graphite should be perfectly clean.—*The Engineer.*

A Ghost Story.—About 9 o'clock on Sunday morning a boiler in Atwood & Mc Caffrey's machine shop on Third street, between Market and Ferry streets, exploded under very peculiar circumstances. The engineer and fireman had been engaged at cleaning the boiler and had run all the water out, pulled out all the fire, and taken the cover of the "man-hole" off, when suddenly the boiler exploded with great force, lifting the roof of the boiler-shed off its supports and otherwise injuring the sheds. No one was hurt, but what is puzzling the firm is what made the boiler explode when it was cold, empty and the man-hole open. Only one similar case has ever been reported, the latter having occurred in Akron, Ohio, some time ago.

The above was clipped from a Pittsburg paper. Our inspector, A. C. Getchell, being in Pittsburg at the time of the accident, called at Atwood & McCaffrey's to inquire into the cause. He found that the engineer had blown out the boilers preparatory to cleaning, and had put in a quart or more of *benzine* to start the scale. This mingled with the air forming an explosive gas. When the engineer opened the mud-drum, to examine its condition, the gas flowed out, and coming in contact with his lamp or torch was ignited, causing a violent explosion. We have never before known of benzine being used to remove scale. Crude pretroleum is sometimes used, mixed with the water to remove sulphate of lime scale—but never when the boiler is empty.

The Locomotive.

HARTFORD, APRIL, 1882.

Mr. D. T. Lawson's Experiments on Boiler Explosions.

The report of Mr. D. T. Lawson's experiment, on exploding boilers at Munhall Farm, near Pittsburg, will be read with interest. It is fuller in detail than any report which we have seen published. We have refrained heretofore from commenting upon these experiments because they had not accomplished all that Mr. Lawson claimed for his theory. Now that the experiments have been carried out according to programme it is time to give our opinions.

Mr. Lawson claims, as we understand, that the sudden release of pressure from a boiler, in quantities sufficient to greatly reduce the pressure for the moment, is liable to, and probably would, send the boiler in pieces, or in other words, the sudden release of pressure from a boiler under steam of ordinary, or what may be regarded as safe working pressure, may produce such a disturbance within as to cause an explosion of the boiler. This release of pressure may be produced by opening the safety-valve too widely and too suddenly, or it may result from a slight rupture primarily, in the shell of the boiler. We have held the opinion for years that a boiler might be injured seriously, if not exploded, by suddenly releasing the pressure, especially if the usual amount of water was in the boiler. The most destructive explosions of which we have had knowledge, have occurred in connection with boilers that have had a full supply of water. An accident occurred in this vicinity a few years since which confirmed this opinion. A manufacturer went into his boiler-room during the dinner hour. The engineer had pumped the water up to its maximum height, and gone to dinner. He had neglected, however, to shut the ash-pit doors, which in this case regulated the draft. The fire was burning brightly and the steam pressure exceeded the point indicated by the weight on the safety-valve lever. The inference was that the valve was "stuck," but instead of drawing or deadening the fires with ashes, and closing the drafts, the proprietor ran for the poker and threw up the safety-valve lever. The result was a violent commotion within the boiler. The safety-valve nozzle was instantly torn from the boiler, and together with valve, ball and lever, carried through the roof of the boiler-house and some distance beyond, across the highway. A column of steam and water shot up out of the opening, and the boiler was nearly emptied. It was strained and weakened but there was no rupture save that caused by tearing off the valve-nozzle. Without entering into a full discussion of the theory of this accident here,—for we have not the space—we will simply say that the release of pressure from the surface of highly heated water in a boiler, causes a violent disturbance in, and rising of the water, and the tendency or flow is violently towards the point of release. When steam is being raised in a boiler, the water arriving at the proper temperature steam escapes into a "steam-room." At first the surface of the water is greatly agitated by the process of ebullition. As the steam pressure increases, the surface of the water becomes more and more quiet, (it is assumed that no steam is being drawn from the boiler,) until it is nearly quiescent. From this point the pressure will increase slowly as shown by Mr. Lawson's experiments. Now suppose the pressure is suddenly released, the superincumbent steam pressure becomes so reduced that the contending force which has been held in place by it, (that is the water, highly heated and ready to give up a large quantity of steam as soon as the superincumbent pressure is reduced,) suddenly rises with a force corresponding to the differences of pressures, and acts upon the resisting metal in the same manner as the enclosed water does upon the end of a glass tube from which the air has been exhausted. (Referring to the water, however) We say, in the same manner, we do not intend to be understood as saying that the release of pressure causes a vacuum. But the differences in pressure would, in our opinion, be sufficient to cause the results which usually follow. When we talk about differences of pressure, etc., it must be understood that the whole process is almost instantaneous. Had we space we could explain more fully our reasons for this opinion, which, if we correctly understand it, is very similar to Mr. Lawson's. The remedy which Mr. Lawson has devised to prevent disasters of this kind, consists of a perforated diaphragm which extends from side to side and end to end of the boiler just above the water line. It is riveted to the sides and ends of the boiler, and convex on its upper side. To construct a boiler with this device would require some fine boiler work. And when we consider the defects and dangers to which boilers are liable from unequal expansion and contraction, corrosion and grooving, we question the utility of his device. Mr. Lawson is, however, entitled to great credit for the intelligent pains-taking, and persevering manner in which he has carried on these experiments.

Notice.

In view of the fact that we are constantly receiving inquiries on different matters relating to the construction and management of boilers, engines, and all matters relating to the use of steam, and believing that many of the questions are of general interest and importance, we have decided to open a department of answers to correspondents, in which we shall endeavor to discuss such points as may be raised, to the best of our ability. Engineers and firemen are especially invited to ask questions on any points which may arise in their daily experience. Address all communications to *Editor of the Locomotive, Hartford, Conn.*

The Superheated Water Theory of Steam Boiler Explosions.

The correspondent of the *Manufacturer's Gazette* takes exception to the sport made of his theory of steam boiler explosions in the LOCOMOTIVE for February last, and recurs to the subject, and cites authorities and experiments to support his views. It was not our intention, originally, to *seriously* comment upon the subject, as we think any one who intelligently examines the matter will be convinced of the absurdity of his views; but as he cites eminent scientific men as supporting his position, it may be well to give a short *résumé* of the facts in the case in order that people may not be misled by his speculations.

To begin with, X seems to be completely at sea in regard to the nature of superheated water. He seems to consider water heated above 212° Fahr., under any condition whatever, to be superheated. This is not so. Whenever water is evaporated at a greater pressure than that due to the weight of the atmosphere, the temperature will be greater than 212°. Thus, to produce ebullition when the pressure is 10 pounds per square inch by the gauge, the water must be heated to 240°; when the steam pressure is 20 pounds, the temperature of the water will be 259°, and so on; but the water under these circumstances is no more *superheated* than it is when it is quietly boiling away in an open vessel at a temperature of 212°. Superheated water is water which is heated above the boiling point due to the pressure on the water at the time, without giving off vapor. Thus water heated above 212° at atmospheric pressure, or above 240° when the pressure is 10 pounds per square inch, or above 259° when the pressure is 20 pounds would be superheated ; and *if* such a state were possible in a steam boiler, it would be a source of great danger, and no one's life would be safe for an instant. We think, however, that we can prove by the authorities whom he quotes, that such a state of affairs in a steam boiler at work is simply impossible.

The present state of our knowledge of the subject of superheating water may be stated in the following words which are extracted from Watts' *Dictionary of Chemistry*, Vol. 3, pages 87 and 88.

" *Circumstances which modify the boiling point.*—Although, when a liquid is heated in such a manner that vapor can escape freely from some part of its surface, the vapor so formed has a tension equal to the pressure upon the free surface of the liquid as soon as the temperature of the latter reaches the boiling point, this temperature may nevertheless be attained, and even considerably exceeded, without the formation of a trace of vapor, *if no portion of the surface of the liquid is freely exposed.* These conditions can be realized by suspending the liquid to be examined in a second liquid of equal specific gravity, but higher boiling point.

" The phenomena which take place under these circumstances have been particularly studied by Dufour. In order to examine them in the case of water, he employed a mixture, in the requisite proportions, of oil of cloves (*previously heated alone to about* 200° C.) and linseed oil. The water, *already heated to* 80° *or* 90° C., was dropped gently into the mixture of oils, so as not to disturb the film which coated the bottom of the vessel, and the temperature of the bath was gradually raised. Under these circumstances the ordinary boiling point of water, 100° C., was passed without the occurrence of any perceptible change, and traces of ebullition scarcely began to show themselves below 110° or 150° C. Even at these temperatures, ebullition scarcely began *except when the globules of water came in contact with the sides of the vessel or with the thermometer.* A burst of vapor then occurred, and the globule, more or less diminished in size, was driven rapidly away, like a pith ball after touching an electrified conductor. These contacts were of course more difficult to avoid in the case of large than of small globules; hence the latter remained liquid, as a rule, to higher temperatures than the former.

" In these experiments it was a rare exception when ebullition occurred between 100° and 110° C.; very commonly globules of 10 millimetres diameter reached 120° or 130° C., and in one experiment the last temperature was attained by a globule of 18 mm. diam., and therefore containing more than 3 cubic centimeters of water. Spheres of 10 or 12 mm. diameter often reached 140° C.; those of 5 or 6 mm. reached 165°; and others from 1 to 3 mm. attained 175° or even 178° C., temperatures at which the elasticity of the vapor which forms at the freely exposed surface is between 8 and 9 atmospheres.

" At these high temperatures, *the contact of a solid body* very generally occasioned the sudden, partial, or complete vaporization of the globules, accompanied by a hissing sound like that produced on immersing red-hot iron in water. This *invariably* occurred when the globules were touched with pieces of *wood or chalk, shreds of cotton, paper, etc.*, but not always on contact with a glass rod or metallic wire, the difference appearing to depend on the *porous structure* of the former substances. A platinum wire appeared to lose, to some extent, by frequent usage, the power of causing sudden vaporization.

" Sudden ebullition, amounting even to an explosion, if the temperature was above 120° C., invariably occurred on passing the discharge of a Leyden jar or induotion coil through a globule. A similar, but less violent, effect was produced by the passage of a weak galvanic current. These results are attributed by Dufour less to the contact of the globules with the conducting wires, than to the *disengagement of gas* at the extremities of the latter.

" Saturated aqueous solutions of various salts—for example, chloride of sodium, sulphate of copper, nitrate of potassium, etc.,—also remained liquid at temperatures much above their boiling points, when immersed in melted stearic acid resting on a layer of melted sulphur. * * * *In all these cases, the same causes that operated in the case of water*, sufficed to occasion the sudden, complete, or partial conversion of the overheated globules into vapor.

"These results throw important light upon the nature of ebullition, and seem to indicate that it is to some extent an accidental phenomenon. In order to understand them, we must remember that the globules being *surrounded on all sides by liquid, evaporation cannot go on at their surface in the ordinary way.* They are, however, in a state of tension, or unstable equilibrium, such that a very slight cause may occasion the sudden formation of vapor of more than the atmospheric tension. *The most effectual of such causes would obviously be the contact of a minute globule of air or other gas:* this globule, *however small*, would be a space into which vapor could be given off, and this vapor, having an elastic force greater than the pressure (that of the atmosphere and the upper layers of the liquid) whereby the globule was prevented from expanding, would force back the liquid walls of the bubble of gas, suddenly converting it into a large bubble of steam. *Hence, the unfailing efficacy, in causing the ebullition of the overheated globules of liquid, of the passage of an electric current or the contact of porous substances* such as chalk, wood, paper, etc., which either allow air to escape from their pores when immersed in the heated liquid, or carry down into it small globules of air adhering to them. These globules afford space for the *commencement* of the formation of vapor, and *this process once begun, the space is increased by the force of the vapor already formed within it.* In the absence of any such space, the liquid globule is in a condition somewhat analogous to that of a drop of melted glass which has been suddenly cooled in water (Rupert's drops) and which falls to powder on receiving the slightest scratch. There is no reason why the formation of vapor should begin at one point of the mass rather than another, and thus the whole remains in a state of molecular tension until something occurs at some particular point to weaken the effect of the forces which oppose the formation of vapor, or until the tension increases, (in consequence of rise of temperature) to such a degree these forces are overcome simultaneously throughout the whole mass." * * * *

"Another illustration of the necessity of some other cause than mere temperature in order to bring about the ebullition of liquids, is afforded by the remarkable observation of Professor Donny, of Ghent, that water, *thoroughly deprived of air* and sealed up in a rather long glass tube *quite free from air*, may be heated to 138° C., at one end of the tube without boiling, and is then suddenly and violently thrown to the other end by a burst of vapor."

Observe now, the conditions which are *absolutely necessary* for the production of superheated water.

First:—No portion of the surface of the water can be exposed to the atmosphere *or any other vapor or gas.*

A very little reflection will suffice to convince any one of ordinary intelligence that this state of things is quite impossible of attainment in a steam boiler. For, when the boiler is first filled with water and the fire is started, the surface of the water in the boiler *is* freely exposed to the air in the steam-space, and after steam has once begun to form, not only the surface of the water but the greater portion of the interior of the water is in intimate contact with steam which has formed, and which, *once begun*, must continue to form as long as heat is applied.

Second:—The water, *already heated to* 80° *or* 90° C., *must* be gently dropped into the mixture of oils, which *must* previously be heated alone to about 200° C.

This requires very little comment. Boilers (in this part of the country at least) are not generally filled with a mixture of oil of cloves and linseed oil mixed in such proportions that its specific gravity is just equal to that of the feed-water at varying temperatures, and then raised to a temperature of 200° C., and the feed-water "carefully dropped in." If there are any boilers running in this vicinity, which are operated as above, we would like to know it, so that we could observe their action and study their economy.

Third :—The *contact* of a solid body, or the smallest particle of *air or gas of any kind* is fatal to the success of the experiment.

The contact of the solid body is *always* obtained from the shell of the boiler, the tubes, braces, etc., and that of a gaseous body is *always* obtained from the atmosphere, and steam, as we have seen above.

Fourth :—If the steam has *once commenced to form*, it goes on and cannot be stopped, even under the conditions above enumerated until the water is all evaporated.

This last point seems to be the one on which all the superheated-water-explosion theorists run aground. All the precautions which must be taken to prevent ebullition at high temperatures are *powerless to stop it when it has once begun.* X says: "I contend that it is possible to have the water in just the quiescent condition described," (that is, so quiet that it may be superheated). "Practical experience indicates this. I am running an engine, taking its usual amount of steam. I try the upper guage and find water, or steam and water. I shut off the steam and again try the guage, when no water comes—nothing but steam. A moment later I turn the next cock and no water flows. The boiler fire is equal to the maintenance of the same steam pressure that it was when the engine was running, still ebullition is ceasing. Does not this indicate that steam is not forming—that the water is becoming quiescent? The heat, however, is entering the water; what is its effect if it does not produce ebullition? As Prof. Cotterill says, it superheats the water, and what is more probable than that, it is this superheated water which is the cause of so many boiler explosions?"

No, Mr. X., ebullition is *not* ceasing; it does *not* indicate that steam is not forming; and Prof. Cotterill does *not* say "it superheats the water, and what is more probable than that it is this superheated water which is the cause of so many boiler explosions?"

The absence of water when you open your gauge after shutting off steam merely indicates that your boiler *foams* to a greater or less extent: That steam *is* forming, and will invariably *continue* to form unless you take measures to check your fire, you will readily perceive by watching your steam-gauge. And this is what Prof. Cotterill says: "If *perfectly* quiescent water, *perfectly free from air or other foreign substance*, be heated in a clean *glass* vessel the temperature may be raised far above 212° Fahr. without occasioning ebullition. * * * * If such an effect *could* be produced in the circumstances of an ordinary steam boiler it would be a source of great danger, * * * * although it is certainly possible that some of the numerous cases of explosions which have occurred immediately after starting an engine *may* be accounted for in this way, yet the circumstances under which the effect is produced are rather those which occur in a laboratory, than in actual practice. * * Subject to these observations, the elastic force of steam is always connected with its temperature, so long as it remains in contact with water, no matter how the steam has been produced; thus if instead of supposing the water confined in a cylinder provided with a piston which rises as the steam is formed, we suppose the steam to be produced in a closed steam boiler, then the *temperature and pressure will keep rising as more and more heat is added, instead of remaining stationary;* but the relation between pressure and temperature remains precisely the same *so long as any water is left.*"

This certainly does not sound much like saying that the water in the boiler becomes superheated when the steam is shut off.

This article, however, is already long enough; if necessary we will recur to the matter again next month, when we shall refer more particularly to Prof. Donny's and Mr. Lawson's experiments; which last, by the way, X. refers to in support of his views, although we have yet to learn that Mr. Lawson sees any connection between his experiments on the *concussion* of water, and *superheated* water. H. F. S.

Safe working pressure for Steam Boilers.

There has been so much said and written about the proper factor of safety for steam boilers, and the working pressure which should be allowed, that anything more on the subject might seem superfluous; but as there seems to be a deep and wide-spread ignorance, even among the best-educated engineers, as to the ultimate strength of iron under the conditions which obtain in practice, perhaps a few words may not be out of place here.

The working pressure of boilers is generally fixed directly from the ultimate tensile strength, so called, and is fixed by different authorities from $\frac{1}{3}$ to $\frac{1}{6}$ of the bursting pressure, or what is the same thing, so that the strain on the plates is from $\frac{1}{3}$ to $\frac{1}{6}$ of the tensile strength of the iron of which they are composed. This tensile strength is obtained by subjecting small pieces of the material to tensile stress in a testing machine, and observing the force required to pull it asunder. Now the results obtained by tests conducted in such a manner are undoubtedly very useful in some cases; but for practical use they are decidedly misleading, for the circumstances and conditions of the test are totally different from those which surround the material in practical use, in such structures as steam boilers, or bridges, for example. In the case of the test we have a gradually increasing stress applied until fracture takes place. In practice we have a somewhat lighter load many times repeated, the number of repetitions depending mainly upon the nature of the structure, while other forces are sometimes called into action, the extent of which are in many cases quite indeterminate.

Now it is well known that a stress *much less* than that required to produce failure by a single application, if often removed and repeated, will cause the rupture of any given piece of material. It is also well known that the magnitude of this stress is even less than the "elastic limit" in the case of iron, and bears no very definite ratio to either the elastic limit or the ultimate strength. It is also well known that, if this stress is applied in opposite directions alternately, we can break any given piece of material with much less force than we can by applying it in one direction only.

A very simple experiment will suffice to demonstrate this conclusively. Suppose we have a bar of iron which we wish to break. We secure one end in a vice, and, grasping the projecting part with our hands, we exert all our strength. The bar remains intact, and if we release it, it springs back to its original position. We try again, and again, and after awhile the bar shows signs of weakening, and if we continue our exertions we finally break it, without, at any time, applying more force than we did at first.

Again, if instead of exerting our strength in bending the bar in the same direction each time we pull in opposite directions alternately, we shall find that we can eventually fracture the bar with the exercise of only *one-half* the force which we exerted when we bent it in the same direction each time. This shows that the force required to fracture the bar does not depend exclusively on the *maximum force applied*, but that two very important factors, to be taken into account in estimating the ultimate resistance of the material, are the *number of repetitions* of the stress, and the *range of variation* of the stress.

These principles seem to be very well known to every one, and we apply them almost instinctively every day of our lives, yet, strange to say, they have received scarcely any attention, scientifically, at the hands of engineers, and they have gone on, always testing materials in the same way for elastic and ultimate strength, and then trusting blindly to a large "factor of safety" (where experience has shown them that it was absolutely necessary) instead of investigating *the specific action of live loads* under circumstances similar to those in practice. The factor of safety as generally applied might, with much more propriety, be called a factor of *ignorance.*

The only definite experiments bearing on this subject that the writer is aware of are those begun by Wöhler, in Germany, and continued by Spangenburg. It appears to him that the above-mentioned experiments have not received the attention from engineers that the very great importance of the subject would seem to warrant. These experiments, although quite extensive, have not been carried out far enough to enable us to deduce decisive rules for practice, in every case; still they are sufficiently extensive to enable us to arrive at a tolerably correct estimate of the proper load for iron, under some of the more simple conditions of practice. They show conclusively that the ultimate tensile strength of ordinary wrought iron subjected to an indefinite number of repetitions of tensile stress, is not over 30,000 pounds per square inch on an average.

This then should be taken as the ultimate strength for such structures as steam boilers, where the stress is always in one direction. The variation of stress in this case is from zero to the maximum working pressure. If the stress due to the steam pressure was the only force the boiler had to resist, we might safely load the iron nearly up to the limit of 30,000 pounds per square inch, but such is not the case. Due allowance must be made for the deteriorating influences of the intense heat to which the plates are subjected, as well as corrosion and other causes which tend to destroy the original strength and elasticity of the iron. The amount of the straining actions due to the influence of heat is quite indeterminate, and varies largely with the design and construction of different boilers, as well as with the care and management which they receive. An examination of the records of the behavior of some thousands of boilers, mainly of the return tubular and drop-flue types, shows that under ordinary circumstances a factor of safety of from two and one-half to three, *calculated on the above basis*, is amply sufficient. Boilers run with the above factor may safely be depended on for a period of upwards of fifteen or sixteen years. Beyond that time, unless the conditions under which they have been used are more than usually favorable, it will be found prudent to run them at a somewhat reduced pressure.

Of course the 30,000 referred to above, as the ultimate tensile strength under repeated stress, cannot be taken as absolutely correct for all kinds of iron. It is merely the average value obtained by Wöhler from the iron he experimented upon. There is very great need of complete and trustworthy experiments on the subject in this country, and it is to be hoped that they may be made before long. When we know accurately the limits to which the materials used in engineering works may be safely loaded, and retain their strength for an unlimited time, then, and then only, can we fix reasonable factors of safety.

H. F. S.

Smallest Locomotive in the World.

Henry Case, of Jamestown, has constructed a perfect locomotive that is the smallest of any in the world. He spent the best part of eight years in its construction. Following is a description of the miniature engine: The engine measures in length, $8\frac{1}{2}$ in., with tender, 12 in.; its height, $3\frac{1}{2}$ in.; gauge, $1\frac{3}{8}$ in.; length of boiler, $4\frac{5}{8}$ in.; diameter of boiler, $1\frac{1}{3}$ in.; fire-box, $\frac{7}{8}$ in. square and 1 in. deep; diameter of drivers, $1\frac{3}{8}$ in.; diameter of truck wheels, $\frac{1}{2}$ in.; stroke of piston, $\frac{1}{2}$ in.; diameter of cylinder, $\frac{5}{16}$ in.; stroke of valve, $\frac{1}{32}$ in.; eccentrics, $\frac{1}{4}''$ diameter; length of links, $\frac{1}{2}$ in.; width of links, $\frac{1}{8}$ in.; link-blocks, $\frac{3}{32}$ in. square; length of main and parallel rods, $1\frac{3}{4}$ in.; put together with straps, gibs, keys, set-screws, bolts and half-boxes, with oil-cups. Whistle, $\frac{5}{32}$ in. in diameter; steam-gauge, $\frac{1}{4}$ in. in diameter; diameter of gong, $\frac{1}{4}$ in.; glass water-gauge in cab; lamp in cab burns one hour; heater pipes and blower-pipes, $\frac{1}{32}$ in. in diameter; headlight $\frac{7}{16}$ in. square, and burns 20 minutes; pop safety-valve in dome. The pumps throw one drop of water per stroke. This engine has 585 screws to hold its parts together. It weighs $1\frac{1}{2}$ pounds, with tender, 2 pounds $2\frac{1}{2}$ ounces.—*Rochester Democrat.*

Explosions in Flour Mills.—A Parliamentary paper just issued contains a report by Mr. Thomas J. Richards, of the Consultative Branch, Board of Trade, to the Home Secretary, respecting an explosion which took place on September 14th at the corn-mill of Messrs. Fitton & Son, at Macclesfield. The effects were of a very disastrous character, a large part of the mill at the north end being levelled with the ground, and the roof over a much larger area destroyed, and the engine man being killed by the fall of part of the building. The damage to the mill was estimated at between £5,000 and £6,000. It appears that some millstones had been running empty at the time of the explosion, that a flame was produced between the millstones, which was sufficient to ignite the flour-dust diffused in the millstone cases, and which being transmitted along the passage to the stive-room by the continued ignition of dust, would cause an explosion of the flour-dust in the stive-room. Mr. Richards has been making general inquiries into the question of fires and explosions in corn-mills. He says that the elements of danger exist in all corn-mills more or less, and notwithstanding the comparative rareness with which disasters of magnitude occur, they are ever liable to take place. Ignitions of flour-dust are apt to cause slight explosions, which, jarring greater bodies of dust into a cloud, are liable to ignite and cause a serious explosion or a general firing of the mill. Whether the effects of the ignition of dust are serious or slight, depends upon the conditions existing at the time. "A large number of fires occur in corn-mills the origin of which is unknown. Mr. Chatterton, the Secretary of the Millers' Mutual Fire Insurance Company, informs me that he has records of 84 serious fires which have occurred in corn-mills since 1876, the origin of 56 being unknown. A majority of those unconnected with the milling business are probably entirely unaware of the danger which may exist in consequence of the presence of a building devoted to the useful, and, to all appearance, harmless occupation of the cleansing and grinding of corn, and the dressing of flour. That insurance companies are alive to the extra risks incurred in corn-mills is shown by the high rate of insurance charged for corn-mills, which I am informed is about 18*s*. to 20*s*. per cent." Mr. Richards adds: "A subject of interest allied to that which has been considered is that of the risks involved in the cleaning and grinding of rice. The experiments I have made on rice stive-dust and ground rice convince me of the facility with which they, and particularly the former, will explode when diffused in air. That the risks involved in rice cleaning and milling are greater even than in corn milling is evidently indicated by the high rates of premiums charged by insurance companies, and that some companies will not accept them at any rate. I am informed that the rate of insurance for rice-mills in London is £6 6*s*. per cent. It is, however, stated to be much less in the country."—*London Times*, *February 27th*.

To prevent the formation of rust on cast-iron, Mr. J. J. Shedlock, of Uxbridge, has patented in Germany the following process: The objects are exposed to the action of dilute hydrochloric acid. The acid dissolves the iron on the surface, and leaves a layer of carbon, or graphite. This layer cannot be destroyed by caustic agents. The pieces are then washed in a cistern with water or steam, in order to take away the iron salts which have formed. The liquid is removed from the cistern, in which the air is rarefied, in order to remove all the water from the articles. A volatile solution of caoutchouc is then brought into the apparatus, by means of which all the pores of the crust formed on the iron are filled. The volatile solvent is then removed by heating.—*Mechanical World*.

If down his throat a man should choose,
In fun to jump or slide,
He'd scrape his shoes against his teeth
Before he went inside.
Or if his teeth were lost or gone,
And not a stump to scrape upon,
He'd see at once how very pat,
His tongue lay there, by way of mat,
And he would wipe his feet on *that*.

HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO.

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The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. III. HARTFORD, CONN., MAY, 1882. No. 5.

Proportions of Riveted Joints.

No one can deny the fact that the safety and durability of a steam boiler depends as much on the proper riveting of its joints as it does on any other element of its construction. This being the case, let us briefly examine the matter of proportioning joints for different thicknesses of plates as it is now practiced by different boiler-makers, and see what we can learn.

We have long held the opinion that there is too much guess work, and too little calculation free from prejudice or preconceived opinions, used in the determination of the proportions for joints in the different thicknesses of boiler plate. No two men use the same proportions, and each and every one is confident that he is just right, for he has learned by experience that no other proportions than those he uses are admissible. While we do not wish to be captious, or to deprecate the practical knowledge gained by

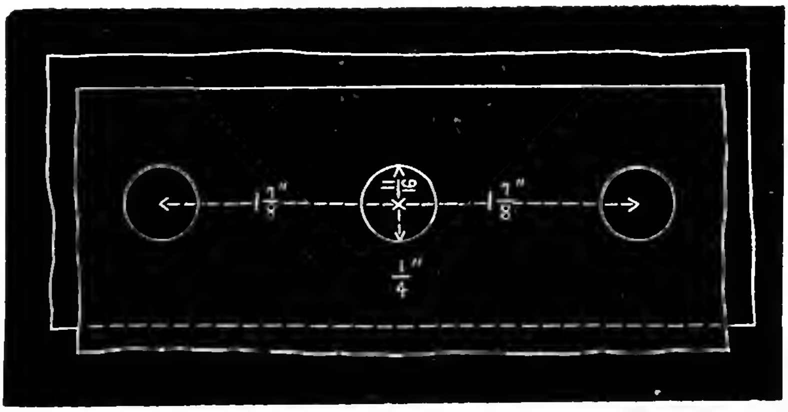


FIG. 1.

boiler-makers through the medium of their every-day work, we cannot help saying that in our opinion, based on very wide observation, very few boiler-makers use their materials to the best advantage.

A very little reflection will make it clear to the mind of any intelligent mechanic, that in order to obtain the greatest strength of a riveted joint with the least amount of material and labor, the diameter and pitch of rivets should be so proportioned that the shearing strength of the rivets will be equal to the tensile strength of the section of plate left between rivet holes. As the tensile strength of ordinary boiler plate is practically equal to the shearing strength of rivet iron, the only condition to fulfill is to make the area of the rivet holes equal to the net section of plate after punching. This condition is rarely fulfilled in practice. No effort seems to be made to even approximate to it. For instance, when one man uses these proportions: Plate $\frac{5}{16}''$ thick, rivet $\frac{3}{4}''$ diam., pitch $2\frac{1}{8}''$, and plate $\frac{1}{2}''$ thick, rivet $\frac{3}{4}''$ diam., pitch 2; and another man these: Plate $\frac{5}{16}''$ thick, rivet $\frac{3}{4}''$ diam., pitch $1\frac{7}{8}''$; and plate $\frac{1}{2}''$ thick, rivet $\frac{3}{4}''$ diam., pitch $2\frac{1}{2}''$; we cannot help thinking that very little judgment has been used in one case or the other. These are not imaginary proportions but were given us by the boiler-makers who practice them daily, and they are ready to maintain that no other proportions *can* be used successfully for th. above thickness of plate.

To determine the relative strength of the plate and rivet at the joint, we have only to apply the following simple rule, when the plate and rivet are both iron.

$\frac{\text{Pitch} - \text{diameter of rivet holes}}{\text{Pitch}}$ equals the percentage of strength of plate at joint as compared with solid plate.

$\frac{\text{Area of rivets} \times \text{No. of rows of rivets}}{\text{Pitch} \times \text{thickness of plates}}$ equals the percentage of strength of rivets at joint as compared with solid plate.

For the sake of illustrating the great diversity of practice among different boiler-makers, we have obtained the proportions of joints used by some of the more prominent boiler-makers throughout the country, and submitted them to analysis by the above rules. The results are given in the following pages. It will be seen that some of them are very well proportioned, indeed, while others are very badly proportioned. The figures given speak for themselves. Referring to Fig. 1 we have,

Plate $\frac{1}{4}''$ thick. Rivet holes $\frac{11}{16}''$ diam. Pitch of rivets, $1\frac{7}{8}''$.

Strength of plate at joint $= \frac{1.875 - .6875}{1.875} = 63$ per cent. of solid plate.

Strength of rivets at joint $= \frac{.37122}{1.875 \times .25} = 79$ per cent. of solid plate.

The rivet strength is greatly in excess of that of the plate; hence the pitch should be increased. This would give a stronger joint with less work and material.

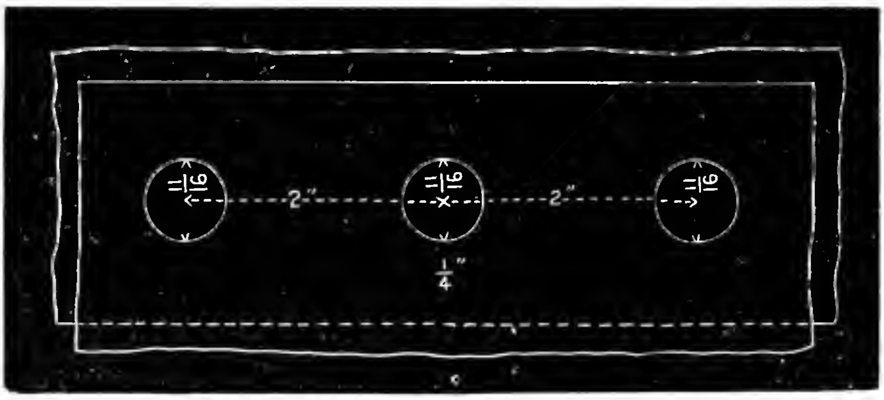


FIG. 2.

Fig. 2. Plate $\frac{1}{4}''$ thick. Rivet holes $\frac{11}{16}''$ diam. Pitch of rivets, $2''$.

Strength of plate at joint $= \frac{2 - .6875}{2} = 66$ per cent. of solid plate.

Strength of rivet at joint $= \frac{.37122}{2 \times .25} = 74$ per cent. of solid plate.

A stronger joint than Fig. 1, although there is still an excess of strength in rivets.

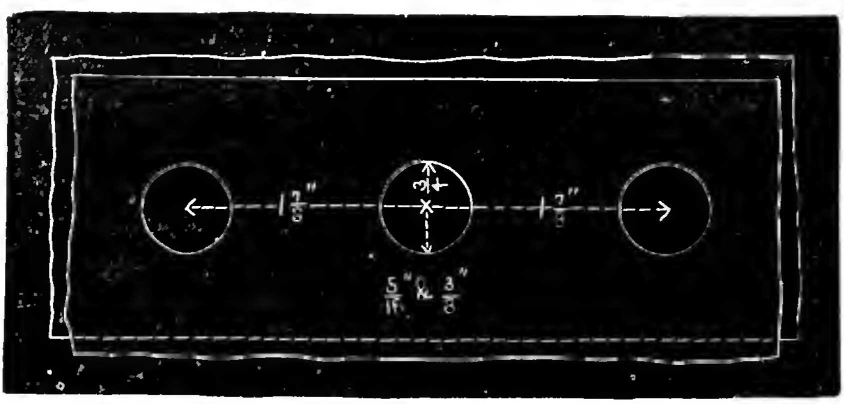


FIG. 3.

Fig. 3. Plates $\frac{5}{16}''$ and $\frac{3}{8}''$ thick. Rivet holes, $\frac{3}{4}''$ diam. Pitch of rivets, $1\frac{7}{8}''$.

Strength of plates at joint $= \frac{1.875 - .75}{1.875} = 60$ per cent. of solid plate.

Strength of rivets in $\frac{5}{16}''$ plate $= \frac{.44179}{1.875 \times .3125} = 75$ per cent. of solid plate.

Strength of rivets in $\frac{3}{8}''$ plate $= \frac{.44179}{1.875 \times .375} = 70$ per cent. of solid plate.

Too many rivets, pitch should be increased. Impossible to proportion joints correctly with different thicknesses of plates, and same sized rivets and equal pitches.

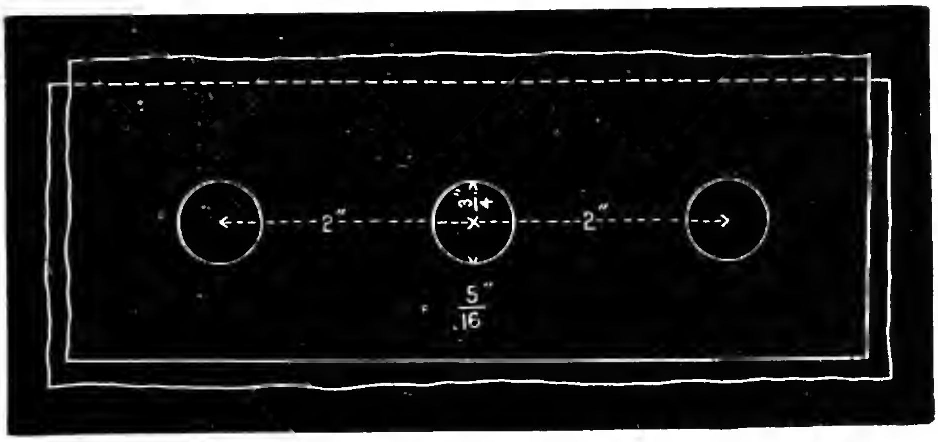


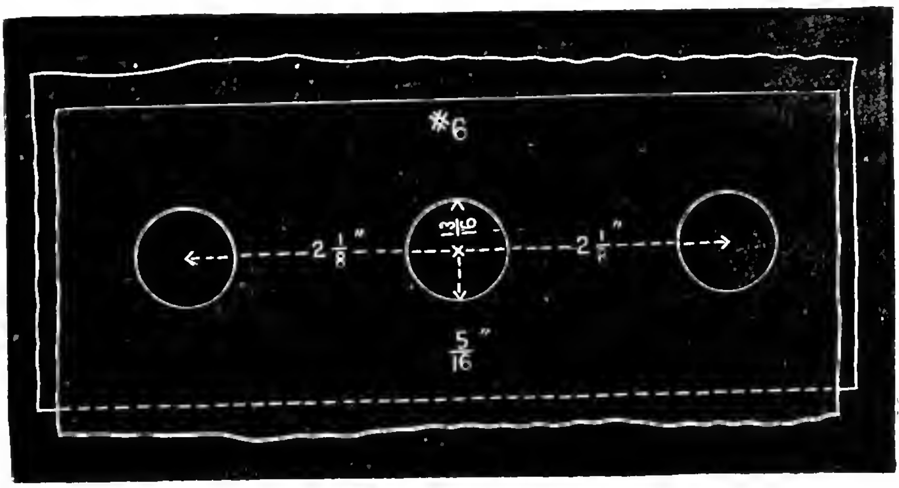
Fig. 4.

Fig. 4. Plate $\frac{5}{16}''$ thick. Rivet holes $\frac{3}{4}''$ diam. Pitch ot rivets, 2".

Strength of plate at joint $= \frac{2 - .75}{2} = 62\frac{1}{2}$ per cent. of solid plate.

Stren_th of rivets at joint $= \frac{.44179}{2 \times .3125} = 71$ per cent. of solid plate.

Plate cut away too much, rivets should be spaced farther apart.



[Fig. 5.

Fig. 5. Plate $\frac{5}{16}''$ thick. Rivet holes $\frac{13}{16}''$ diam. Pitch of rivets $2\frac{1}{8}''$.

Strength of plate at joint $= \frac{2.125 - .8125}{2.125} = 62$ per cent. of solid plate.

Strength of rivets at joint $= \frac{.51849}{2.125 \times .3125} = 78$ per cent. of solid plate.

Pitch about right. Rivets larger than is necessary.

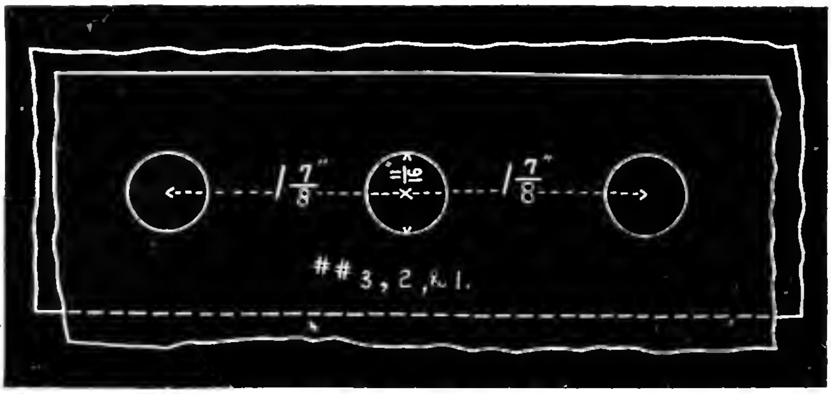


FIG. 6.

Fig. 6. Plate Nos. 3, 2, and 1. Rivet holes $\frac{11}{16}''$ diam. Pitch of rivets $1\frac{7}{8}''$.

Strength of plates at joint $= \frac{1.875 - .6875}{1.875} = 63$ per cent. of solid plate.

Strength of rivets at joint No. 3 plate $= \frac{.37122}{1.875 \times .259} = 76$ per cent. of solid plate.

Strength of rivets at joint No. 2 plate $= \frac{.37122}{1.875 \times .284} = 70$ per cent. of solid plate.

Strength of rivets at joint No. 1 plate $= \frac{.37122}{1.875 \times .3} = 66$ per cent. of solid plate.

Pitch too small, especially for Nos. 2 and 3. Same remarks apply as in the case of Fig. 3.

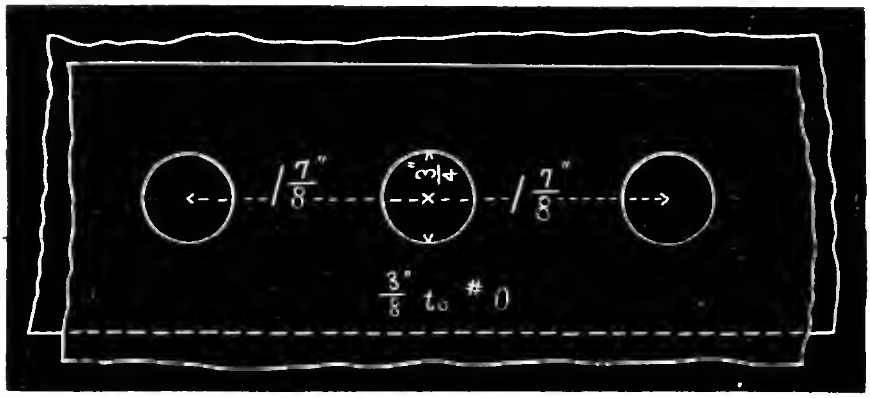


FIG. 7.

Fig. 7. Plates Nos. 0, 00, and $\frac{3}{8}''$. Rivet holes $\frac{3}{4}''$ diam. Pitch of rivets $1\frac{7}{8}''$.

Strength of plates at joint $= \frac{1.875 - .75}{1.875} = 60$ per cent. of solid plate.

Strength of rivets at joint in No. 0 plate $= \frac{.44179}{1.875 \times .34} = 69$ per cent. of solid plate.

Strength of rivets at joint in No. 00 plate $= \frac{.44179}{1.875 \times .358} = 66$ per cent. of solid plate.

Strength of rivets at joint in $\frac{3}{8}''$ plate $= \frac{.44179}{.1875 \times .375} = 63$ per cent. of solid plate.

Fig. 8. Plate $\frac{3}{8}''$ thick. Rivet holes $\frac{13}{16}''$ diam. Pitch of rivets, $2\frac{1}{4}''$.

Strength of plate at joint $= \frac{2.25 - .8125}{2.25} = 64$ per cent. of solid plate.

Strength of rivets at joint $= \frac{.51849}{2.25 \times .375} = 62$ per cent. of solid plate.

A first-rate proportion for $\frac{3}{8}''$ plate.

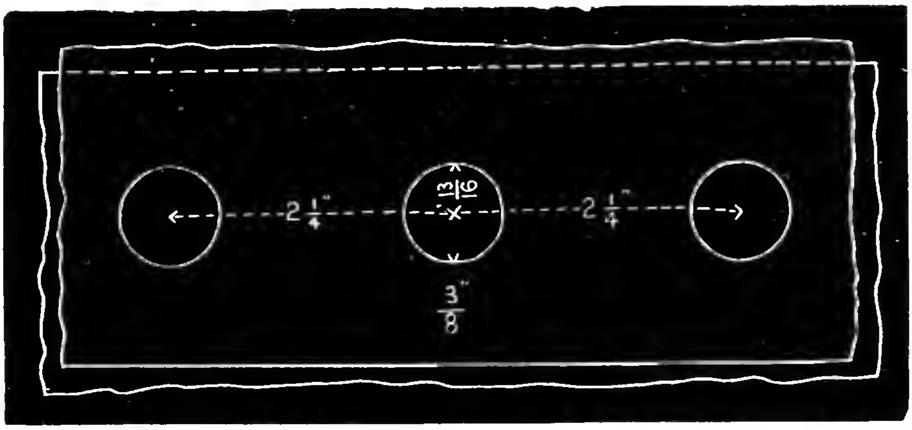


Fig. 8.

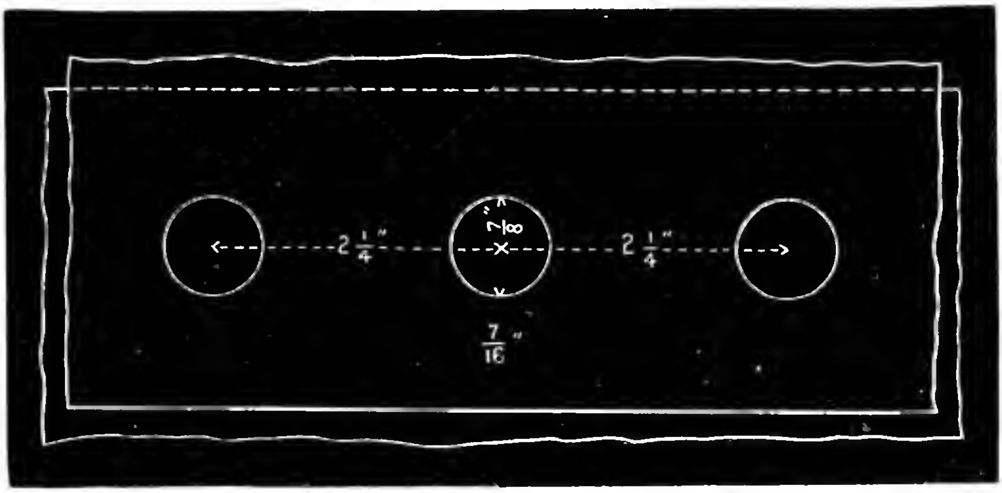


Fig. 9.

Fig. 9. Plate $\frac{7}{16}''$ thick. Rivet holes $\frac{7}{8}''$ diam. Pitch of rivets, $2\frac{1}{4}''$.

Strength of plate at joint $= \frac{2.25 - .875}{2.25} =$ 61 per cent. of solid plate.

Strength of rivets at joint $= \frac{.60132}{2.25 \times .4375} =$ 61 per cent. of solid plate.

A well proportioned joint.

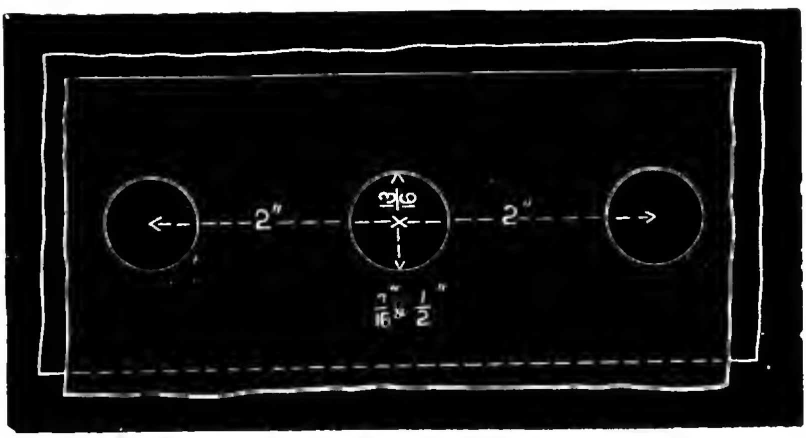


Fig. 10.

Fig. 10. Plates $\frac{7}{16}''$ and $\frac{1}{2}''$ thick. Rivet holes, $\frac{13}{16}''$ diam. Pitch of rivets 2″.

Strength of plate at joint $= \frac{2. - .8125}{2} = 59$ per cent. of solid plate.

Strength of rivets at joint in $\frac{7}{16}''$ plate $= \frac{.51849}{2 \times .4375} = 59$ per cent. of solid plate.

Strength of rivets at joint in $\frac{1}{2}''$ plate $= \frac{.51849}{2 \times .50} = 52$ per cent. of solid plate.

Rivet too weak for $\frac{1}{2}''$ plate. It would be better to use larger rivets and greater pitches in both cases. See Fig. 3.

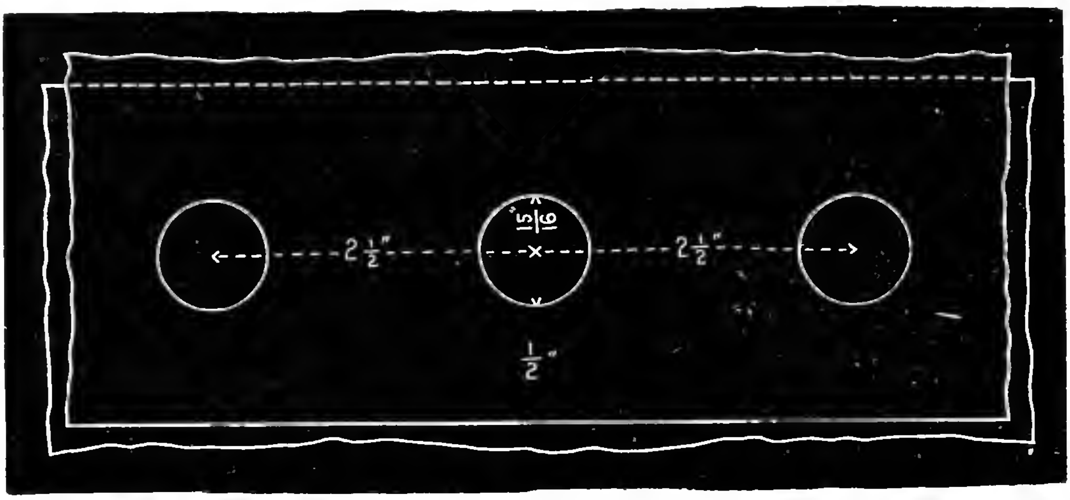


FIG. 11.

Fig. 11. Plate $\frac{1}{2}''$ thick. Rivet holes $\frac{15}{16}''$ diam. Pitch of rivets $2\frac{1}{2}''$.

Strength of plate at joint $= \frac{2.5 - .9375}{2.5} = 62\frac{1}{2}$ per cent. of solid plate.

Strength of rivets at joint $= \frac{.69029}{2.5 \times .5} = 55$ per cent. of solid plate.

Rivet about right, but pitch should be slightly lessened.

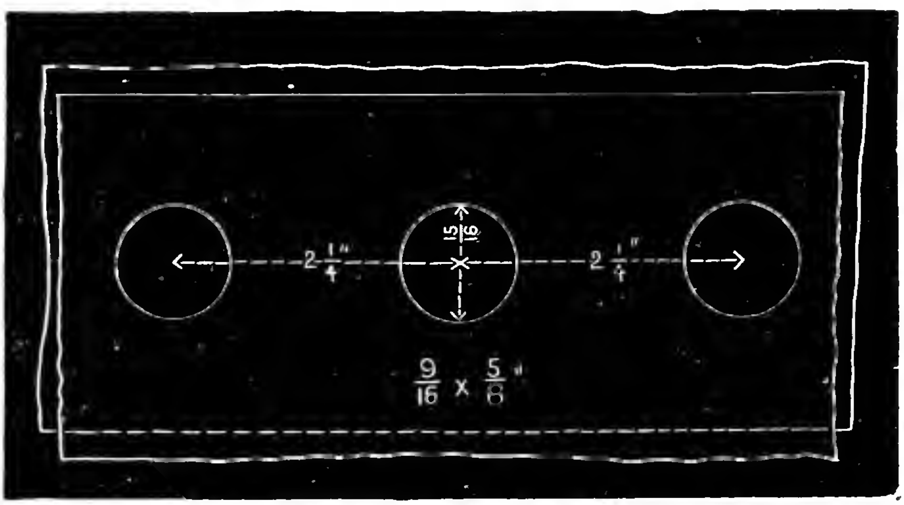


FIG. 12.

Fig. 12. Plates $\frac{9}{16}''$ and $\frac{5}{8}''$ thick. Rivet holes $\frac{15}{16}''$ diam. Pitch of rivets, $2\frac{1}{4}''$.

Strength of plates at joint $= \frac{2.25 - .9375}{2.25} =$ 58 per cent. of solid plate.

Strength of rivets at joint in $\frac{9}{16}''$ plate $= \frac{.69029}{2.25 \times .5625} = 54\frac{1}{2}$ per cent. of solid plate.

Strength of rivets at joint in $\frac{5}{8}''$ plate $= \frac{.69029}{2.25 \times .625} =$ 49 per cent. of solid plate.

Rivets and pitch both too small, especially for the $\frac{5}{8}''$ plate. See remarks under Fig. 3.

The foregoing figures show most of the proportions used for single riveted lap joints. Our next number will be devoted to *double riveted* joints, and we shall endeavor to call attention to some important points which are generally overlooked by boiler-makers.

Inspectors' Reports.

MARCH, 1882.

The one hundred and eighty-sixth monthly report of the Inspection Corps shows the very gratifying fact, that the number of boilers inspected during the month of March last, was over 22 per cent. greater than for the corresponding month last year. The number of visits of inspection made was 2,070; the total number of boilers examined was 4,642; while the number of complete internal inspections foots up 1,508. The hydrostatic test was applied in 326 cases.

The number of boilers condemned was 50. Below is given the usual analysis of the defects found.

Nature of defects.	Whole number.	Dangerous.
Cases of deposit of sediment,	231	44
Cases of incrustation and scale,	362	38
Cases of internal grooving,	14	5
Cases of internal corrosion,	101	22
Cases of external corrosion,	116	33
Broken and loose braces and stays,	56	23
Settings defective,	38	9
Furnaces out of shape,	108	33
Fractured plates,	164	89
Burned plates,	100	38
Blistered plates,	245	34
Defective riveting,	224	7
Defective heads,	23	7
Leakage around tubes,	227	23
Leakage at seams,	105	27
Water-gauges defective,	45	20
Blow-out defective,	14	4
Cases of deficiency of water,	19	13
Safety-valves overloaded,	36	10
Safety-valves defective in construction,	19	8
Pressure gauges defective,	132	24
Boilers without pressure gauges,	3	2
Total,	2,382	526

There seems to be a desire on the part of certain people to promulgate the belief that the Hartford Steam Boiler Inspection and Insurance Company is always ready to insure "anything in the shape of a boiler," for money. In accordance with this scheme, every accident to any boiler under our care is eagerly pounced upon, spread throughout the country with a great flourish, and the opportunity improved to throw all possible odium upon the company and its operations generally. This, we wish to be distinctly understood, is a very great mistake. This company always refuses to insure anything that, in the judgment of its trained inspectors, is not perfectly safe, if properly managed; and we will remark here, that no boiler whatever is safe for one minute, unless it *is* properly managed. If we chose to publish the fact every time we declined to insure a boiler, and give the locality of the boiler, and our reasons for declining to accept a risk on it, we think we could keep the public in a chronic state of alarm throughout most of the territory in which the company operates.

We have lately received from the agent of the company in a certain district where an explosion has lately occurred, a canceled policy, with a memorandum accompanying it from the chief inspector, which so peculiarly illustrates the matter in question, that we give it *verbatim* for the benefit of the public. Similar cases are constantly occurring, as we can prove to any one who is sufficiently interested in the matter to investigate it.

The following is the memorandum which accompanies the canceled policy in question:—

This party, after insuring with us, found his boiler leaking one day, and by a second-hand dealer was induced to change it for another; which other, we reported to him, was not a good one. Nevertheless, he put it in without informing us, and we insist on canceling from date of change, Feb. 16th, 1882. ——— ———, *General Agent.*

The following is the report of the inspector upon the boiler in question, which is now running in a busy street in a populous city:

To J—— M——.

Report of an Internal and External Examination of your Steam Boiler made by us, Feb. 16th, 1882.

Locomotive boiler with engine bolted fast on top. Furnace very badly pitted and corroded away. Blistered on back leg externally. A spot where blistered, was covered up and filled flush with putty to hide defect. Dangerously eaten away around hand-hole on back leg. Furnace sheets bulged in several places, also on front head around hand hole. Shell near back end cracked. Owing to poor condition, and considering it unsafe, we respectfully decline to continue our insurance on this boiler.

Very Resp'y, —— —— ——, *Chief Inspector.*

The above is a fair sample of many cases that have occurred in our experience. If the boiler in question gives out and any one is killed, we shall anxiously await the coroner's verdict, and the official inspector's explanation of the disaster.

Notice.

Wanted:—At this office, copies of The Locomotive, No. 10, Volume IV, August, 1871, for which 50 cents per copy will be paid. Must be in good condition for binding.

Parties having the above copies to spare will confer a favor by communicating with this office.

Getting up Steam.

The following communication lately received from a well-known dealer in machinery, is a very good illustration of one way to get up steam—and keep it after you have got it.

Editor LOCOMOTIVE :

We have a story too good to keep. A gentleman applied to us for a "cheap boiler," one that "would be good for two pounds or so." The only one we had had just been tested at 150 lbs. to the square inch, but that was "too good." He said he once bought one for $30.00, and ordered a young man in his employ to get up steam in it. He went away and was gone longer than he expected, and on his return he found a raging fire in the furnace, a pot filled with bricks on the safety valve lever, and a very much frightened young man hanging on to the same lever with all his weight, and both hands. The boy said in explanation, that he didn't know anything about a boiler, but he supposed that if he "let any steam get out of that thing on top, it would blow him and the shop to smithereens." "Ah!" said he, "I'm glad ye came, for I couldn't howld it much longer." It evidently came very near being another mysterious (?) explosion.

Yours, &c., J. S. M.

Krupp's Muzzle Pivot Gun.

The Germans seem determined to be ahead of this or any other country, in their practical efforts towards the adoption of every new idea in scientific warfare that will give them power in Europe. Once more Herr Krupp has come to the front. This enterprising maker of warlike material, has recently conducted a series of experiments with a new kind of gun and shell. The gun is on the muzzle pivoting system, and the shell has been specially designed for torpedo effect, that is, to burst on penetration of armored ships with a result similar to the explosion of a torpedo. The idea of the muzzle pivot gun is not novel. It has been known to our War Office authorities for some years; but they have not thought proper to thoroughly or practically test its utility. They have during late years been either allowing what little inventive faculty they possess to lie dormant, or have been content with watching the operations of other powers in the direction of improvements in ordnance and other warlike material, and then copying their results. Unfortunately, the latter has only become too patent, and the position which Great Britain has consequently slipped back to, is now admitted by every practical or scientific person. Herr Krupp's recent experiments at Meppen were considered to be highly satisfactory, and quite sufficient to justify the great German manufacturer of weapons, in taking immediate measures for the production of larger guns and shells than those tried. The gun experimented with was of 21 centimetre calibre, with a long shell having a tremendous bursting charge, so arranged that the shell should explode only after penetrating some distance into the armor plating. The gun's muzzle pivot is carried down into a socket fixed in the hold of a vessel, in such a way as to prevent the slightest recoil even with the heaviest charge. Herr Krupp's gun was worked during the trials with great ease and certainty of aim, and obtained for the shell a very high velocity. This description of weapon has been designed for gunboats built to carry guns up to 40 centimetres. These gunboats are to be of light draught, high rate of speed, and exceedingly handy. In fact, two or even three of such armed boats would be very ugly customers for a first-class armored ship to cope with, owing to their rapid power of manœuvring, and their small size rendering them difficult to hit. Their cost would be but an eighth or a tenth of a first-class ironclad. The Germans are certainly a very practical race. A good idea once conceived and well considered in all its bearings, they then do not take very long to work it out. We shall hear more ere long of Herr Krupp's muzzle pivoting guns and torpedo shells.—*Engineering.*

The Locomotive.

HARTFORD, MAY, 1882.

On another page will be found a paper on "*Running Iron Works on the Sabbath*," read before the meeting of the Sabbath Observance Convention, recently held at Pittsburgh, by Mr. John Fulton of Johnstown, Pa., which is so thoroughly in accord with the sentiments of all good people who are anxious that the present and rising generations shall not drift away from the customs of our fathers into indifference and skepticism, that we ask for it a careful reading.

In times of great business prosperity, when every manufacturing establishment is driven to its fullest capacity, it is easy for the manufacturer to persuade himself that he can better make repairs on Sunday than to stop his works on week days. The custom is quite common in manufacturing communities, and even among some good men it is regarded as necessary work.

Our attention is especially called to this subject by the frequent demands for inspections of boilers on Sunday, and if all these demands were complied with, our inspectors would be employed every Sunday in the year.

We believe firmly in the observance of the Sabbath—that every employee should have that day uninterrupted to himself. No business is so important or driving that one day in the year cannot be afforded for the examination of the boilers. We appeal, on behalf of the Inspection Department, to all manufacturers, to elect some day other than Sunday for the examination of their boilers. We are not superstitious, but we believe it will be a gain to every one to so arrange their business as that the Sabbath will not be violated, but that every person employed can feel that it is truly a day of rest.

Article on Riveting in the *Miller's Journal* for May 17, 1882, taken verbatim from The Locomotive for September, 1881. No credit.

Article on Boiler Tubes taken from The Locomotive of May, 1881, including account of our experiments. No credit.

The *Boston Journal of Commerce* now appears in quarto form, cut and pasted. This improves its form very much, as it is vastly more convenient. The matter does not need improving as it is always the very best. It is worthy of note in a recent number of the *American Naturalist*, in an article on cotton fiber, special attention is called to the microscopic investigations of cotton fiber by the editor of the *Journal of Commerce.* He is among the first to turn microscopic investigation in this direction. We are pleased to make this note of a progressive paper, managed by a progressive man.

The report of Mr. Henry Hiller, chief engineer of the National Boiler Insurance Company, Limited, Manchester, England, for 1881, has just been received. It contains much that is interesting in regard to defects in Steam Boilers, their cause and remedy. Statistics relating to explosions in England during the past year, and fac similes of several indicator diagrams, which illustrate in a very forcible manner the value of the indicator to the steam user, who wishes to economize in the use of coal.

In the Iron Trade Report for March, 1882, issued by Rolling & Rowe, of London, Eng., extensive manufacturers of iron and steel, we find the following startling statement:
"The total losses of ships of all nations during 1881 is estimated as follows: 425 steam vessels; 2,750 sailing vessels; total, 3,175. Tonnage, 1,250,000, or more than the whole tonnage launched during the years 1878, 1879, and 1880.

The series of articles on *Structural Steels* by Albert F. Hill, C. E., now appearing in The *Iron Age* and *Mechanics*, are of very great interest and value to iron-workers generally, and boiler-makers especially.

Running Iron Works on the Sabbath.

At the recent meeting of the Sabbath Observance Convention, at Pittsburg, a paper was presented by Mr. John Fulton of Johnstown, on "Iron Works on the Sabbath," the main points of which we give below. After stating the obligations and necessity of keeping the Sabbath, and the results of experiments to abolish it, he continues:

There are other claims arising in the several branches of industry, which are sought to be added to the exemptions to excuse the sin of Sabbath work. At iron works, in blast furnaces, it is alleged that the nature of the operations of iron making requires continuous work, especially in the production of a uniform quality of pig iron for Bessemer steel. That to produce a graphitic, or gray pig iron, there must be sustained heat, and therefore continuous blast into the furnace. It is not contended, by any person at all familiar with blast-furnace operations, that the furnace work cannot be suspended over the Sabbath, for the fact is well known that the operations have been suspended, during times of repairing furnace, for twenty-four, forty-eight, and seventy-two hours. It is difficult, if not impossible, to believe that any intelligent manager of iron works, superintendent of furnace or furnace keeper, can seriously entertain the idea that furnace work compels men to break the Lord's day. For this would be assuming them to occupy the fearful attitude of impeaching the Divine wisdom, in charging God with foolishness in requiring men to "keep holy the Sabbath day," and yet ordaining a physical law to abrogate or nullify His spiritual law! No. This is not their attitude. For every intelligent furnace superintendent knows, that it is quite practicable to rest the furnace on the Sabbath day. That in suspending the blast heat, compensation must be made for it by increased charges of coke or other fuel, at such time, near the close of the week, so that it may come into action during the suspension of the hot blast.

A large number of furnaces rest on the Lord's day, both in this country and Europe. Seventeen are reported from one state to London *Iron*, without exhausting the record. Baird, of Scotland, rested all his furnaces on the Sabbath day, and closed a very successful life, by a final donation to the Lord's treasury of a quarter million of dollars. But there exists a certain undefined and undefinable fear that if the Sunday work is abated, there may be a falling off in quantity of pig iron produced. That as others do it there must be some unexplainable virtue in continuous work, and hence each works, fears to initiate the Sabbath rest reform, lest they may suffer loss and be exposed to ridicule. One famous manager testifies: "We do not claim that we can make as much iron in six days as we could in seven, but in the long run—a year—the Sabbath-keeping furnaces make more than those who do not rest." The fact is submitted here that obedience to God's laws insures the best results, physically, morally, and financially. That violation of law is destructive in every respect, body, soul, and pocket. With the accurately kept statistics of furnaces and iron works, the economy or loss of Sabbath-breaking could be clearly shown. The burden of this proof lies at the door of the Sabbath-breaker. It cannot be denied that a large waste in labor and materials accompanies Sabbath work. Men who work on the Sabbath require some inducements to violate so clear made law—an increase of wages, or abatement of the hours of work, or both. These range from 30 to 400 per cent. in excess of week-day work. But in addition to the direct loss in wages and time worked, there is a further continued loss in the quality of work, which is usually hastily and imperfectly performed.

Another loss is even more than this, arising from the debility of workmen employed on the Sabbath, and which is carried through the work of the six days following. Every such work of the Lord's day is a constant loss, both in its direct and reflex influences. It would not be just to charge managers of iron works with the whole sin of Sabbath work, for it is well-known that too many of the workmen desire such work. But the manager could readily abate very much of the work now performed on the Sabbath. The mode has been indicated for resting the furnaces on the Sabbath day. The Bessemer converting works, blooming mills, rolling mills, with their associated plant, are mainly at rest on the Sabbath day. A large amount of work, however, is done in their repairs and renewals. It is plain that this can be abated. It will require investment in keeping on hand a sufficient stock of duplicate machinery, to replace breakages promptly and to enable repairs to be made during the week. It is submitted that the excess of wages paid and loss in work, would afford a large interest on the capital required for duplicate machinery for repairs. As the works close early on Saturday, sufficient time is afforded to replace and repair the breakages and wear of ordinary work. That this can be done, is just as clear as that the furnace can be rested. Sunday work in all departments of iron works is poor work. It is frequently followed with disastrous breaks. It also induces a great waste by breakages in the neglect to repair them promptly under the plea, "Oh, that can be fixed up next Sunday." Necessity of Sabbath work in any department of iron making cannot be defended. If the furnace can be rested, all other operations of iron manufacture can more easily be rested. There can be nó conflict of physical and moral laws, for both have the same source in one Creator.

It is confidently submitted that by Sabbath rest at iron works great saving would follow. That a faithful effort to rest on the Lord's day would reduce the expenses of repairs and maintenance of machinery and appliances—secure more regular work, and largely reduce "breakages." It would be followed by better work during the week—more vigorous, clear-headed, and sustained. It is not even remotely implied, that the iron works managers are "sinners before the Lord exceedingly." In many cases they have had the Sabbath breaking sin handed down to them. All that can be urged is, that they have not given this great question the attention its importance demands. On the other hand, it is the glory of American iron works managers, that they have cherished the material interest of their workmen with persistent care. They have planted a great protecting shield in the tariff laws, on which the world may read in letters of gold: "We desire it understood that we shall not enter into competition with European iron managers on the basis of starving the workmen to make cheap products. Our men must be well fed and cared for, with such wages as will enable them to educate their successors, making them more valuable workmen and better citizens—thus contributing to material progress in iron making and to the perpetuity of our republican form of government.

This position is deserving of much praise. But the Creator admonishes, "that men cannot live by bread alone." Food and education are good, but man must be cultivated in his entirety. He cannot attain his full degree of usefulness, until every element of his being is cultured and brought into harmonious action. The moral qualities of the man must be developed. He is a religious being. Just so long as the Creator's monitor throbs its approval or disapproval in his heart, just so long must it be harmonized, or else the whole is discord. Christianity is the complement of manhood. It is cheering to know that we are living in an age of material and moral progress. The clouds of slavery have been lifted. Polygamy totters in its mountain pastures. Intemperance is being dismembered piece by piece. May we not hope that the managers of iron works will consider this sin of Sabbath desecration, and plant before the eyes of the world, a second moral protecting shield, on which shall be inscribed: "As for us and our workmen, we shall endeavor to keep holy the Lord's day." "For the wages of sin is death."—*Iron Age.*

Standard Time for the World.

At the meeting of the American Society of Civil Engineers at Washington, D. C., May 17th, an interesting report upon the subject of standard time was read by Mr. Sanford Fleming of Ottawa, Canada. Mr. Fleming is the chairman of a committee appointed by the American Society of Civil Engineers at its meeting in Montreal on June 15th, 1881, to take into consideration the question of standard time. At the annual meeting of the society in New York last January, the committee made its first report, submitted a scheme for the establishment of a prime meridian, and of uniform standard time, and suggested the expediency of obtaining an expression of opinion upon the various points which presented themselves from as large a number of practical and scientific men as possible. This suggestion was approved by the society, and the committee was authorized to take such steps as might be necessary to obtain information which would enable it to report definitely at a future meeting. The committee prepared a series of questions to cover the whole subject, and sent copies of it to a large number of persons throughout the country who are practically interested in the question.

By the scheme referred to, it is proposed :—

First.—To establish one universal standard time, common to all peoples throughout the world, for the use of railways, telegraphs, and steam-boats, for the purposes of trade and commerce, for general scientific observations, and for every ordinary local purpose.

Second.—It is proposed that standard time everywhere shall be based on the one unit measure of time denoted by the diurnal revolution of the earth, as determined by the mean solar passage at one particular meridian to be selected as a time zero.

Third.—The time zero to coincide with the initial or prime meridian to be common to all nations for computing terrestrial longitude.

Fourth.—The time zero and prime meridian of the world to be established with the concurrence of civilized nations generally.

Fifth.—For the purpose of regulating time everywhere it is proposed that the unit measure, determined as above, shall be divided into 24 equal parts, and that these parts shall be defined by standard time meridians established around the globe, 15° of longitude, or one hour, distant from each other.

Sixth.—It is proposed that standard time shall be determined and disseminated under governmental authority; that time signal stations be established at important centers for the purpose of disseminating correct time with precision, and that all the railway and local public clocks be controlled electrically from the public time station, or otherwise kept in perfect agreement.

Seventh.—The adoption of the system in the United States and Canada would, exclusive of Newfoundland and Alaska, have the effect of reducing the standards of time to four. These four standards, precisely one hour apart, would govern the time of the whole country, each would have the simplest possible relation to the other, and all would have equally simple relations to the other standards of the world.

Finally.—It is proposed to have only one series of hours in the day, extending from midnight to midnight and numbering 1 to 24, without interruption, to number the hours between midnight and noon (1 to 12) precisely as at present, and to denote the hours between noon and midnight by letters of the alphabet.

To the series of questions which accompanied this scheme, the committee has received hundreds of replies, and Mr. Fleming in his report to the society to-day, gave a classified statement of their purport, as follows: Ninety-seven per cent. of all the writers approve the scheme. 76 per cent. express themselves as in favor of four standard meridians in North America, one hour or 15° apart. 6 per cent. favor two meridians, and a small minority prefer one continental meridian. In reply to the question with regard to a change in the notation of the hours of the day, a very large majority of the committee's correspondents—92 per cent. of the whole number—express themselves in favor of counting from 1 to 24 consecutively. In conclusion Mr. Fleming said: "Upon the replies received to its questions, the committee is fully warranted in reporting that there is throughout the country a very strong sentiment in favor of establishing a system of standard time, upon the basis of the scheme which the society now has under consideration. The report of the committee was approved by the society, and resolutions were adopted requesting Congress to take the initiative step, by endeavoring to establish a prime meridian which shall be common to all nations."

Overloading Safety Valves.

The practice, which prevails extensively, of loading the safety-valves of steam boilers beyond the proper limit is a most dangerous one, and cannot be too strongly condemned. Cases are very frequent, where, by this means, old boilers, worn and thinned by corrosion, are regularly worked at a much higher pressure than they were originally intended for when new. There can be but one result of such a course, and that points unerringly toward disaster. The wear and tear of a boiler so overloaded and overworked is vastly increased, so that little if any economy results from the practice. It is true, that in times of great business prosperity, when every department of a manufacturer's establishment is driven to its utmost capacity, that the temptation to overwork a steam boiler is very strong, still the practice is, under any circumstances, wholly inexcusable. With most kinds of machinery the only result of overwork is simply the failure of the machinery and the consequent pecuniary loss; but with steam boilers the case is different. Here the damage in case of accident is not confined to the boiler itself, or even destruction of adjacent property, but human lives are almost invariably sacrificed. We think everyone will agree with us when we say under *no* circumstances is the imperilment of people's lives justifiable. Everything should be done that human knowledge renders possible to make the use of steam perfectly safe.

The Hartford Steam Boiler Inspection and Insurance Company intends to deal fairly with all its patrons, and always allows a pressure which the judgment of its inspector deems safe, when boilers are placed under its care. It has no disposition or motive to deal unfairly with anyone. Its inspectors are selected solely on their merits and capacity to fulfill their duties intelligently; consequently their judgment may be relied upon as far as it is possible to rely upon human judgment in any given matter. When they fix upon a certain definite pressure for any given boiler that pressure may be considered to be consistent with safety.

Now this company cannot afford to, and will not, insure a boiler for a certain pressure and then have the weight on the safty-valve increased at the will of the engineer or owner of the boiler the minute the inspector's back is turned. This is frequently done, as may be seen by reference to the Inspectors' Monthly Reports, published in the

Locomotive. We wish it to be distinctly understood by everyone that this renders the policy of insurance void, and that we cannot, and will not, be held responsible for damage caused by accidents which occur under such circumstances. Cases have occurred very recently where we have been obliged to cancel policies for the above reason. In case of explosion under such circumstances the damage to the company is twofold. In addition to the pecuniary loss involved, the judgment of the company is called in question, and the matter is eagerly seized upon and spread far and wide for the sole purpose of injuring its business. We have abundant proof in our possession that some of the worst accidents that have occurred to boilers under our care have been brought about by a violation of the conditions of the policy in this respect. We think any fair-minded person will agree with us, that we are justified in canceling our policies where such a state of things exists, both for our own protection and for the purpose of putting the responsibility where it belongs.

Notes and Queries.

C., Waterbury, Ct., asks:—How long will a superheating steam-drum last, when exposed to a temperature varying from 500 to 1,200 degrees Fahr.? The drum to be made of wrought-iron, T. S. 50,000, $\frac{3}{8}$ inches thick, 30 inches diam., double-riveted?

Ans. We are of the opinion that the drum would be rendered worthless the first time it attained the temperature of 1,200 deg., which is a full red-heat. The tightness of the joints would certainly be destroyed. Leaving the above questions out of consideration, the iron would be rapidly oxydized by the action of the steam at such a high temperature that the shell would probably be wholly destroyed in a few months. Cases have occurred where the lining of steam chimneys have been reduced from $\frac{3}{8}''$ to $\frac{1}{16}''$ in fourteen months. This, however, is an extreme case.

A., Hartford, Ct., inquires:—Why will an internally fired boiler, such as a round water-front for example, when set in brick-work, always leak on the *under* side when the products of combustion are led directly to the chimney after passing through the flues, or when they are returned over the top of the shell?

Ans. The leakage is caused by unequal expansion of the top and bottom of the shell, which is due to difference of temperature between top and bottom, the top being much the hotter in either case. This difference of temperature is due to the imperfect circulation of the water in the boiler, owing to absence of heat on the under side of the shell. The difficulty may be remedied by returning the heat along the under side, as is usually done in the case of drop-flue boilers. Boilers designed to be used in this way, would be improved by double-riveting the girth seams, and caulking inside and out.

J. H., Boston, Mass., inquires:—Is a six inch tube as effective as a stay, as a three inch tube? In other words, if I have in one case a boiler-head, say 60″ diam., containing 64 three inch tubes, and in another case a head of the same size in which are 32 six inch tubes, which head would be the more effectively stayed?

Ans. The one with the three inch tubes. A head containing 64—3″ tubes, would hold only 16—6″ tubes, not 32. A 6″ tube will sustain twice as much as a 3″ tube, but there can be only *one-fourth* as many in a given area; consequently, this would reduce the staying power *one-half*. In addition to this, the area between tubes on which the steam pressure acts, is twice as great in the case of the 6″ tubes, as in the case of the 3″ tubes; thus there is a *further* reduction of one-half in the staying power. Hence, it is evident that you have *twice* as much pressure to sustain in one case as you have in the other, and only *one-half* the power to resist it; therefore, the effective staying power with 6″ tubes is only one-fourth what it is with 3″ tubes.

W. S., Brooklyn, N. Y., inquires:—Is there any *simple* rule for determining the thickness of flat, unstayed, cast-iron boiler heads?

Ans. Yes, the following: $\sqrt{\frac{D^2 \times P}{24,000}} =$ thickness; in which D denotes the diam. of the head, and P, the required safe-working pressure.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. III. HARTFORD, CONN., JUNE, 1882. No. 6.

Proportions of Riveted Joints.

Last month we showed various proportions for single-riveted lap joints; in this number we give the double-riveted joints from the same sources, with a comparison of their efficiencies. One of the commonest forms of joint is shown in Figs. 1 and 2. Here the

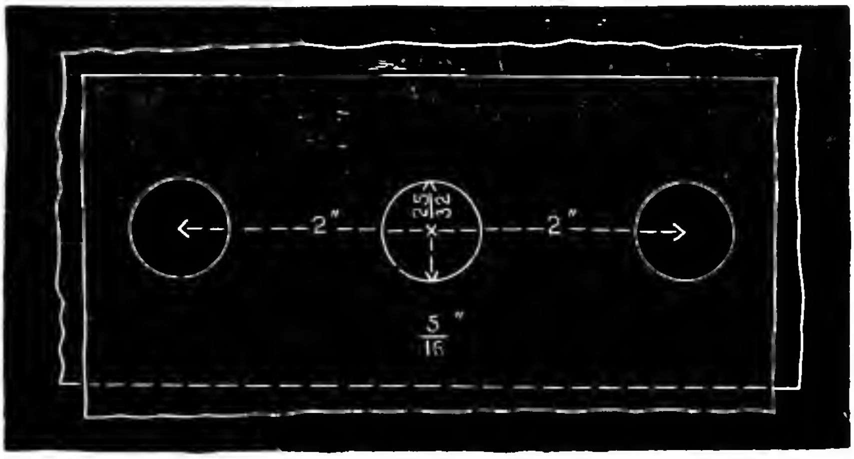


FIG. 1.

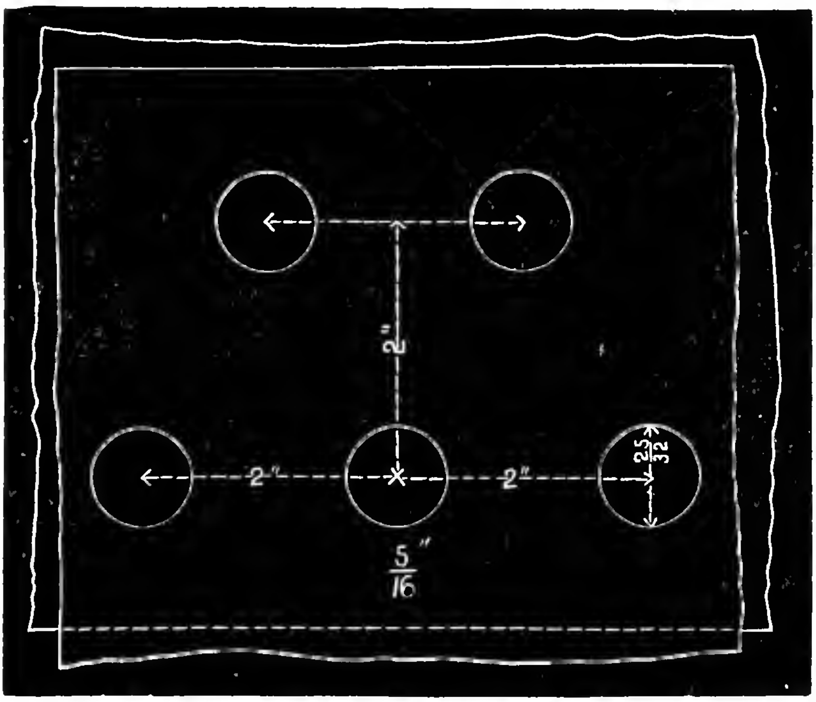


FIG. 2.

pitch and rivet diameter are the same in both the single and double joints. In the single riveted joint the strength of plate at joint as compared with the solid plate is

$\frac{2-\frac{25}{32}}{2} = 61$ per cent.; and the strength of the rivets as compared with the solid plate is $\frac{.47937}{.2\times\frac{5}{16}} = 77$ per cent., from which it will be seen that the rivets are much the stronger. This being the case, what use is it to put in another row of rivets and make a double-riveted joint without increasing the section of the plate? It merely *adds to the expense* of the boiler without in the least increasing its strength or durability. Purchasers of boilers who specify double-riveted joints would do well to look to this point and insist upon reform.

We give the proportions as we find them.

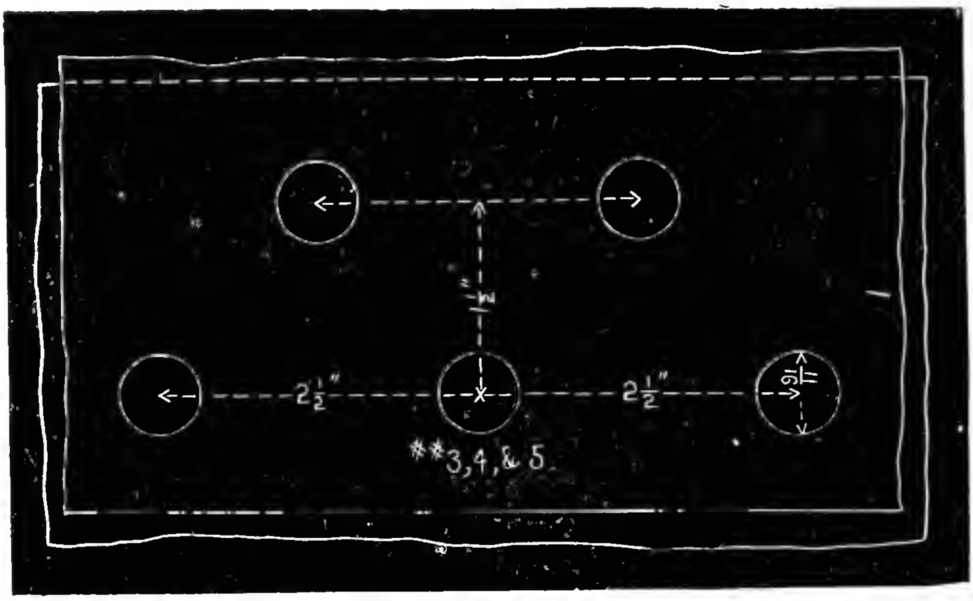


FIG. 2.

Fig. 3. Plates Nos. 5, 4, 3, 2, and 1. Rivet holes, $\frac{11}{16}''$ diam. Pitch of rivets = $2\frac{1}{2}''$.

Strength of plate at joint = $\frac{2.5-.6875}{2.5} = 72\frac{1}{2}\%$ of solid plate.

Strength of rivets at joint No. 5 plate = $\frac{.37122\times2}{2.5\times.22} = 135\%$ of solid plate.

Strength of rivets at joint No. 4 plate = $\frac{.37122\times2}{2.5\times.238} = 125\%$ of solid plate.

Strength of rivets at joint No. 3 plate = $\frac{.37122\times2}{2.5\times.259} = 115\%$ of solid plate.

Strength of rivets at joint No. 2 plate = $\frac{.37122\times2}{2.5\times.284} = 104\%$ of solid plate.

Strength of rivets at joint No. 1 plate = $\frac{.37122\times2}{2.5\times.30} = 99\%$ of solid plate.

The strength of the rivets is out of all proportion to the strength of the plate. The pitch should be increased, and the diam. of the rivets reduced.

Fig. 4. Plates, 2, 1, 0, and 00. Rivet holes $\frac{3}{4}''$ diam. Pitch of rivets = $2\frac{1}{2}''$.

Strength of plate at joint = $\frac{2.5-.75}{2.5} = 70\%$ of solid plate.

Strength of rivets at joint No. 2 plate = $\frac{.44179\times2}{2.5\times.284} = 124\%$ of solid plate.

Strength of rivets at joint No. 1 plate = $\frac{.44179\times2}{2.5\times.30} = 118\%$ of solid plate.

Strength of rivets at joint No. 0 plate = $\frac{.44179\times2}{2.5\times.34} = 104\%$ of solid plate.

Strength of rivets at joint No. 00 plate $= \frac{.44179 \times 2}{2.5 \times .358} = 99\%$ of solid plate.

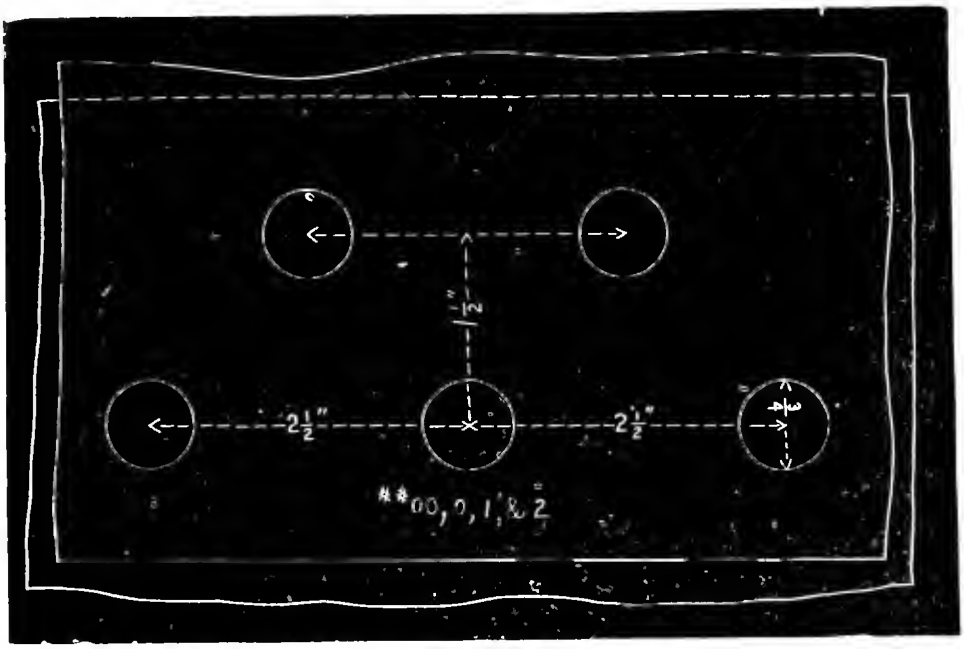


Fig. 4.

In the above examples the pitch is the same, and in the second example the joints would be better proportioned if the rivet holes were $\frac{11}{16}''$ diam. If one should ask the man who uses $2\frac{1}{2}''$ pitch in No. 00 plate why he didn't use a larger pitch and get a stronger joint he would probably say he could not make a tight joint if he did. And yet the first man uses the same pitch ($2\frac{1}{2}''$) in plates only .22″ thick or less than two-thirds the thickness, and he has no difficulty in keeping the joints tight. Surely one or the other must be wrong.

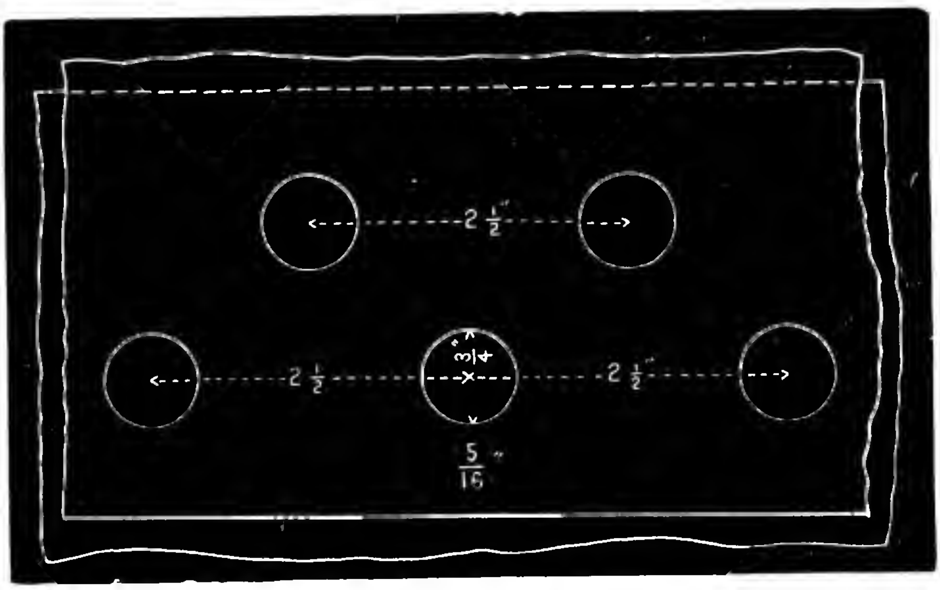


Fig. 5.

Fig. 5. Plate $\frac{5}{16}''$ thick. Rivet holes $\frac{3}{4}''$ diam. Pitch of rivets $= 2\frac{1}{2}''$.

Strength of plate at joint $= \frac{2.5 - .75}{2.5} = 70\%$ of solid plate.

Strength of rivets at joint $= \frac{.44179 \times 2}{2.5 \times .3125} = 113\%$ of solid plate.

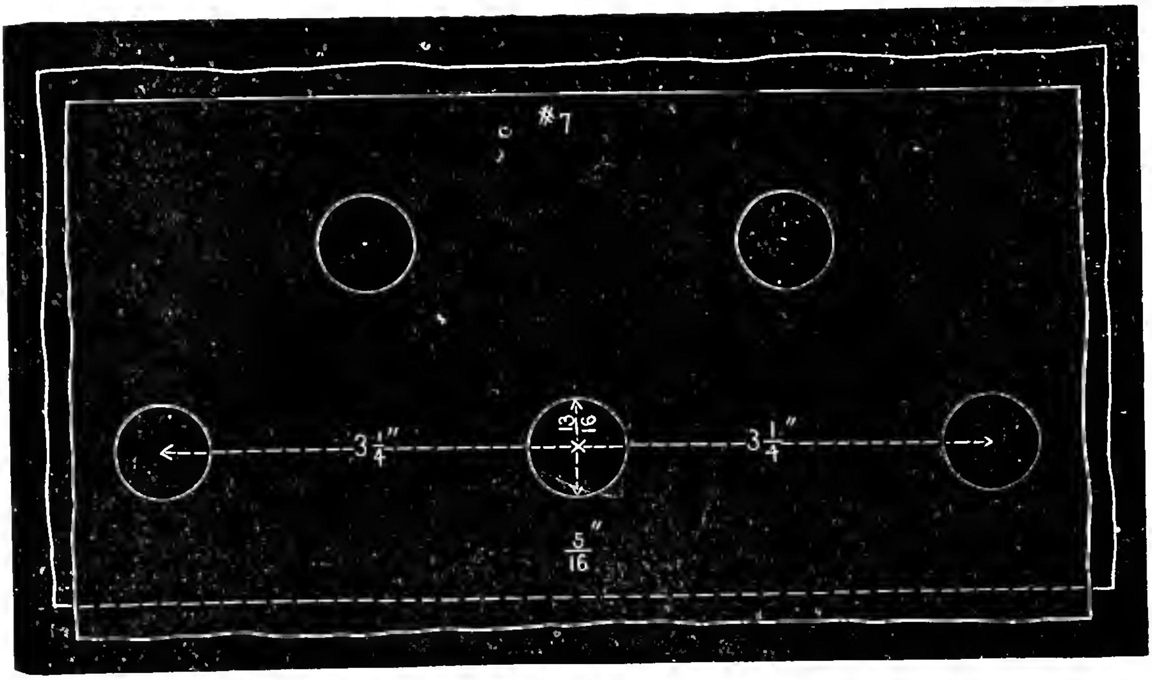


FIG. 6.

Fig. 6. Plate $\frac{5}{16}''$ thick. Rivet holes $\frac{13}{16}''$ diam. Pitch of rivets $= 3\frac{1}{4}''$.

Strength of plate at joint $= \frac{3.25 - .8125}{3.25} = 75\%$ of solid plate.

Strength of rivets at joint $= \frac{.51849 \times 2}{3.25 \times .3125} = 102\%$ of solid plate.

The above is the best proportioned double-riveted joint we have seen thus far. Those who maintain that a tight joint cannot be made with a wide pitch may perhaps be consoled by the statement that the above is the proportion used by the largest and most successful builders of locomotives in this country. As a matter of fact the secret of the whole thing is this: Do the work in an intelligent manner. Do not depend on the hammering which the rivet receives to bring the plates together. Press your plates tightly together and *hold them* while the rivet is being driven.

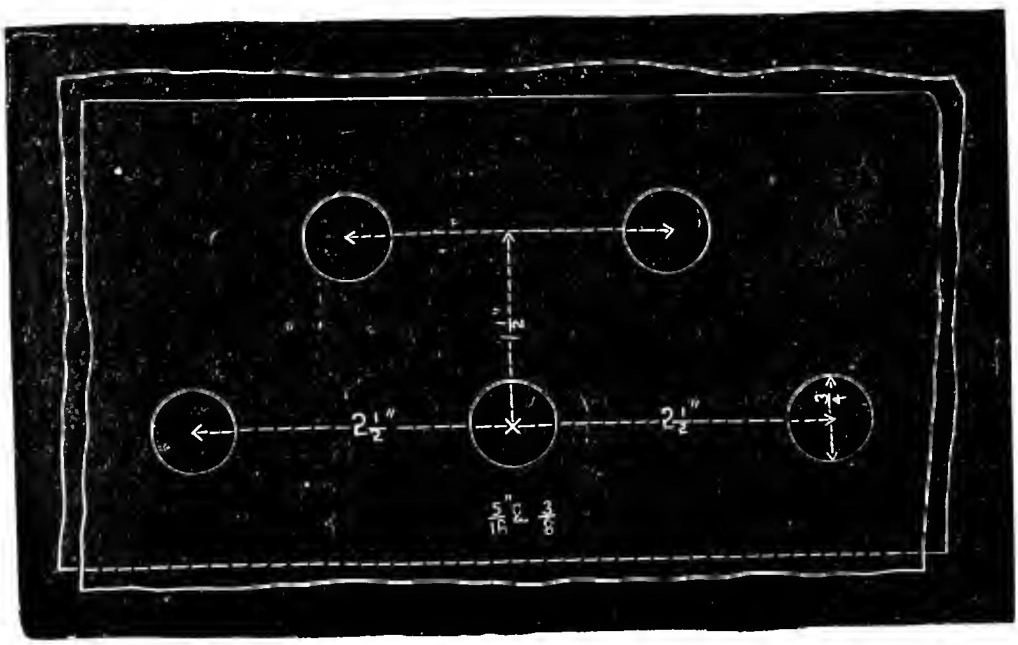


FIG. 7.

Fig. 7. Plates $\frac{5}{16}''$ and $\frac{3}{8}''$ thick. Rivet holes $\frac{3}{4}''$ diam. Pitch of rivets $= 2\frac{1}{2}''$.

Strength of plate at joint $= \frac{2.5-.75}{2.5} = 70\%$ of solid plate.

Strength of rivet at joint $\frac{5}{16}''$ plate $= \frac{.44179 \times 2}{2.5 \times .3125} = 113\%$ of solid plate.

Strength of rivet at joint $\frac{3}{8}''$ plate $= \frac{.44179 \times 2}{2.5 \times .375} = 94\%$ of solid plate.

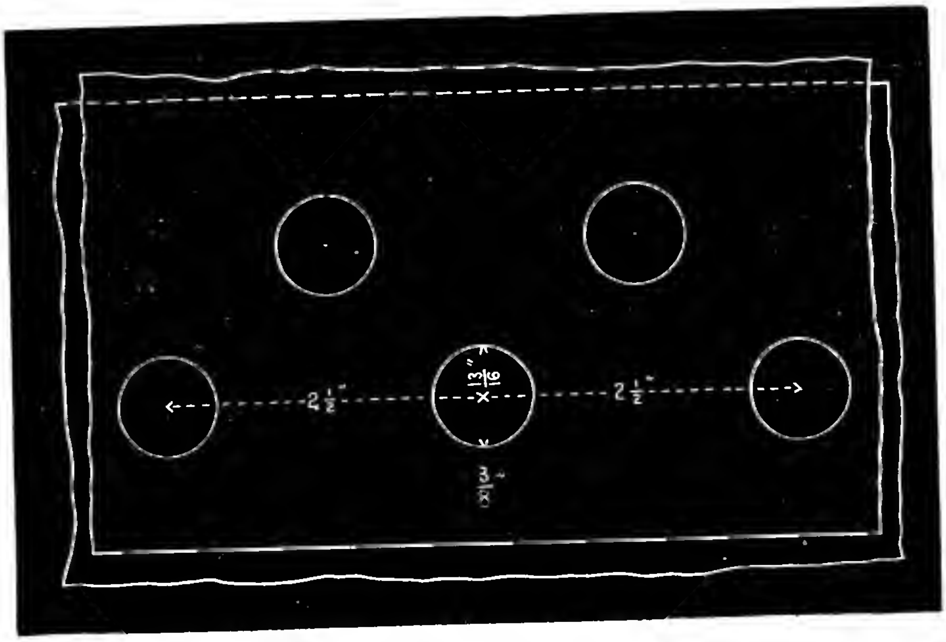


Fig. 8.

Fig. 8. Plates $\frac{3}{8}''$ thick. Rivet holes $\frac{13}{16}''$ diam. Pitch of rivets $= 2\frac{1}{2}''$.

Strength of plate at joint $= \frac{2.5-.8125}{2.5} = 67\frac{1}{2}\%$ of solid plate.

Strength of rivets at joint $= \frac{.51849 \times 2}{2.5 \times .375} = 111\%$ of solid plate.

A difference of over 50 per cent. in strength between rivet and plate.

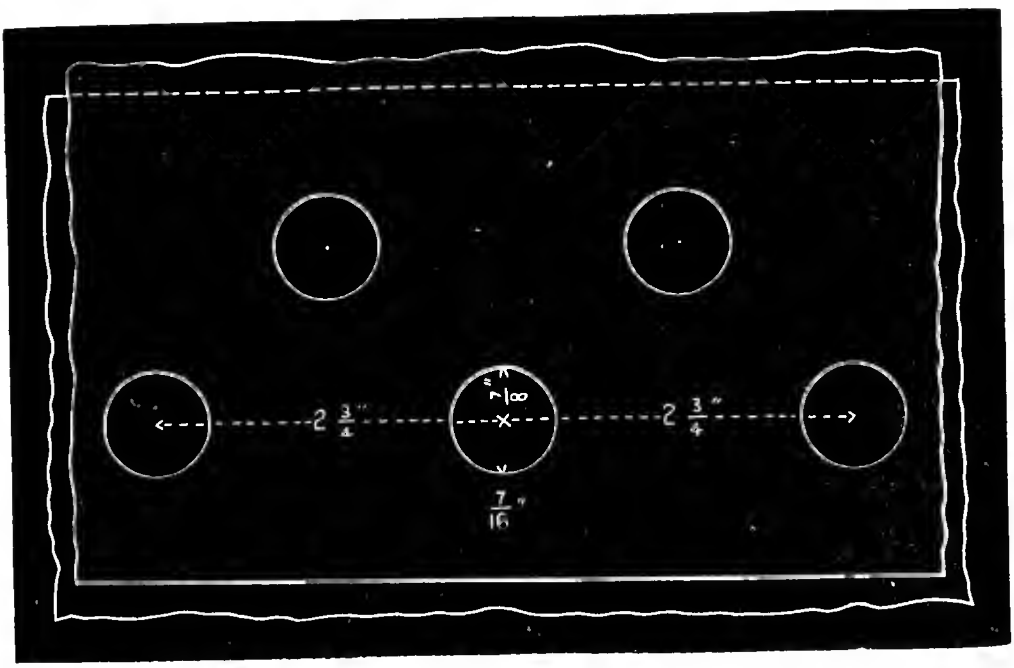


Fig. 9.

Fig. 9. Plate $\frac{7}{16}''$ thick. Rivet holes $\frac{7}{8}''$ diam. Pitch $= 2\frac{3}{4}''$.

Strength of plate at joint $= \dfrac{2.75 - .875}{2.75} = 68\%$ of solid plate.

Strength of rivets at joint $= \dfrac{.60132 \times 2}{2.75 \times .4375} = 100\%$ of solid plate.

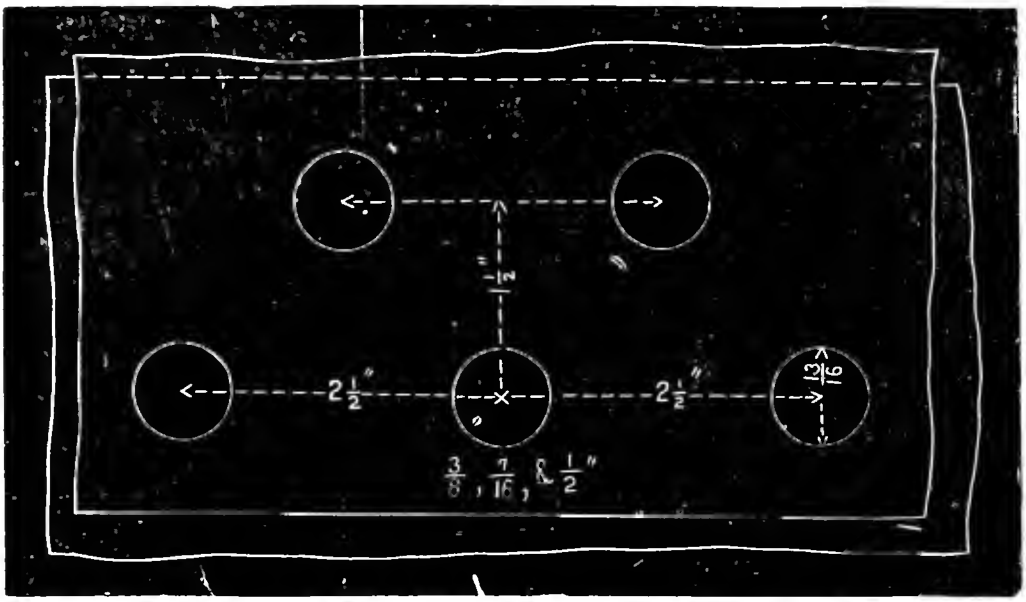


FIG. 10.

Fig. 10. Plates, $\frac{3}{8}''$, $\frac{7}{16}''$, and $\frac{1}{2}''$ thick. Rivet holes $\frac{13}{16}''$ diam. Pitch of rivets $= 2\frac{1}{2}''$.

Strength of plate at joint $= \dfrac{2.5 - .8125}{2.5} = 67\frac{1}{2}\%$ of solid plate.

Strength of rivets at joint in $\frac{3}{8}''$ plate $= \dfrac{.51849 \times 2}{2.5 \times .375} = 110\%$ of solid plate.

Strength of rivets at joint in $\frac{7}{16}''$ plate $= \dfrac{.51849 \times 2}{2.5 \times .4375} = 95\%$ of solid plate.

Strength of rivets at joint in $\frac{1}{2}''$ plate $= \dfrac{.51849 \times 2}{2.5 \times .50} = 83\%$ of solid plate.

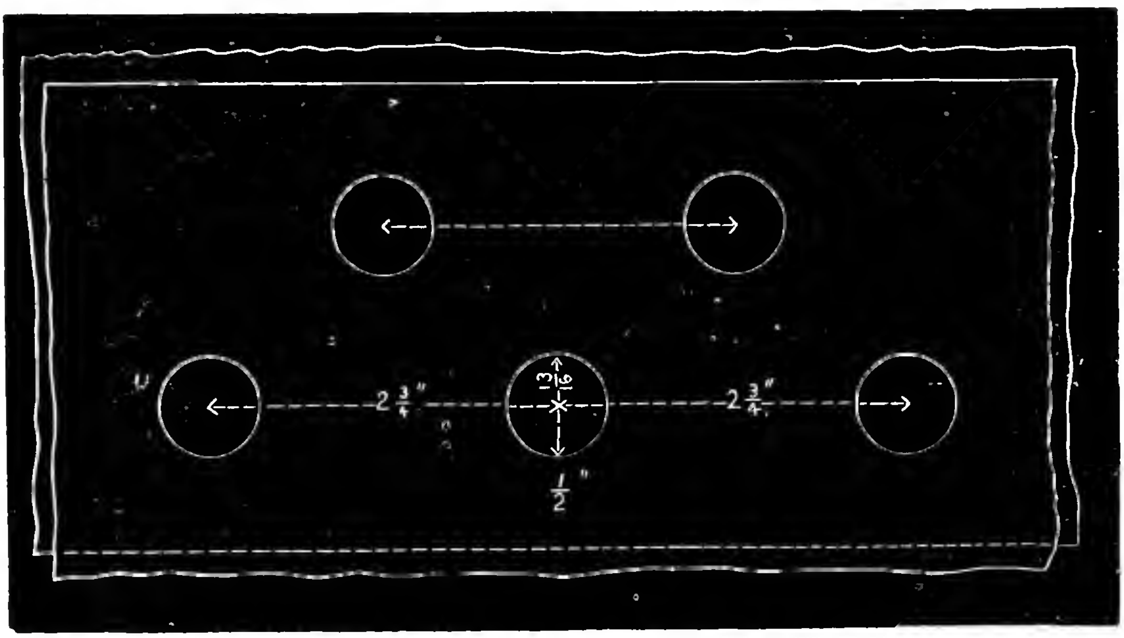


FIG. 11.

Fig. 11. Plate $\frac{1}{2}''$ thick. Rivet holes, $\frac{13}{16}''$ diam. Pitch $= 2\frac{3}{4}''$.

Strength of plate at joint $= \frac{2.75 - .8125}{2.75} = 70\%$ of solid plate.

Strength of rivets at joint $= \frac{.51849 \times 2}{2.75 \times .50} = 75\%$ of solid plate.

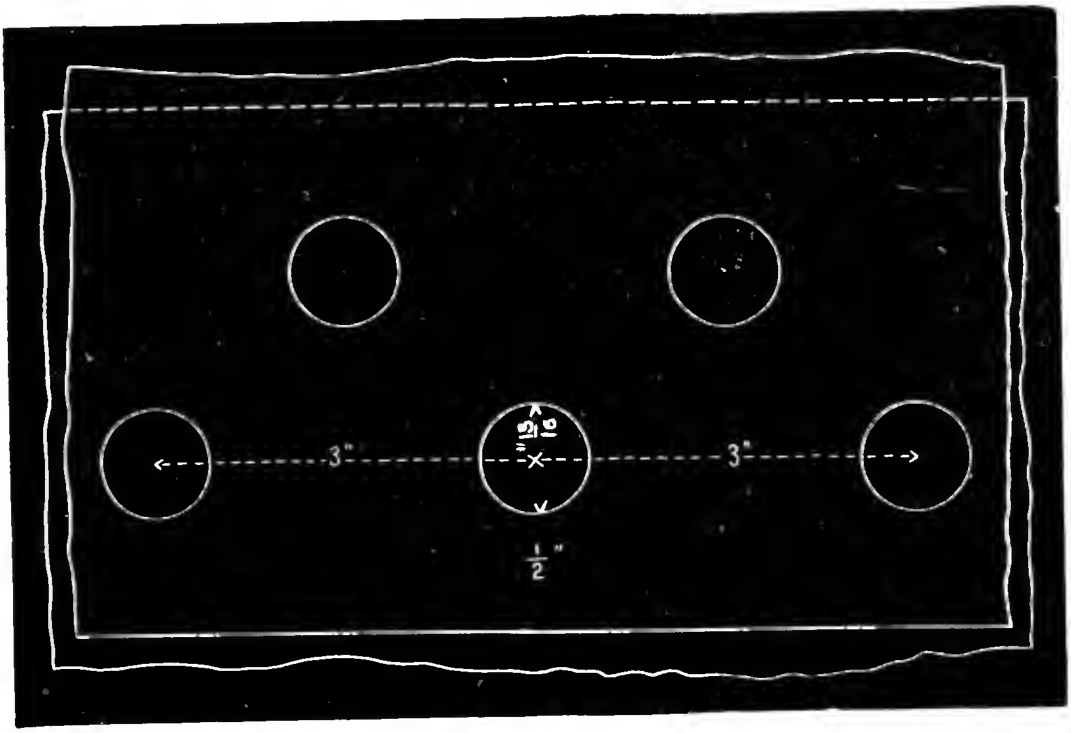


FIG. 12.

Fig. 12. Plate ½" thick. Rivet holes $\frac{15}{16}$" diam. Pitch of rivets = 3".

Strength of plate at joint $= \frac{3 - .9375}{3} = 69\%$ of solid plate.

Strength of rivets at joint $= \frac{.69029 \times 2}{3 \times .50} = 93\%$ of solid plate.

Next month we shall submit what we think are the proper proportions for single and double-riveted joints, and invite a candid and thorough criticism from all boiler-makers and others interested in the matter.

Inspectors' Reports.

APRIL, 1882.

Below is given the usual summary of the work of the Company's Inspectors for the month of April last. From it we learn that the number of visits of inspection made was 2009, during which a total of 4,533 boilers were examined. The number inspected both externally and internally foots up 1762, and 412 were tested by hydrostatic pressure. The number of boilers condemned as being unfit for further use was 57. Below is given the usual summary of defects noted:

Nature of defects.	Whole number.	Dangerous.
Cases of deposit of sediment,	263	34
Cases of incrustation and scale,	351	30
Cases of internal grooving,	22	11
Cases of internal corrosion,	130	34
Cases of external corrosion,	134	30

Broken braces and stays,	67	32
Settings defective,	118	18
Furnaces out of shape,	77	21
Fractured plates,	146	59
Burned plates,	95	27
Blistered plates,	233	41
Defective riveting,	459	22
Defective heads,	40	22
Leakage at tubes,	304	50
Leakage at seams,	174	53
Water-gauges defective,	43	15
Blow-out defective,	23	6
Cases of deficiency of water,	8	2
Safety-valves overloaded,	40	20
Safety-valves defective in construction,	33	15
Pressure gauges defective,	158	26
Boilers without pressure gauges,	7	1
Total,	2,925	569

A New Galvanometer for Powerful Currents.

A novel form of galvanometer for the measurement of intense electric currents was recently presented to the French Academy of Sciences by MM. Zerquem and Damien. It consists essentially of a magnetic needle pivoted at its middle like the ordinary tangent galvanometer needle, but the conductor conveying the current in its vicinity, instead of being in the form of a coil of wire round the needle, is constructed of a stout band of copper, so that the instrument has practically no internal resistance, and it passes under the needle and parallel with it when in the zero position. Several of these bands (there were six in the specimen exhibited) run below the needle through a block of insulating wood, and parallel to one another, this block of wood carrying the conductors, and the needle is mounted on a vertical stem of wood planted in a socket, so that it can be turned round by hand to any angle, and the current can be led to any band desired by means of vertical bands of copper, and a contact screw. The mode of using the apparatus consists in sending the current through one or other of the bands according to its degree of strength, and thereby getting a deflection of the needle. The block or bowl of the compass is then turned round until the needle points to the zero of the scale. The current is then interrupted, and the deflection angle of the needle read off. This deflection gives the rotation of the bowl, and the sine of the angle is proportional to the intensity. The several bands give the apparatus a certain range of power, and if the current is too strong for that nearest the needle it can be sent through one further off. Coefficients for finding the relative powers of the bands can be found by experiment. Moreover, for each band a curve or table of intensities corresponding to given deflection can be calculated. Such an apparatus will measure the current of a dynamo-electric machine without the use of shunts; and it appears to be very simple and effective. —*Engineering.*

The reports for 1881 of the *Märkischer Verein zur Prüfung und Ueberwachung von Dampfkesseln* in Frankfurt a. Ober, and also that of the *Verein zur Ueberwachung der Dampfkessel* mit dem Sitz in Hannover, have just been received. They contain much information of a valuable character relating to the proper management of boilers.

The Locomotive.

HARTFORD, JUNE, 1882.

The Locomotive on the Track.

A correspondent signing himself X has been taking up considerable space of late in the *Manufacturers' Gazette*, on a subject which apparently he is not very familiar with, or has an unfortunate infelicity in expressing his views. In a recent number he felt called upon to criticise our editorial on the experiments of Mr. Lawson, making wild assertions about our "being off the track," contradicting ourselves, etc. We have to say simply that the views which we expressed are the same that we have entertained and given expression to from the first. We quote from an article which we published in the LOCOMOTIVE in 1868, as follows: "Now if water subjected to high heat is confined, as in a steam boiler, its temperature may be increased almost indefinitely. For instance, in a boiler steam may be raised to a pressure of one hundred and forty pounds, which would be at a temperature of three hundred and sixty degrees, or one hundred and forty-eight degrees above the temperature required to produce steam, with the water surface open to atmospheric pressure. Now, if when the water has been so heated the pressure is removed, the water cannot remain in its original condition, as water merely, but a part of it becomes immediately converted into steam; and, if the pressure is excessive (or very high) and suddenly removed, it will cause a tremendous blow to be discharged upon the sides of the boiler sufficient, no doubt, not only to extend any existing rupture but to completely rend the boiler in pieces. There is reason to believe that steam alone, striking at a great velocity upon a solid surface, can discharge a violent blow, in addition to whatever effect it may produce by its pressure when at rest. Many steam users and theorists formerly contended that this *percussive* action of steam was sufficient to account for the most destructive boiler explosions; but more recent investigations have led engineers to look beyond this for an explanation. The following letter from Mr. D. K. Clark to the editors of the *Mechanics' Magazine* gives his views on the subject, based upon careful investigation:

"'GENTLEMEN: I have, within the last few months, given some attention to the subject of boiler explosions—their cause and their *rationale*. I observe, in the discussions that have appeared in contemporary papers, that the percussive force of the steam suddenly disengaged from the heated water in a boiler, acting against the material of the boiler, is adduced in explanation, and as the cause of the peculiar violence of the result of explosion. Now, gentlemen, a little calculation would show that the percussive force of steam is not capable of causing such destructive results as are occasionally produced; and I beg leave to suggest that the sudden dispersion and projection of the water in the boiler against the bounding surfaces of the boiler is the cause of the violence of the results, the dispersion being caused by the momentary generation of steam throughout the mass of the water and its efforts to escape. It carries the water before it, and the combined momentum of the steam and the water carries them like shot through and amongst the bounding surfaces, and deforms or shatters them in a manner not to be accounted for by simple over-pressure or by simple momentum of steam.

"'Your obedient servant, D. K. CLARK.'"

We have copied only a portion of the article which we wrote in 1868, but sufficient to show that our views have undergone no change. Our publications since have maintained the same views as against the dangerous "mysterious agency" theory, which comes to the surface now and then. It is fair to presume that X has been a diligent reader of the publications of this company, and that what few sound views he gives expression to have been derived from that source. He seems to be a *tyro* at the business, and probably had not commenced his investigations when the above article was written—he may not have been born. In a *Locomotive* article, written some time ago, on boiler explosions, we summed up their causes under four heads, viz., *bad material, faulty in type, bad work in construction, and inefficiency and carelessness in management.* X desires to know under which of these four heads Mr. Lawson's theory should be classed. If this inquiry came from some sources we might be surprised, but nothing that X says surprises us. If he will read carefully our report in the April *Locomotive*, commencing on first page, he will be able to understand how Mr. Lawson's experiments were conducted. It will be seen that as the pressure increased the safety-valve was opened at intervals of from two to six minutes. The object was to *burst the boiler*, and observe the conditions under which it "let go." It was run up to excessive pressures. This was perfectly proper for Mr. Lawson to do. His work was experimental. He did not aim to run the boiler carefully or safely. Suppose a manufacturer should introduce the same practice into the boiler-house of his mill—run the boilers up to near their bursting pressure, erect a "bomb proof" to protect the man in charge, provide a cord to enable him to raise the safety-valve at intervals of three or five minutes as the pressure increased, would that be regarded as safe practice? *It would be condemned at once as the height of carelessness—criminal carelessness in management.* If X had fully comprehended this subject, he would hardly have asked so foolish a question. He is evidently in the fog of "super-heated water," which, judging from his expressions, he fails utterly to understand. Investigations in this direction intelligently made are valuable contributions to the literature of the subject. Experiments on the Donny theory, as relating to boiler explosions, were made at the Massachusetts School of Technology several years ago, and the results, instead of furnishing any explanation of the causes of boiler explosions, exploded the theory itself. Such experiments, made by such men as the professors of this school of science, and their conclusions, have weight and are valuable. But the value of X still remains an unknown quantity.

Riveted Joints.

The articles on the strength of riveted joints which are being published in the LOCOMOTIVE are based upon the rules recommended by the English Board of Trade, and will be found in their "Manual of Instructions as to the Survey of the Hull, Equipment, and Machinery of Steam Ships Carrying Passengers." There are two rules: *First*, one for ascertaining the percentage of plate at joint as compared with the solid plate; and *Second*, one for ascertaining the percentage of strength of rivets as compared with the solid plate.

The formulæ are thus:

$$\frac{\text{(Pitch—Diameter of rivets)}}{\text{Pitch}} \quad \ldots\ldots\ldots\ldots \quad (1)$$

$$\frac{\text{(Area of rivets} \times \text{No. of rows of rivets)}}{\text{(Pitch} \times \text{thickness of plate)}} \quad \ldots\ldots\ldots \quad (2)$$

Having ascertained the results of these two problems, the smallest of the two percentages must be accepted as the maximum strength of the joint, and should be used in calculating the safe working pressure of the boiler. These rules were adopted by the Philadelphia Commission recently appointed to revise the ordinance regulating the inspection of steam boilers. The application of these rules to many of the joints of boilers now in use and being constructed will show that the greatest possible strength of joint is rarely attained. The size and pitch of rivets should be in such proportion to the thickness of plate that the results of the two problems shall be the same. Then we have the strongest form of joint attainable. We shall show in these articles what the proportions are for the strongest joint. There is an aversion on the part of many boiler-makers to increase the pitch beyond their usual practice from the fear that a tight joint cannot be secured. We believe, however, that some slight changes can be made that will secure a stronger joint and at the same time a tight one.

The Hon. William S. Slater, of Providence, R. I., died May 28, 1882, in that city, aged sixty-six years. Mr. Slater was prominently connected with the manufacturing interests of Rhode Island. He was the son of John Slater. His ancestors came to this country in 1790, and erected the first cotton-mill in America, at Pawtucket. Mr. Slater was a much-esteemed citizen of Providence. His gifts to the Rhode Island Hospital, Brown's University, and Free Public Library, were munificent. He had been for many years a member of the Board of Directors of the Hartford Steam Boiler Inspection and Insurance Company.

"X"traordinary.

It is a sad sight and a sorrowful commentary on the alleged perfection of the human brain (?) to see a man set out to demonstrate the truth of the views which he entertains on a certain subject, and become so thoroughly mixed up before he gets through that he entirely loses sight of his original ideas. The spectacle is made more especially mortifying when the aforesaid man suddenly wakes up, and, finding himself advocating his opponent's views, says that those were his views all along, and very deliberately accuses his antagonist of trying to switch on to his track. There may be no analogy between the two cases, still it reminds me very forcibly of the story about the drunken man who was one day riding upon a horse-car, and, being somewhat confused, fell over the tail-board of the car into the mud. After floundering around awhile he was finally helped up, and indignantly demanded why the car ran off the track. Upon being informed that the *car* had been on the track all the time, and that there had been no *collision*, he confidentially informed the bystanders that "if he had known that he wouldn't got off."

Such seems to be the plight into which X has fallen. Originally setting out to prove that superheated water was the sole cause of boiler explosions, he speculates along in a desultory way for several months in a series of articles entitled, "Why Boilers Burst." In this series of articles (?) I have looked in vain for any very decided reference to boiler explosions; but, after he has proved in a very labored way, by dint of using many "therefores" and "hences," that the presence of a thick coating of scale on the internal surfaces of a boiler is an efficient safeguard against over-heating the plates, and also that it takes longer and requires more heat to get up steam from water after it begins to boil than it does from the same water when it is cold, he discovers that experiments made to determine the effect of the shock which is produced by suddenly opening a large valve in a boiler under high pressure, illustrates exactly what he has been trying to demonstrate. The funny part of the matter consists in his suddenly straddling this and calling it "his theory"; and when he finds that the LOCOMOTIVE thinks much harm may be done to a weak boiler in this manner, he says that he "is glad that the LOCOMOTIVE has been converted to his view, even though it be an eleventh-hour repentance." If X will be so good as to refer to the LOCOMOTIVE for January, 1868, he will find the same matter discussed there in a manner which cannot fail to convince him that the LOCOMOTIVE is not "off the track," neither is it "switching with some difficulty on to a new line," as he alleges. This must be all the more distasteful to him by reason of his emphatically-expressed aversion to anything bearing upon boiler explosions "formulated more than twelve years ago." He may also perceive that the only person in any immediate danger of getting "left" is the aforesaid man who fell over the tail-board into the mud.

Now, why doesn't X stick to his original theory and sink or swim with it, and not suddenly throw it overboard and grasp at one propounded and discussed in the LOCOMOTIVE more than fourteen years ago? Why doesn't he confine his arguments to proving that water really can be superheated in a steam boiler, and that this superheating may be brought about by merely shutting off the steam, as he asserts in his first paper? That he has changed his views may readily be seen. Referring to my statement that he evidently considered water heated above 212° Fahr., under any circumstances, to be superheated, he says: "I adhere to my original statement, that, under ordinary conditions, with the atmospheric pressure of fifteen pounds to the square inch, these steam bubbles are not perceptible until the water arrives at a temperature of 212°; but when we repeat this test under a vacuum we observe that ebullition occurs at a far lower temperature, showing that, with the removal of the pressure on the water, steam is generated with a lower degree of heat, and proving, likewise, that the greater this pressure, the greater the degree of heat the water must absorb to produce a given steam force. This explains the phenomenon of superheated water, or water raised above 212° without making steam."

On the contrary, it does *not* "explain the phenomenon of superheated water." It merely illustrates what every one is familiar with, viz., the dependence of the boiling point on the external pressure, and has not the remotest connection with the phenomenon of superheated water. Moreover, it is not X's "original statement," nor does it agree with his original statement in any particular. It is strange X cannot quote his own language correctly, but such is the lamentable fact. His "original statement" appears in the *Manufacturer's Gazette* of January 28th, and reads exactly as follows: "Now let steam be cut off from the engine. What is the result? The steam keeps on forming, and the globules accumulate until the pressure they exert is equal to the pressure of the fire. The two forces being equal, action ceases. . . . But there is a subtle force at work all this while. It is true that steam is not being formed *actively; but the heat is entering the water, and is absorbed by it.*"

Now if any one can discover any resemblance between the above two "original statements," they are justly entitled to a large reward. The latter one is the true explanation of superheated water, *not* the former, which X avers to be his "original" explanation. But I showed conclusively in the April LOCOMOTIVE that it was impossible for the water to attain such a state in a steam boiler, and X has not yet disputed it. As he studiously avoids any discussion of this point, which is the only question on which I have taken issue with him, I incline to the belief that this Jumbo of modern steam engineers is trying to crawl under the tent to get out of the clown's way!

But as he evades discussion of the point at issue and seeks to create a diversion by "catching on" to the LOCOMOTIVE'S theory, I will take leave of him by recalling one paragraph which he has written, which well illustrates the keenness of his intellectual vision and broad grasp of his subject generally. In the *Gazette* of May 6th he says: "In 1874 I examined a steam boiler which had been in use for some twenty years. . . . I found the flues at the back end of the boiler so corroded as to leave a mere shell only, a *slight blow upon which with a small hammer* was sufficient to produce a break. . . . Now, will the insurance companies inform me at what stage of its existence the *hammer test* would have condemned that boiler?"

Probably the inspectors, and all others who know what the hammer test is, will appreciate the sublime ignorance displayed by asking the above question after making such a statement. The guilelessness displayed is about equal to that of the man who wanted to know what time the three o'clock train started for Podunk!

In conclusion I would caution X against biting into that "literary sandwich" too recklessly, lest he find it too hard for his teeth.

H. F. S.

The Blue Process of Copying Tracings.

As we have had several inquiries recently in regard to the best method of copying tracings by what is known as the "blue printing process," we will give a brief description of the method employed by us; we do not say it is the best, but it certainly is as simple as any other, and has always given us perfect satisfaction.

The materials required are as follows:—

1st. A board a little larger than the tracing to be copied. The drawing-board on which the drawing and tracing are made can always be used.

2d. Two or three thicknesses of flannel or other soft white cloth, which is to be smoothly tacked to the above board to form a good smooth surface, on which to lay the sensitized paper and tracing while printing.

3d. A plate of common double-thick window glass of good quality, slightly larger than the tracing which it is wished to copy. The function of the glass is to keep the tracing and sensitized paper closely and smoothly pressed together while printing.

4th. The chemicals for sensitizing the paper. These consist simply of equal parts, by weight, of Citrate of Iron and Ammonia, and Red Prussiate of Potash. These can be obtained at any drug store. The price should not be over 8 or 10 cents per ounce for each.

5th. A stone or yellow glass bottle to keep the solution of the above chemicals in. If there is but little copying to do, an ordinary glass bottle will do, and the solution made fresh whenever it is wanted for immediate use.

6th. A shallow earthen dish in which to place the solution when using it. A common dinner-plate is as good as anything for this purpose.

7th. A brush, a soft paste-brush about 4″ wide, is the best thing we know of.

8th. Plenty of cold water in which to wash the copies after they have been exposed to the sunlight. The outlet of an ordinary sink may be closed, by placing a piece of paper over it with a weight on top to keep the paper down, and the sink filled with water, if the sink is large enough to lay the copy in. If it is not, it would be better to make a water-tight box about 5 or 6 inches deep, and 6 inches wider and longer than the drawing to be copied.

9th. A good quality of white book-paper.

Dissolve the chemicals in cold water in the following proportions:—1 ounce of citrate of iron and ammonia, 1 ounce of red prussiate of potash, 8 ounces of water. They may all be put into a bottle together and shaken up. Ten minutes will suffice to dissolve them.

Lay a sheet of the paper to be sensitized on a smooth table or board; pour a little of the solution into the earthen dish or plate, and apply a good even coating of it to the paper with the brush; then tack the paper to a board by two adjacent corners, and set it in a dark place to dry; one hour is sufficient for the drying; then place its sensitized side up, on the board on which you have smoothly tacked the white flannel cloth; lay your tracing which you wish to copy on top of it; on top of all lay the glass plate, being careful that paper and tracing are both smooth and in perfect contact with each other, and lay the whole thing out in the sunlight. Between eleven and two o'clock in the summer time, on a clear day, from 6 to 10 minutes will be sufficiently long to expose it; at other seasons a longer time will be required. If your location does not admit of direct sunlight, the printing may be done in the shade, or even on a cloudy day; but from one to two hours and a half will be required for exposure. A little experience will soon enable any one to judge of the proper time for exposure on different days. After exposure, place your print in the sink or trough of water before-mentioned, and wash thoroughly, letting it soak from 3 to 5 minutes. Upon immersion in the water, the drawing, hardly visible before, will appear in clear white lines on a dark blue ground. After washing, tack up against the wall, or other convenient place, by the corners to dry. This finishes the operation, which is very simple throughout.

The Effect of Extravagant Promises.

There is a somewhat familiar story of a man who upon estimating at the end of the week the probable results of adopting all the "improvements" offered during the preceding six days—improvements all looking to the saving of fuel in connection with his engine and boiler—found that so far from buying any more coal he could open a coal-yard, with reasonable prospects of supplying a fair trade. Whatever of truth there may be, literally, in this story, it is entitled to the legend—"Founded on fact."

In view of the general increase of knowledge in matters pertaining to steam engineering, it might with reason be supposed that extravagant assertions of prospective saving by the use of new devices, or by the re-employment of ancient contrivances, would be less frequent than when there was a good deal of excusable ignorance in relation to such matters. That is, this ignorance might be taken as an excuse why the inventor should, if quite honest in his intention, deceive himself, or if not entirely sincere, should attempt to deceive the purchaser.

The *possibilities* of the use of coal, in connection with the steam engine, according to known methods, are made reasonably plain to those who read, or inquire, notwithstanding which there is apparently no end of those who are anxious to agree to reverse all known laws, by means which it is apparent contemplate no addition to existing knowledge of the subject. Instead of decreasing, the list of wonderful steam motors and remarkable appliances that save considerably more than is wasted, were probably never so numerous as just now.

No exception can be taken to those who look to doing more work—in the steam engine for instance—for less money. On the contrary, any one who accomplishes a desired end in this direction, or even who honestly attempts its accomplishment, is in a plain sense a benefactor. There is no trouble with what *is* accomplished, but rather in the fact that the exaggerated statements of what *is to be* accomplished, serves the end of preventing the trial and probable adoption of really valuable devices. A wise man with a few hundred dollars puts it into some institution that can afford to pay the interest it agrees to pay, rather than invest it with some one who offers 25 per cent. With equal reason the purchaser of mechanical devices inquires as to the possibility of the results talked of, and finding them impossible, sets the vender down as a fool or knave, exactly which making no difference in the consequences.

The mistake made in this respect, and it is a mistake that often results disastrously to the inventor or introducer, is that it is necessary to tell a large story to secure attention, while the fact is, that no one likes to be approached as if devoid of ordinary intelligence. In effect, extravagant assertions of this kind made to those, who, however limited their specific knowledge of the subject may be, are yet well enough acquainted with it in a general way to recognize their absurdity, have much the effect of intensely qualified expressions of any sort; that is, they discredit whatever of truth there may be in the entire statement.

We noticed recently in a circular of a new valve gear, with which it is proposed to displace an extensively-used and reasonably-economical type of cut-off gear, a claim—made particularly prominent—of a saving of the new over the old of 50 per cent. For all we know to the contrary, there are points of merit in the new arrangement that ought to bring it into immediate general use. If this is true, it is a pity that it should go seeking public favor handicapped with such an extravagant claim. The class of men with whom this is to find favor particularly, know that it is impossible that it should bring about any such saving; and it would seem that no better plan, not to have it considered, could be devised. As considerably better (?) than this, the result of the fuel economy of using a device in connection with a locomotive, a device which has for its principal object the bringing about of more cleanliness and hence comfort on the train, is given as more than 70 per cent. Such statements are simply absurd on their face, and the wonder is, that it is not quite apparent that they go far to neutralize anything of good there may be in the arrangement.

The writer remembers a few years ago, being applied to by a party—a stranger—to examine a grate-bar for a boiler furnace, and, if thought well of, to give the exhibitor a note that might possibly assist him in making a beginning in the locality. It was purely a matter of good-will that led him to accompany the inventor to an establishment for the purpose of introducing him to the engineer—a man who had grown old in the business, and whose word would be sufficient in the matter of its adoption, or at least its trial.

The engineer was favorably impressed, and, although using what he considered the best grate of which he knew, was quite determined to give the new grate a trial, until in an unfortunate moment the inventor sacrificed all possibility of his doing so, by asserting that it would save 30 per cent. in fuel. The extravagance of the claim, perhaps in its effect heightened somewhat by the covert insinuation that thirty years of experience had only been sufficient to educate him up to waste 30 per cent. of the coal, effectually settled the grate-bar, so far as that party was concerned.

As previously intimated, such assertions are entirely uncalled for, and always work to the detriment of the party making them. As a rule, purchasers are satisfied with a reasonable saving, and are more inclined to meet a seller who only promises what is at least possible, than one who promises impossibilities. Beyond the point of the selling of something of the kind referred to, the seller can never get so good a recommend as that of having it do more than he promised, nor so poor a one as the having it do materially less.

The effect of extravagant promises is entirely adverse to the interest of the seller—in the first place as operating against the probability of his selling what he has to dispose of, and in the second place as resulting in dissatisfaction, should he succeed in selling.—*American Machinist.*

Notes and Queries.

W. L. G., Hamilton, N. Y., inquires: "What is the best method of removing scale collected in feed-pipe? Pipe runs through front head of boiler over furnace, no circulating pipe inside. Where does one apply for engineer's license? What is the best weekly paper to take to gain information regarding engines and boilers?"

Ans. (1) Try solvents dissolved in the feed water. If the scale is a lime scale, soda ash or tannic acid will be found useful. If this fails you had better take the pipe out and remove the scale by mechanical means. (2) In the cities of New York and Brooklyn, to the Boiler Inspector's Department, at Police Headquarters. In the smaller towns we believe no license is required. (3) For sources of information regarding engines and boilers see answer to W. T., below. The *Boston Journal of Commerce*, the *American Machinist*, and *Mechanics* are all good papers for an engineer to take.

E. L., St. Louis, Mo. Your suggestion is a good one, but it lies outside of our specialty.

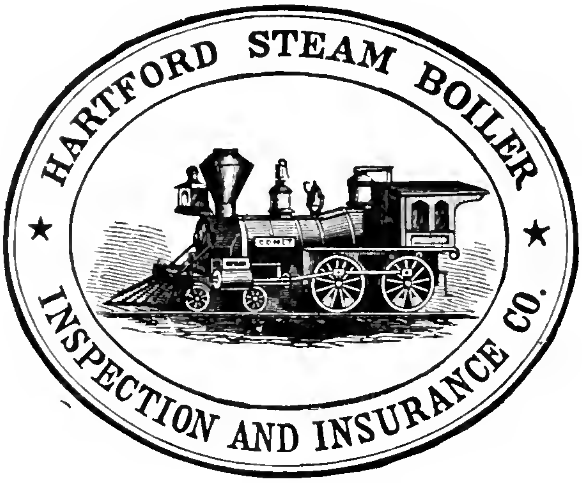
From W. T., Cambridge, Mass.: "What are the disadvantages of the Compound Tubular Boiler other than not being able to get to lower shell to clean it, and its priming? What is a good elementary book on steam-boilers and engines?"

Ans. (1) There are no other especial disadvantages if the boilers are well constructed of good material. (2) The best work on boilers is Wilson's *Treatise on Steam Boilers*, published by Crosby, Lockwood & Co., of London. For works devoted more particularly to engines we can recommend Thurston's *Rise and Growth of the Steam Engine*, King's *Practical Notes on the Steam Engine*, and Forney's *Catechism of the Locomotive*. If you are already familiar with the construction and practical operation of different types of engines, we would advise you to read Cotterill's *Steam Engine Considered as a Heat Engine* and D. K. Clark's *Fuel, its Combustion and Economy*. All of the above may be obtained of any bookseller.

D. W. C. H., Willimantic, Conn., asks: "What is the proper way to leave a common tubular boiler which is to remain out of use during the summer, it being used as a heating boiler in the winter? Should it be left full of water, or empty?"

Ans. Blow the boiler off while the setting is somewhat warm. Remove the man and hand-hole plates immediately; and, if the blow-off pipe does not enter through the bottom of the shell, syphon out what water remains, so that the shell and tubes may be thoroughly dried. The man-hole and hand-holes should be left off to allow thorough circulation of air. If the location of the boiler is very damp, it may be necessary to build a fire of shavings under it beneath the grates, every few weeks, to keep it in proper condition.

Incorporated 1866.



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

COVERING ALL LOSS OR DAMAGE TO

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ARISING FROM

Steam Boiler Explosions.

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Or at any Agency.

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The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. III. HARTFORD, CONN., JULY, 1882. No. 7.

Proportions of Riveted Joints.

The cuts in last month's *Locomotive* show better practice than the average. They were selected from the proportions of the best and most prominent manufacturers only. The general practice in the greater number of shops was shown in Figs. 1 and 2, where the pitch is the same in both single and double-riveted plates. The practice cannot be too strongly condemned, and it is strange that such a system can find followers anywhere among intelligent boiler makers.

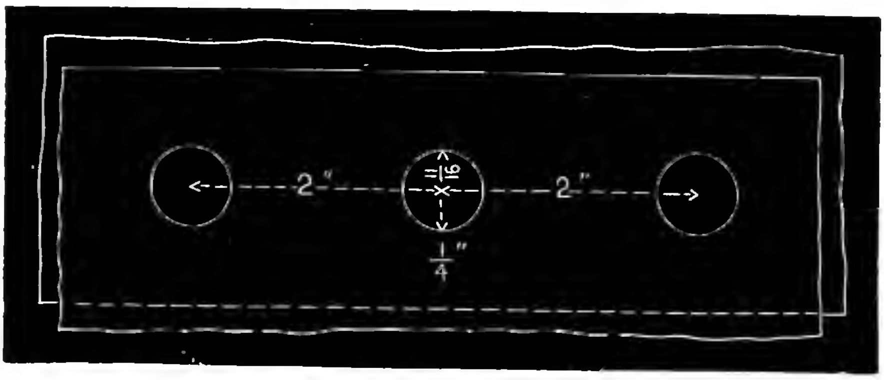


FIG. 1.

Having shown the great diversity of practice in proportioning riveted joints, the question arises, what are the best proportions for the different thicknesses of plate? We have shown that the strongest form of joint is seldom realized in practice, and that double-riveting is invariably badly proportioned. Different reasons are given for this wide departure from the strongest proportion, the principal one being the impossibility of making a tight joint with wide pitches. Now we maintain that tight joints can be made with much wider pitches than are generally used, for we know of several places where it is done without any trouble whatever. If ordinary skill is used there will be found no trouble whatever in using 3″ pitch for a double-riveted joint in a quarter-inch plate.

Another strong argument in favor of the widest possible pitch is the fact that more metal remains to resist the effects of corrosion, which always affects the plate more than it does the rivet. All things being equal, the life of the boiler will be greater in proportion to the amount of effective material we have to resist deteriorating influences.

After extended observation and mature reflection, we have arranged the following scale of pitches and rivet diameters for different thicknesses of plates. It will be noticed that the distance between the two rows of rivets in the double-riveted joints is such that the distance from the center of any rivet in one row to the center of the next rivet in the other row is about equal to the pitch in single riveting. This is an important point and should never be overlooked. By this means we get the advantage of the staunchness due to a small pitch with the extra metal and greater strength of the wider pitch. We give cuts of the proportions with calculations of their efficiencies, and invite careful consideration of them, and candid criticism if anyone is disposed to be critical.

Referring to Fig. 1 we have:—

Plate $\frac{1}{4}''$ thick. Rivet hole $\frac{11}{16}''$ diam. Pitch of rivets, $2''$.

Strength of plate at joint $= \frac{2.-.6875}{2} = 66$ per cent. of solid plate.

Strength of rivets at joint $= \frac{.37122}{2\times .25} = 74$ per cent. of solid plate.

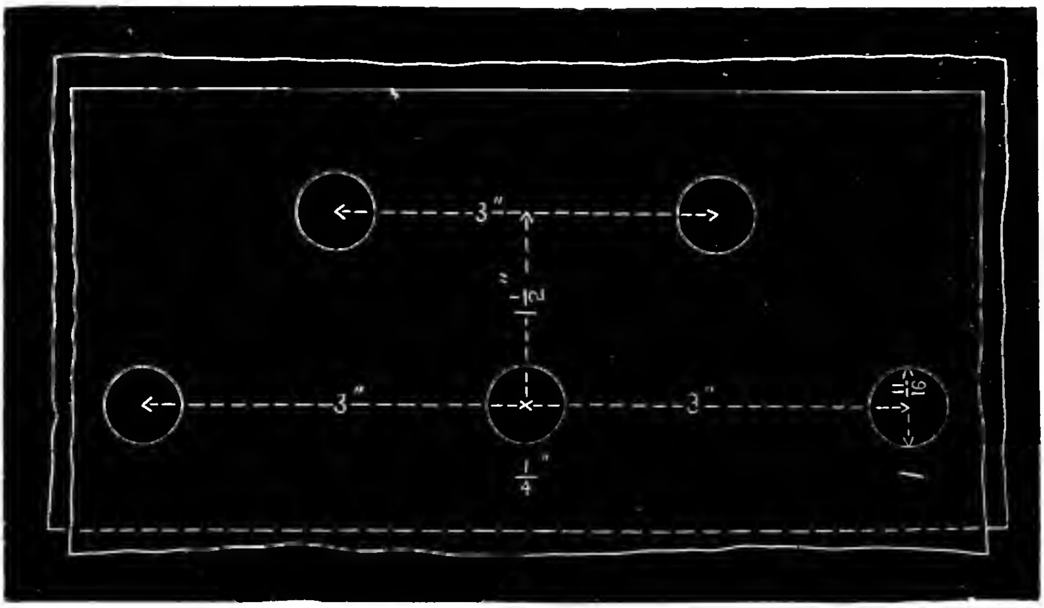


Fig. 2.

Fig. 2. $\frac{1}{4}''$ plate, double-riveted. Rivet holes, $\frac{11}{16}''$ diam. Pitch of rivets, $3''$.

Strength of plate at joint $= \frac{3.-.6875}{3} = 77$ per cent. of solid plate.

Strength of rivets at joint $= \frac{.37122\times 2}{3\times .25} = 99$ per cent. of solid plate.

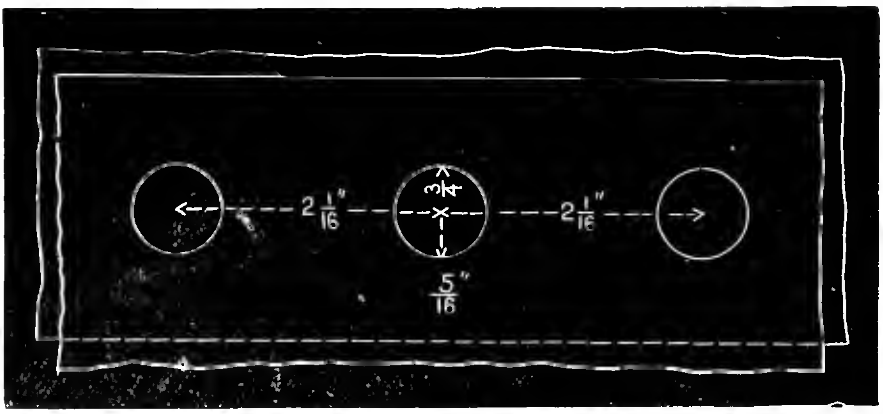


Fig. 3.

Fig. 3. $\frac{5}{16}''$ plate, single riveted. Rivet holes $\frac{3}{4}''$ diam. Pitch of rivets$=2\frac{1}{16}''$.

Strength of plate at joint $= \frac{2.0625-.75}{2.0625} = 64$ per cent. of solid plate.

Strength of rivets at joint $= \frac{.44179}{2.0625\times .3125} = 68$ per cent. of solid plate.

Fig. 4. $\frac{5}{16}''$ plate, double-riveted. Rivet holes $\frac{3}{4}''$ diam. Pitch of rivets$=3\frac{1}{8}''$.

Strength of plate at joint $= \frac{3.125-.75}{3.125} = 76$ per cent. of solid plate.

Strength of rivets at joint $= \frac{.44179\times 2}{3.125\times .3125} = 90$ per cent. of solid plate.

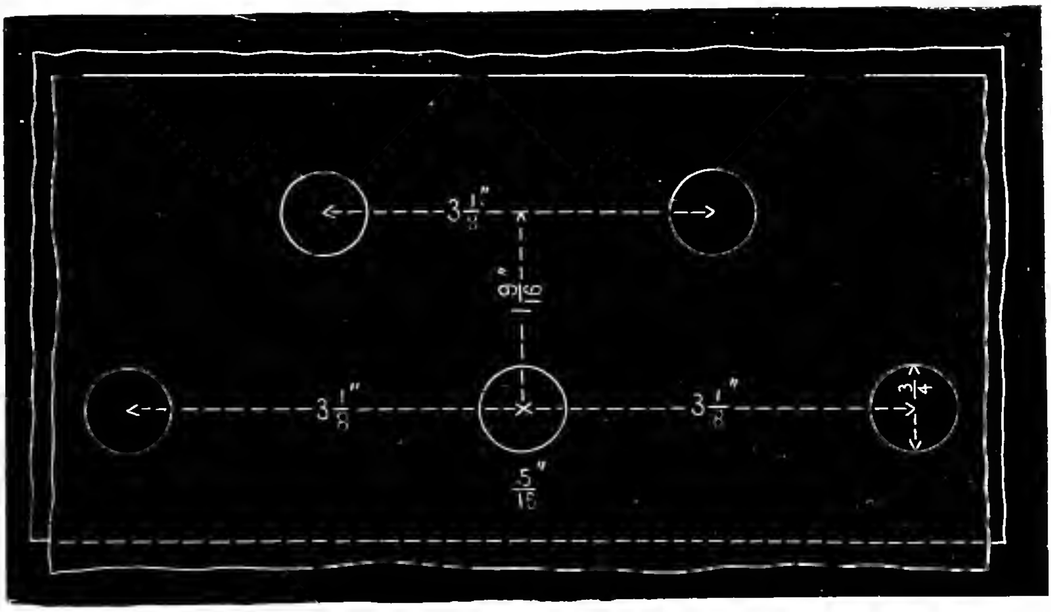


Fig. 4.

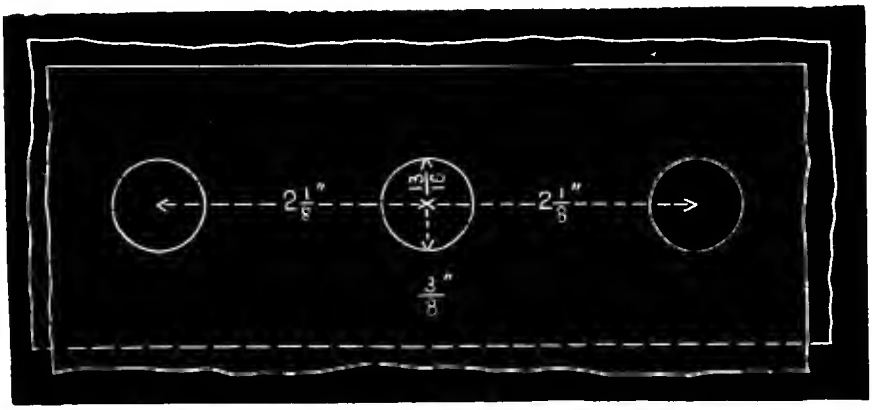


Fig. 5.

Fig. 5. $\frac{3}{8}$" plate, single-riveted. Rivet holes, $\frac{13}{16}$" diam. Pitch of rivets $= 2\frac{1}{8}$".

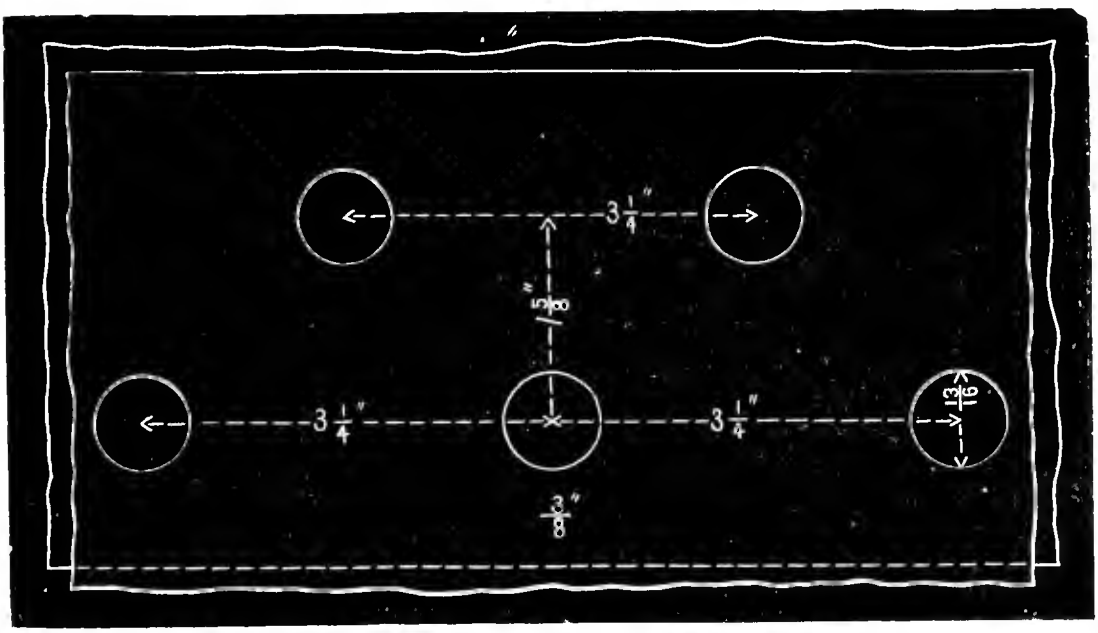


Fig. 6.

Strength of plate at joint $= \frac{2.125-.8125}{2.125} =$ 62 per cent. of solid plate.

Strength of rivets at joint $= \frac{.51849}{2.125 \times .375} =$ 65 per cent. of solid plate.

Fig. 6. $\frac{3}{8}''$ plate, double-riveted. Rivet holes, $\frac{13}{16}''$ diam. Pitch of rivets$=3\frac{1}{4}''$.

Strength of plate at joint $= \frac{3.25-.8125}{3.25} =$ 75 per cent. of solid plate.

Strength of rivets at joint $= \frac{.51849 \times 2}{3.25 \times .375} =$ 85 per cent. of solid plate.

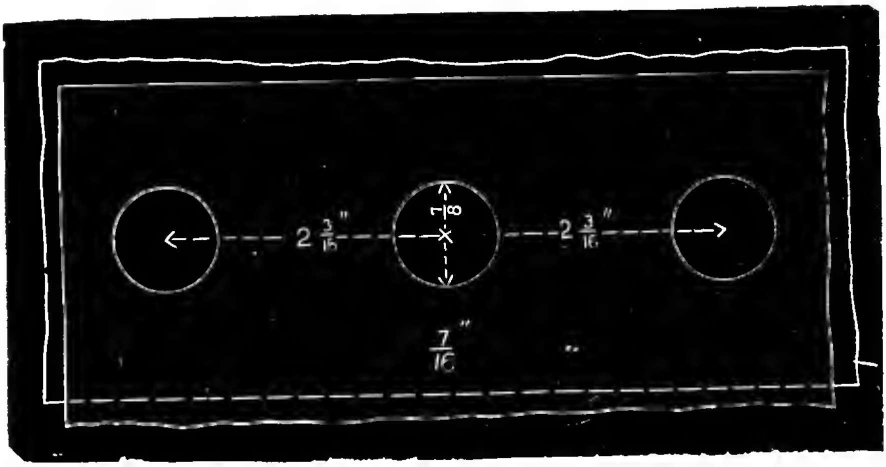


FIG. 7

Fig. 7. $\frac{7}{16}''$ plate, single-riveted. Rivet holes, $\frac{7}{8}''$ diam. Pitch of rivets$=2\frac{3}{16}''$.

Strength of plate at joint $= \frac{2.1875-.875}{2.1875} =$ 60 per cent. of solid plate.

Strength of rivets at joint $= \frac{.60132}{2.1875 \times .4375} =$ 63 per cent. of solid plate.

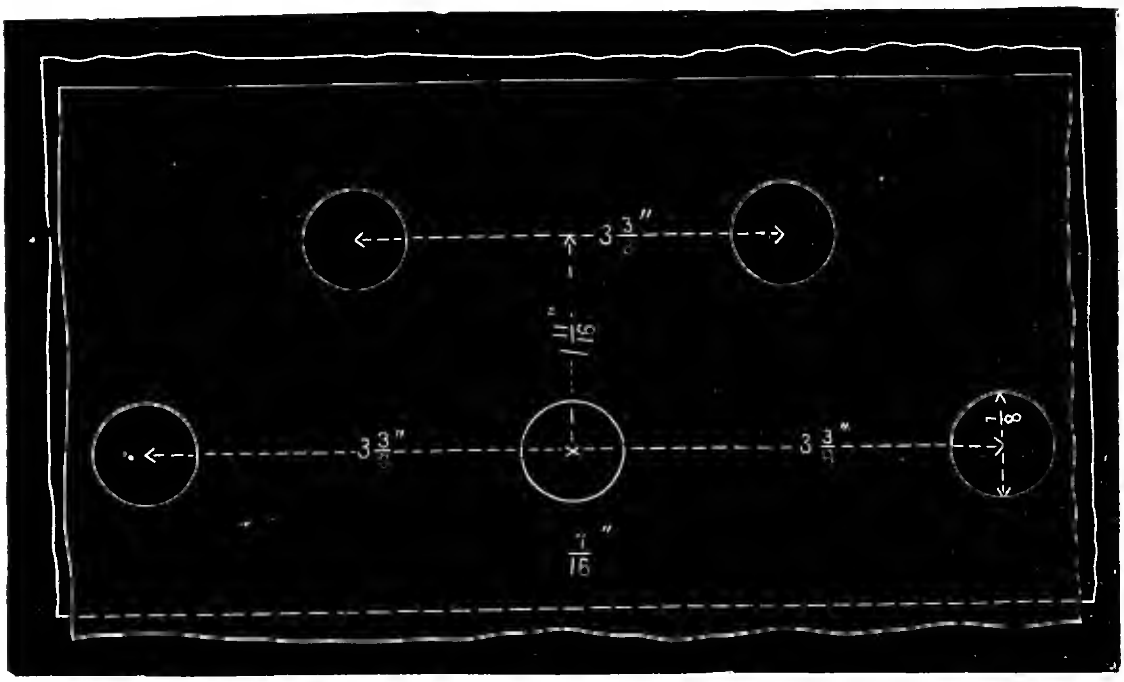


FIG. 8.

Fig. 8. $\frac{7}{16}''$ plate, double-riveted. Rivet holes, $\frac{7}{8}''$ diam. Pitch of rivets$=3\frac{3}{8}''$.

Strength of plate at joint $= \frac{3.375-.875}{3.375} =$ 74 per cent. of solid plate.

Strength of rivets at joint $= \frac{60132 \times 2}{3.375 \times .4375} = 81$ per cent. of solid plate.

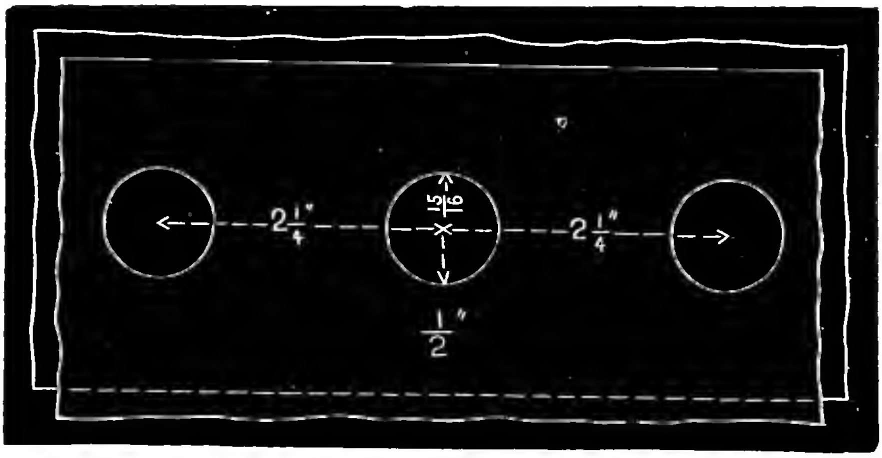


FIG. 9.

Fig. 9. $\frac{1}{2}''$ plate, single-riveted. Rivet holes, $\frac{15}{16}''$ diam. Pitch of rivets $= 2\frac{1}{4}''$.

Strength of plate at joint $= \frac{2.25 - .9375}{2.25} = 58$ per cent. of solid plate.

Strength of rivets at joint $= \frac{.69029}{2.25 \times .5} = 61$ per cent. of solid plate.

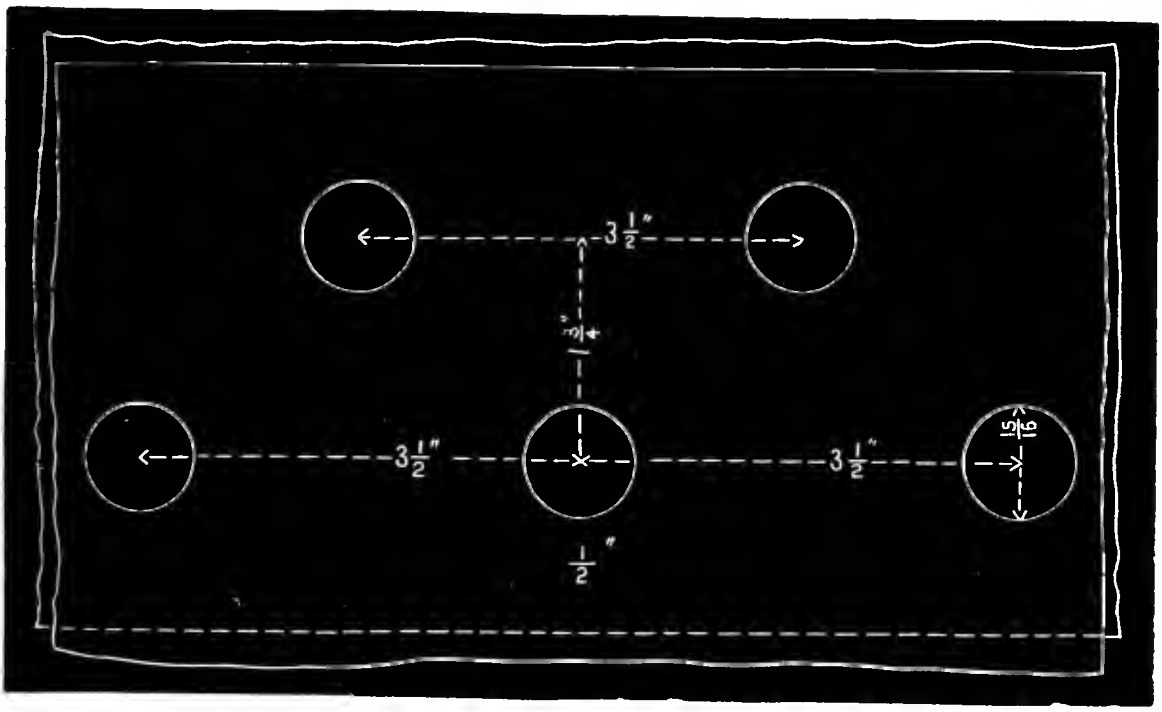


FIG. 10.

Fig. 10. $\frac{1}{2}''$ plate, double-riveted. Rivet holes, $\frac{15}{16}''$ diam. Pitch of rivets $= 3\frac{1}{2}''$.

Strength of plate at joint $= \frac{3.50 - .9375}{3.50} = 73$ per cent. of solid plate.

Strength of rivets at joint $= \frac{69029 \times 2}{3.50 \times .50} = 79$ per cent. of solid plate.

The above we believe to be as good and systematic proportions for riveted joints as have been published by anyone. We have given the size of the rivet-holes in estimating the strength, in every case. The rivets would of course be $\frac{1}{16}''$ smaller. In practice the holes generally are not more than $\frac{1}{32}''$ larger than the rivets which are driven in them; in that case, the proportionate strength of plate given above would be somewhat increased.

Plates more than $\frac{1}{2}''$ thick should never be joined with lap-joints. When it is necessary to use them, a butt joint with a double fish plate should always be used. In recommending the above proportions, we assume that the workmanship is always fair. In these days there is no excuse for poor and slouchy workmanship under any circumstances.

TABLE OF THE FOREGOING PROPORTIONS.

Thickness of plate,	$\frac{1}{4}''$	$\frac{5}{16}''$	$\frac{3}{8}''$	$\frac{7}{16}''$	$\frac{1}{2}''$
Diameter of rivet,	$\frac{5}{8}$	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$
Diameter of rivet-hole,	$\frac{11}{16}$	$\frac{3}{4}$	$\frac{13}{16}$	$\frac{7}{8}$	$\frac{15}{16}$
Pitch—single-riveting,	2	$2\frac{1}{16}$	$2\frac{1}{8}$	$2\frac{3}{16}$	$2\frac{1}{4}$
Pitch—double-riveting,	3	$3\frac{1}{8}$	$3\frac{1}{4}$	$3\frac{3}{8}$	$3\frac{1}{2}$
Strength of single-riveted joint,	.66	.64	.62	.60	.58
Strength of double-riveted joint,	.77	.76	.75	.74	.73

Inspectors' Reports.

MAY, 1882.

The usual monthly summary of the work done by the Inspectors of the company during the month of May last, is given below. From it we learn that 2,612 visits of inspection were made, during which 5,419 boilers were examined. The number of complete internal inspections foots up 1,874, and 487 others were subjected to hydrostatic pressure. The number of boilers considered worn out and unfit for further use was 39.

The total number of defects found was 2,859, of which number 637 were considered to be of so serious a character, as to impair the safety of the boilers in which they were located. The following detailed statement of defects shows their precise nature.

Nature of defects.	Whole number.	Dangerous.
Cases of deposition of sediment,	285	62
Cases of incrustation and scale,	428	56
Cases of internal grooving,	36	19
Cases of internal corrosion,	98	21
Cases of external corrosion,	129	46
Broken and loose braces and stays,	54	20
Settings defective,	97	23
Furnaces out of shape,	91	19
Fractured plates,	174	108
Burned plates,	92	17
Blistered plates,	225	41
Cases of defective riveting,	269	4
Defective heads,	16	8
Leaky tubes,	402	84
Leaky seams,	141	18
Water-gauges defective,	56	11
Blow-out defective,	27	15
Cases of deficiency of water,	6	4
Safety-valves overloaded,	35	17
Safety-valves defective in construction,	19	11
Pressure gauges defective,	174	30
Boilers without pressure gauges,	5	2
One dangerous defect unclassified,		1
Total,	2,859	637

The Locomotive.

HARTFORD, JULY, 1882.

The following article was originally prepared for *The Boston Journal of Commerce*, and appeared in its issue of July 1st:

Some months ago I prepared an illustrated article for the *Journal of Commerce* on machine riveting. My object was not to condemn machine riveting, but to call the attention of boiler makers who used riveting machines to the fact that, unless such machines were under the management of skillful men, very poor work might be turned out. It was shown that the failure to so adjust the parts—that the axes of the moving cup-shaped die, fixed die, and rivet hole, were coincident—would result in forming the head on one side of the body of the rivet. The illustrations, made from rivets in this office, could not fail to convince any careful observer of the necessity of great care in the use of the riveting machine. When business is driving and the boiler maker is overwhelmed with orders, he finds the riveting machine of great service, because the work can be so much more rapidly done by it, and it is just here that the liability to carelessness comes in. With due care in adjustment there is no doubt but that a very effective, I will say, superior joint, can be made by a riveting machine.

I introduce here illustrations of three (3) rivets which have come into my possession since the last article was written:

Fig. 1. Fig. 2. Fig. 3.

They only furnish additional evidence that the proper adjustment of the machine and the work to be done is sometimes overlooked.

The question has been raised as to whether the great force with which the rivet is driven will not tend to so enlarge or expand the body of the rivet as to endanger that portion of the plate extending from the rivet holes to the edge; that is, start a fracture from the holes outward. I have watched for this defect, but have failed to detect it. I am told, however, that others have satisfied themselves that it is sometimes true.

If it is so, may it not result from using a rivet of too great length for the thickness of plate?

We can readily see that when the rivet is driven, any excess of metal must find a place for itself somewhere. My own observations have been that, under such circumstances, it flows out underneath the face of the die, forming a "*fin*," as shown by the following illustrations:

FIG. 4.

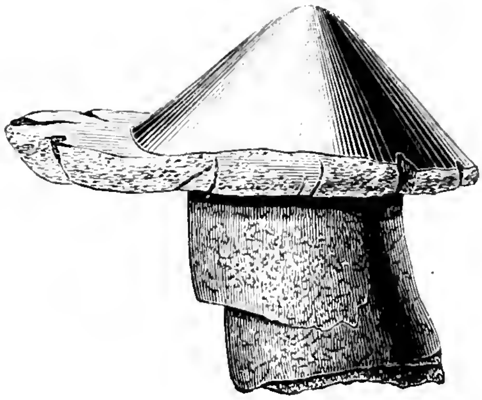


FIG. 5.

It has been said that a "fin" could not be formed on a rivet head made by a machine. But suppose we have a rivet containing more than metal sufficient to fill the rivet hole and the cup-shaped dies; it must flow somewhere, and it will go in the place of least resistance, which will be out underneath the face of the die. This point of relief is to my mind sufficient to prevent any damaging strain being brought upon the plates from the enlarging of the body of the rivet. But it is well to bear in mind that the rivets should be adapted in length to the thickness of plate, and to the capacity of the cup-shaped die, or dies.

In hand riveting, an excess of metal is disposed of by distributing it over a larger area, or by giving the apex of the head greater altitude above the plate. In machine riveting, the shape and size of the head is determined by the die. J. M. ALLEN.

Prof. Antonio Favaro of the Royal University of Padova, Italy, has published a very interesting and valuable work on Acoustics, as applied to the construction of churches, public halls, &c. It has been our privilege to have more or less correspondence with Prof. Favaro on this subject, and we are gratified to have the results of his investigations. The laws of Acoustics are so little understood, or so little attention is given to the subject by builders of churches and public halls, that there are many in this country as well as foreign countries, where everything is sacrificed to architectural effect. The Professor points out these defects, and lays down some rules by which these bad effects may be remedied or avoided. The work is printed in Italian; we are not aware that it has been translated into English.

In John W. Nystrom's Treatise on Steam Engineering, page 102, he says, under the heading *Double-Riveted Lap Joints:* "Double-riveted joints, if properly proportioned, increase the strength of the boiler about forty per cent., on account of the rivets being spaced farther apart, leaving more section of plate between them to resist the strain. The rivets are arranged in two rows, ziz-zag over one another, as shown in the illustration. For the greatest strength the distance between the rivets in the direction of the joint should be double the distance between the center lines of the two rows, and the rivets will then form a right angle, or 90° with one another."

The illustration which he gives is in accord with our own views, and will, with due proportion of size of rivet to thickness of plate, give the strongest double-riveted joint. Our own method of arriving at the size of rivet is based upon the thickness of plate, and the pitch is determined from the thickness of plate and size of rivet. The distance of the center lines of the two rows of rivets we make equal to half the pitch. This gives the same result as is shown in Mr. Nystrom's illustration, viz., the rivets form a right angle, or 90° with one another.

We have noticed of late articles on Riveted Joints in several mechanical journals which were stolen bodily from an article prepared in this office, and which appeared in the LOCOMOTIVE of September, 1881. One English paper has copied it, crediting it to an *Exchange.* We do not object to having articles copied from the LOCOMOTIVE, but expect that every honorable journalist will give us due credit. To copy *verbatim et literatim*, with no credit, is no better than stealing, and we are ready to believe that no honorable journalist would knowingly be so discourteous. It is proper to say that the attention of those who have done this has been called to the matter, and their explanations in the main have been satisfactory. Some of our articles have been prepared at no little expense and labor, and if they are used by others, due credit should be given.

We are indebted to the Pennsylvania Iron and Steel Co. for specimens of riveted joints. There are hand-driven, button set, and hydraulic machine-driven rivets. The work in each case is first-class. The relative merits of the different methods can be readily seen. The Pennsylvania Iron & Steel Company say that they give the preference to machine riveting in their works.

We also are favored with a specimen joint made with Johnson's Riveting Machine. Mr. Johnson of New Orleans, the inventor, explained to us personally the peculiarities of his machine. The work is so adjusted that the rivets stand perpendicular when driven. He has a piston within a piston, one to bring the plates together and the other to drive the rivet. He claims that with his machine a rivet cannot be driven with the head offset. We have had numerous communications bearing on the question of machine riveting, since we called attention to the bad work that is sometimes done through carelessness, with such machines.

We are indebted to Howard Lockwood, Esq., Publisher, for a copy of Grimshaw's work, called the *Miller, Millwright, and Mill-furnisher.* It is a book of between 500 and 600 pages, and pretty thoroughly covers the ground indicated by its title. It will no doubt have a large sale among men engaged in the milling business.

The *Mechanical Engineer* of New York is growing in favor among mechanics. It senior editor, Mr. E. P. Watson, was formerly editor of the *Scientific American*, and he knows how to make a valuable paper. Read their articles entitled the "Professor in the Machine Shop."

At the meeting of the Master Car-Builders' Association, held in Philadelphia on June 13th, Mr. M. W. Forney, of the *Railroad Gazette*, stated that from 1,200 to 1,500 employees are killed annually on our railroads, and from 5,000 to 10,000 injured.

A BRASS steam-whistle, thought to be the largest ever made, has just been finished by the Eaton, Cole & Burnham Co., 58 John St., New York. It is of cast brass, 4 ft. 9 in. in length, the bell having a diameter of twenty in. Its weight is 400 lb., and its value $500. The supply pipe is 4 in. in diameter. It goes to a large steam saw mill in Canada, where it is to be employed, with a system of signals, to give orders to the lumbermen at a distance, and to summon the widely scattered employees in case of fire. —*Scientific American.*

Specific Gravity Table.

The following table of Specific Gravities, etc., has been condensed from Trautwine's Engineers' Pocket Book. The third column, which will be found useful in many cases, has been added by us. The table will be found of very great use in ascertaining the weight of anything which it is not convenient to weigh, but can be measured. Such, are boilers, large masses of metal, beams, floors, and walls of buildings, tanks and barrels of water, etc. The cubic contents being obtained by measurement, the weight may easily be computed.

TABLE OF THE WEIGHT AND SPECIFIC GRAVITY OF DIFFERENT SUBSTANCES.

NAME OF SUBSTANCES.	Average Specific Gravity.	Weight of one Cubic ft.	Weight of one Cu. in.
Air, atmospheric at 60° and under the pressure of one atmosphere, or 14.7 lbs. per sq. inch, weighs $\frac{1}{815}$ part as much as water at 60°,	.00123	.0765	
Alcohol, pure,	.793	49.43	.0286
Alcohol of commerce,	.834	52.1	.0301
Ash, American white, dry,* (see foot note, p. 108,)	.61	38	.022
Ash, American white, 1,000 ft. board measure weighs 3,167 lbs.,			
Bismuth, cast. Also native,	9.74	607	.3512
Brass, (Copper and Zinc) cast, 7.8 to 8.4. Average,	8.1	504	.2916
Brass, rolled-sheet,	8.4	524	.3032
Bronze, gun metal, copper 8 parts, tin 1, 8.4 to 8.6,	8.5	529	.3061
Brick, best pressed, 1,000 = 5,750 pounds ($8\frac{1}{4}'' \times 4'' \times 2''$),		150	.0868
" common hard, 1,000=4,800 " " "		125	.0723
" soft inferior, 1,000=3,850 " " "		100	.0579
Charcoal, of pines and oaks,		15 to 30	
Coal, Anthracite, of Pennsylvania, 1.3 to 1.7, average,	1.5	93.5	.0541
" " broken, of any market size, loose,		52 to 56	
" " " " " " " shaken,		56 to 60	
" " a heaped bushel, loose, weighs 77 to 83 lbs.,			
" " 2,240 lbs., loose, averages from 40 to 43 cu. ft.,			
" " 2,000 " " " " 36 to 39 " "			
" Bituminous, 1.2 to 1.5, average,	1.35	84	.0486
" " broken, of any market size, loose,		47 to 52	
" " " " " " " shaken,		51 to 56	
" " a heaped bushel, loose, 70 to 78 pounds,			
" " 2,240 lbs. occupies 43 to 48 cubic feet,			
" " 2,000 " " 39 to 43 " "			
Cherry, perfectly dry,* (see foot note, p. 108,)	.672	42	.0243
" 1,000 ft. board measure weighs 3,500 pounds,			
Chestnut, perfectly dry,* (see foot note, p. 108,)	.66	41	.0237
" 1,000 ft. board measure weighs 3,416 pounds,			
Cement—hydraulic, Rosendale, ground, loose, average,		56	
" " " U. S. struck bushel=70 lbs.,			
" " Louisville, " " " " =62 "		49.6	
" " English, Portland, U. S. struck bushel= 100 to 128,		81 to 102	
Cement—hydraulic, English, Portland, a barrel=400 to 430 lbs.,			
Copper, cast, 8.6 to 8.8,	8.7	542	.3136
" rolled, 8.8 to 9.0,	8.9	555	.3212
Cork,	.25	15.6	
Earth, common loam, perfectly dry, loose,		72 to 80	
" " " " " shaken,		82 to 92	
" " " " " moderately rammed,		90 to 100	
" " " as a soft flowing mud,		104 to 112	
Elm, perfectly dry,* average, (see foot note, p. 108,)	.56	35	.0202
" " " 1,000 ft. board measure weighs 2,916 lbs.,			

Name of Substances.	Average Specific Gravity.	Weight of one Cubic ft.	Weight of one Cu. in.
Glass, 2.5 to 3.45, average,	2.98	186	.1076
Glass, common window, average,	2.52	157	.0908
Granite, 2.56 to 2.88, average,	2.72	170	
Gneiss, common 2.62 to 2.76, average,	2.69	168	
Gravel, about the same as sand, which see.			
Gold, cast, pure, or 24 carat,	19.258	1204	.6967
" native, pure,	19.32	1206	
" pure hammered, 19.4 to 19.6,	19.5	1217	.7042
Hemlock, perfectly dry,* (see foot note, p. 108.)	.4	25	.0145
" 1,000 ft. board measure weighs 2,083 pounds.			
Hickory, perfectly dry,* (see foot note, p. 108.)	.85	53	.0306
" 1,000 ft. board measure weighs 4,415 pounds.			
Iron, cast,	6.9 to 7.4	430 to 461	
" " usually assumed at,	7.21	450	.2604
When 1 cubic ft.=450 lbs.; 1 cubic in.=.2604 lb. and one pound=3.84 cubic in., 2,000 pounds=7,680 cubic in.			
Iron, wrought,	7.6 to 7.9	474 to 493	
" " large rolled bars,	7.6	474	
" " " " " usually assumed at,	7.69	480	.2778
" " sheet,		485	.2807
When 1 cubic ft.=480 lbs., 1 cubic in.=.2778 lb., one pound=3.6 cubic in., 2,000 pounds=7,200 cubic in.			
Ice,	.92	57.4	.0332
Lead, average,	11.41	711	.4114
Lime, quick, average,	1.5	93	
" " either in small irregular lumps or ground, loose, 50 to 58,		53	
Lime, quick, ground, loose, 62 to 70 lbs. per struck bushel,		53	
" " " well shaken, 80 " " " "		64	
" " " thoroughly shaken, 93$\frac{3}{4}$ lbs. per struck bushel,		75	
Mahogany, dry Spanish,* average, (see foot note, p. 108.)	.85	53	
" " Honduras, "	.56	35	
Maple,* dry, average, (see foot note, p. 108.)	.79	49	.0283
1,000 ft. board measure=4,083 pounds.			
Masonry, of granite or limestone, well dressed throughout,		165	
" " " well scabbled mortar rubble, $\frac{1}{5}$ mortar,		154	
" " " " " dry rubble,		138	
" " brickwork, medium quality,		125	
Mercury at 60°,	13.58	846	.4896
Mortar, hardened, 1.4 to 1.9, average,	1.65	103	
Oak, live, perfectly dry,* " (see foot note, p. 108.)	.95	59.3	.0343
" white, " " "	.77	48	.0278
" red, " " "		32 to 45	
Pine, white, perfectly dry,* .35 to .45, average, (see f't n'te, p.108.)	.40	25	.0145
1,000 ft. board measure=2,083 pounds.			
Pine, yellow Northern,* .48 to .62, average, (see f't note, p. 108,)	.55	34.3	.0198
1,000 ft. board measure=2,858 pounds.			
Pine, Southern,* .64 to .80, average, (see foot note, p. 108.)	.72	45	.026
1,000 ft. board measure=3,750 pounds.			
Powder, slightly shaken,	1.00	62.3	
Platinum, 21 to 22,	21.5	1342	.7766
Salt, coarse, per struck bushel, 56 pounds,		45	
" fine, for table use,		49	
Sand, dry and loose, 112 to 133 lbs. per struck bushel,	2.65	90 to 106	
Sand, at the average of 98 lbs. per cubic ft., one cubic inch=.0567 lb., 2,000 lbs.=20.4 cubic feet, one struck bushel =122$\frac{1}{2}$ pounds.			
Sand, perfectly wet,		118 to 129	

Name of Substances.	Average Specific Gravity.	Weight of one Cubic ft.	Weight of one Cu. in.
Snow, fresh fallen,		5 to 12	
" moistened and compacted by rain,		15 to 50	
Slate, 2.7 to 2.9, average,	2.8	175	
Silver,	10.5	655	.379
Steel, 7.7 to 7.9, average,	7.85	490	.2835
Spruce, perfectly dry,* average, 1,000 ft. board measure=2,083 pounds.	.4	25	.0145
Zinc, 6.8 to 7.2, average.	7.0	437.5	.2532
Tin, cast, 7.2 to 7.5, average,	7.35	459	.2656
Water at 32° Fahr.,	7.35	62.417	
" " 60° "	1.00	62.355	.03607
" " 212° "		59.7	
Water at 60° Fahr., a cubic inch=.03607 lb.=.57712 oz., and a pound=27.724 cubic in., which is equal approximately to a cube 3″ on each edge—more exactly, the cube will be 3.0263″ on each edge.			

* *Green timbers* usually weigh from one-fifth to nearly one-half more than dry; and ordinary building timbers when tolerably seasoned, about one-sixth more than perfectly dry.

Things Worth Remembering about Water.

The following was condensed from D. K. Clark's *Manual of Rules*, edition 1877.

Four notable temperatures, viz.:

32° = the freezing point under one atmosphere of pressure.
39°1′ = the point of maximum density.
62° = the British standard temperature.
212° = the boiling point under one atmosphere of pressure.

Weight of one cubic inch of water.

At 32° = .03612 pounds = .5779 ounce = 252.84 grains.
At 39°1′ = .036125 pounds = .578 ounce = 252.875 grains.
At 62° = .03608 pounds = .5773 ounce = 252.595 grains.
At 212° = .03451 pounds = .5522 ounce = 241.5875 grains.

Weight of one cubic foot of water.

At 32° = 62.418 pounds.
At 39°1′ = 62.425 pounds = greatest weight of one cubic foot.
At 62° = 62.355 pounds = Standard temperature.
At 212° = 59.640 pounds.

Volume of one pound of pure water.

At 32° = .016021 cubic feet = 27.684 cubic inches.
At 39°1′ = .016019 cubic feet = 27.680 cubic inches.
At 62° = .016037 cubic feet = 27.712 cubic inches.
At 212° = .016770 cubic feet = 28.978 cubic inches.

The volume of one ounce of pure water at 62° = 1.732 cubic inches.

The weight of water contained in a cylindrical vessel one foot in diameter and one foot high at 62° = 48.973 pounds.

The weight of water contained in a cylindrical vessel one inch in diameter and one inch high at 62° = .02833 pound, or .4533 ounce.

The weight of one gallon of water at 62° = 10 pounds.

The volume of one gallon of water at 62° = 277.123 cubic inches, or .160372 cubic foot.

One cubic foot of water contains $6\frac{1}{4}$ gallons nearly.

The volume of water at 62° in cubic inches, multiplied by .00036, gives the capacity in gallons.

The capacity of one gallon is equal to one square foot 1.924 inches deep = 2" inches nearly, or to one circular foot 2.45 inches deep = $2\frac{1}{2}''$ nearly.

One ton (2,240 pounds) of water at 62° contains 224 gallons.

One ton (2,000 pounds) of water at 62° contains 200 gallons.

One hundred pounds of water at 62° contains 10 gallons.

Volume of given weights of water at 52°3′ = 62.4 pounds per cubic foot.

1 ton	=	35.9 cubic feet.
1 hundred weight	=	1.795 cubic feet.
1 quarter	=	.449 cubic foot.
1 pound	=	.016 cubic foot = 27.692 cubic inches.
1 ounce	=	1.731 cubic inches.

One cubic yard, or twenty-seven cubic feet of water weighs about fifteen hundred weight, or three-fourths of a ton.

A pipe three feet long holds about as many pounds as the square of its diameter in inches (exactly two per cent. more).

Pressure of water.

A pressure of *one pound per square inch* is exerted by a column of water 27.71 inches, or 2.3093 feet high at the temperature of 62°.

A pressure of one atmosphere, or 14.7 pounds per square inch, is exerted by a column of water 33.947 feet high at 62°.

A column of water at 62°, one foot high, presses on the base with a force of .433 pound, or 6.928 ounces per square inch.

A column of water one inch high presses on the base with a force of .5773 ounce per square inch., or 5.196 pounds per square foot.

Water is only slightly compressible. Experiments show that for every atmosphere, or every 14.7 pounds pressure per square inch applied to it, it is reduced $47\frac{1}{2}$ millionths of its bulk.

The U. S. standard gallon contains 231 cubic inches instead of the 277.274 of the British standard.

The U. S. standard ton contains 2,000 pounds instead of 2,240, as in the British ton, and the quarter and hundred weight are in the same proportion.

The pound used in this article is the Standard Avoirdupois pound and the *grain* is the Troy grain of which the Avoirdupois pound contains exactly 7000 and the Avoirdupois ounce $437\frac{1}{2}$. The Troy grain is much used at the present time in weighing small quantities by Avoirdupois weight.

One of the most remarkable features brought out at the meeting of the Master Car Builders' Association at Philadelphia on the 13th ult., and at the last two or three meetings, has been the introduction of railroad freight car brakes which are practically automatic in their application, and which can be used by the engine when the cars to which they are applied are scattered through a long train and unconnected with each other, save through the ordinary links and pins of the draw-bars. Probably no problem in the mechanical world ever presented greater difficulties than this, and yet from the last reports of the Master Car Builders' Committee on Train Brakes for Freight Cars, it would seem that a very high degree of efficiency has already been obtained.—*Mechanics.*

Iron and Steel Production in 1881.

The report of the Secretary of the American Iron and Steel Association for 1881, just completed, gives the following summary of the year's work: Production of pig iron in net tons, 4,641,564, including 21,086 tons of spiegeleisen; production of all rolled iron, including nails and excluding rails, 2,155,346 tons; Bessemer steel rails, net tons, 1,330,302; open hearth steel rails, net tons, 25,217; iron and other rails, net tons, 488,581; production of iron and steel street rails included in above, 21,554; crucible steel ingots, net tons, 89,762; open hearth steel ingots, net tons, 146,946; Bessemer steel ingots, net tons, 1,539,157; blister and patent steel, net tons, 3,047. Production of all kinds of steel, net tons, 1,778,912. Production of blooms from ore and pig iron, net tons, 84,606. Imports of iron and steel, $61,555,078. Imports of iron ore, gross tons, 782,887. Exports of iron and steel, $15,782,282. Production of Lake Superior iron ore, gross tons, 2,336,335; production of iron ore in Jersey, gross tons, 737,052. Total production of iron ore in census year 1880, net tons, 7,974,705.

Production anthracite coal in census year 1880, net tons, 28,646,995. Production of bituminous coal in census year 1880, net tons, 42,420,581. Production of anthracite coal in 1881, gross tons, 28,500,016. Miles of railway completed in 1881: 9,650 miles of railway track in the United States, December 31, 1881, including double track and siding estimated, 130,000. Iron ships built in the United States in the fiscal year ending June 30, 1881, 42.—*Scientific American.*

Specifications for Boiler and Fire Box Steel, issued by the Pennsylvania Railroad Company, February 1, 1881.

First. A careful examination will be made of every sheet, and none will be received that show mechanical defects.

Second. A test strip from each sheet, taken lengthwise of the sheet, and without annealing, should have a tensile strength of 55,000 pounds per square inch, and an elongation of thirty per cent. in section originally two inches long.

Third. Sheets will not be accepted if the test shows a tensile strength of less than 50,000 or greater than 65,000 pounds per square inch, nor if the elongation falls below twenty-five per cent.

Fourth. Should any sheets develop defects in working they will be rejected.

Fifth. Manufacturers must send one test strip for each sheet (this strip must accompany the sheet in every case), both sheet and strip being properly stamped with the marks designated by this company, and also lettered with white lead, to facilitate marking.

The Treasury Department on June 9 issued a circular addressed to supervising and local inspectors of steam vessels, boiler makers and others, suspending the operation of the formulas for the construction of boiler flues less than 16 inches in diameter, which were promulgated by the department circular, No. 30, issued March 14th of this year. The object of this suspension is to permit the objections of boiler makers to the formulas as originally laid down, to be presented to the Board of Supervising Inspectors for consideration at its next meeting. From representations made by the leading boiler makers in the West, it appears that the formulas in question are, in many respects, impracticable. These views, we understand, are endorsed by the Supervising Inspector-General, which leads to this action upon the part of the Government.—*Mechanics.*

Notes and Queries.

An Engineer, Duluth says:—Please give me through the *Locomotive* a simple rule or determining the correct diameter and "lift" of check valves, of single acting plunger pumps such as are generally attached to direct acting steam engines?

Ans. We have never seen any rule in any of the various treatises on the steam engine, for determining the lift of check-valves under varying circumstances. For fast running pumps, such as locomotive feed-pumps, the lift must of course be less than for slow running pumps. Forney in his *Catechism of the Locomotive*, says the lift of locomotive feed-checks varies from $\frac{3}{16}''$ to $\frac{1}{2}''$. In our own opinion $\frac{1}{2}''$ is too much. An old master mechanic on one of our Eastern roads says, that the practice some years ago was to give checks $\frac{1}{4}''$, $\frac{5}{16}''$ or $\frac{3}{8}''$ lift according to size of valve. The tendency of locomotive builders of the present day, however, when pumps are used, is to increase the diameter of the valve and give it less lift.

Our own experience with feed pumps for stationary engines, convinces us that $\frac{1}{4}''$ is about as much lift as a check-valve should have under any circumstances. We use the following empirical rule for determining the lift of checks under ordinary circumstances, and it has always given good satisfaction.

Divide $2\frac{1}{2}$ by the square root of the number of strokes per minute made by the pump; the quotient will be the proper lift in fractions of an inch. Suppose we have a pump making 120 strokes per minute; then $\sqrt{120} = 11$ nearly. $2\frac{1}{2} \div 11 = .23''$ lift.

Having determined the lift, the diameter of the valve should be such that the area of clear opening in valve, should be about equal to area of pipe in which the valve is placed, and it may be calculated by the following rule:

Multiply the internal area of the pipe in which the valve is to be placed by 1.4, divide the product by the lift of the valve, from the quotient subtract the product of half the lift multiplied by 3.1416; the remainder is the circumference of the opening through valve, which divided by 3.1416 will give the required diameter.

For example suppose we wish to find the size of valve required for a one inch feed pipe.

Assume for simplicity that the speed of the engine is slow, then the lift of the valve may be $\frac{1}{4}$ of an inch.

The internal area of a one inch pipe is given by the makers as .86 of a square inch.

Then we have $\frac{.86 \times 1.4}{.25} = 4.82$; 4.82 minus $(3.1416 \times \frac{1}{8}) = 4.42$; and 4.42 divided by $3.1416 = 1\frac{4}{16}$ = required diameter of valve.

The area of opening for a miter valve of any given diameter and lift is found as follows: Multiply half the lift of the value by 3.1416, and add the product to the circumference of the opening through valve; multiply this sum by the lift; and divide this last product by 1.4; the quotient will give the area of the clear opening in square inches.

According to the *Sacramento Record*, the largest locomotive in the world was recently completed at the Central Pacific shops in that city. The cylinders are 19″ × 30″; four pairs of drivers; weight on drivers, 53 tons. The boiler shell is of Otis steel, 5 feet in diameter and 17 feet long, with 166 tubes $2\frac{1}{4}''$ diameter; dome, 26″ diameter by 40″ high. The total length of boiler is 29 feet $2\frac{1}{4}$ inches, and the weight 14 tons. The distribution of steam is assisted by supplementary valves working on the back of the main slide. The capacity of tank is 3,000 gallons of water, and of tender 5 tons of coal.—*Am. Machinist.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. III. HARTFORD, CONN., AUGUST, 1882. No. 8.

Boiler Construction and Setting.

In the March number of THE LOCOMOTIVE we gave an illustrated article showing the construction and setting of a horizontal tubular boiler, 20 feet long, 66 inches in diameter, containing 54 tubes, each 4 inches in diameter. A number of boilers of this type have been built and set under the supervision of the HARTFORD STEAM BOILER INSPECTION AND INSURANCE CO., and they have in every case worked fully up to and beyond our expectations. They are of unusual dimensions, and to insure the best results the setting must be carefully done. In most cases chimneys have been planned with special reference and adaptation to them, so that we have not recommended them except where an entirely new boiler-house and chimney were to be erected. A more common size of boiler is 16 feet 3 inches long outside and 60 inches in diameter, containing 66 tubes, each 3 inches in diameter. The front of the boiler is what is known as the projecting front, as shown in the following Fig. 1. The tube-heads are 15 feet apart; tubes 15 feet

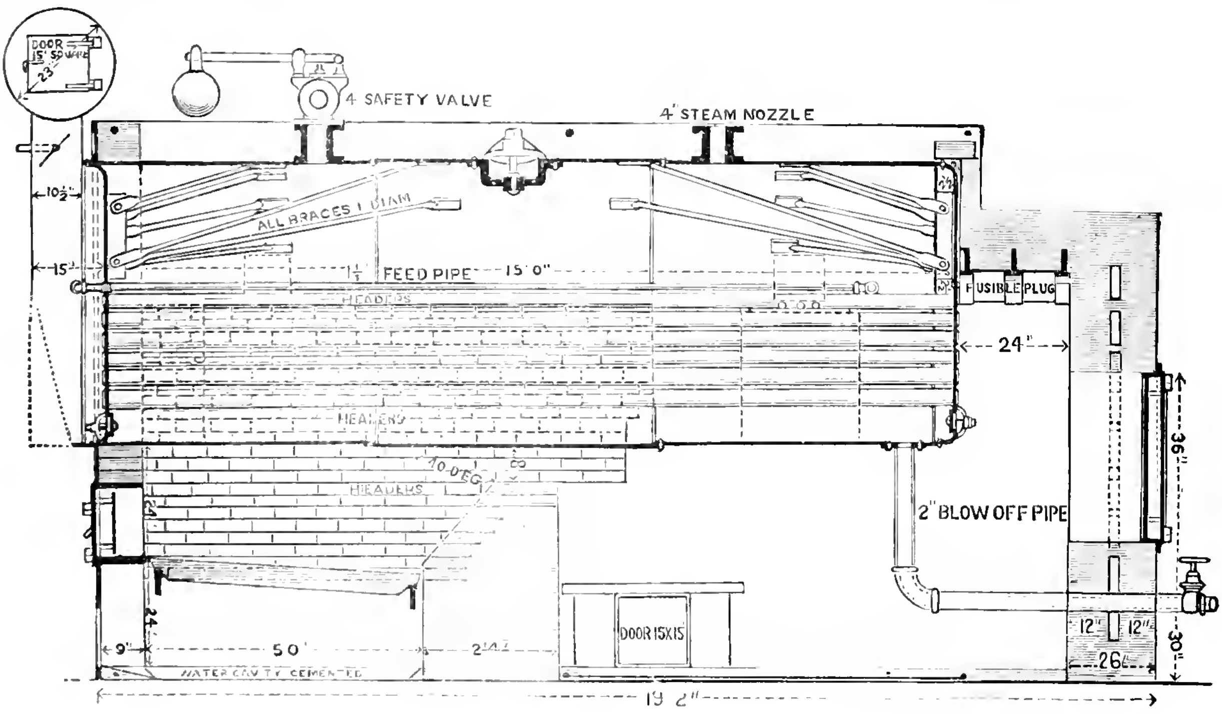


FIG. 1.

long. They are set in vertical and horizontal rows, with a broader central vertical space. The tubes are arranged to secure the best circulation of water. There are 20 braces in all — 10 on each head. These braces are secured to pieces of T-iron placed radially on each head, as shown in Fig. 2. We have found this method of securing braces advantageous for two reasons. The pull of the brace is straight from the web of the T-iron, a jaw being made on the end of the brace, which is pinned and keyed to the web; and second, the pieces of T-iron riveted to the head give it stiffness. The braces should be made of iron at least one inch in diameter, *with no weld.*

Every boiler should be supplied with two nozzles, one for steam and one for safety-valve. The practice of putting up a nest of boilers with only one safety-valve is dangerous and pernicious. Every boiler should have its own independent safety-valve. It will be noticed in Fig. 1 that there is a door at rear end of setting 3 feet by 2 feet. This is important to facilitate cleaning the bottom of boiler, and for removing ashes that may accumulate in rear of bridge wall. We would call attention also to the man-hole frame. It should be put on the inside of boiler shell. If well done, a more effective re-inforcing of the strength of man-hole is secured, as well as a tighter joint. We have discussed this point in The Locomotive in previous numbers, and we have also tested it in practice. In preparing the foundations for boiler settings great care should be taken to see that they are firm. Many boiler foundations are simply brick-work laid on the ground. When the boiler has been used a short time the foundations settle and the walls crack and tumble down. Do the work well, even if it costs a little more to begin with; it will be economy in the end. The walls should be heavy, with air spaces in the center to prevent fractures from expansion and contraction. Fig. 3 shows the plan of boiler and setting. The feed should be introduced through its own independent pipe, with suitable check and stop-valves. It is not good practice to blow and feed through the same pipe. There are many details in the designing construction, and setting of boilers which must not be neglected if safety and economy are to be attained.

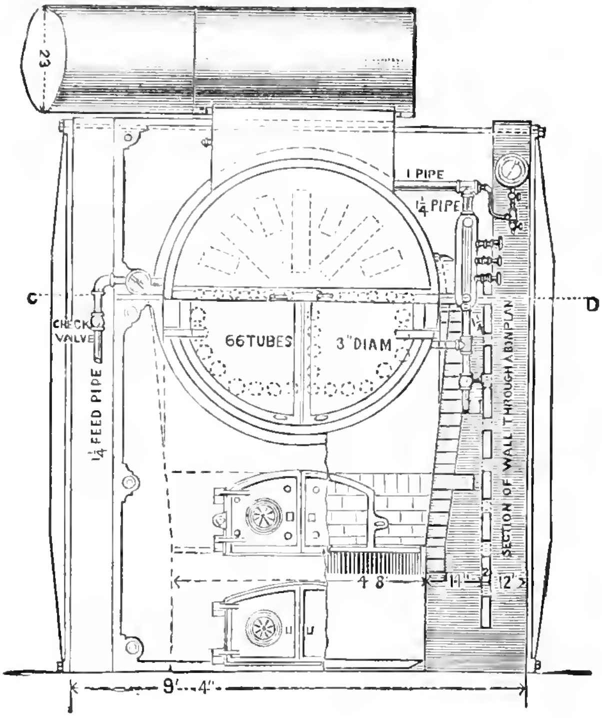


Fig. 2.

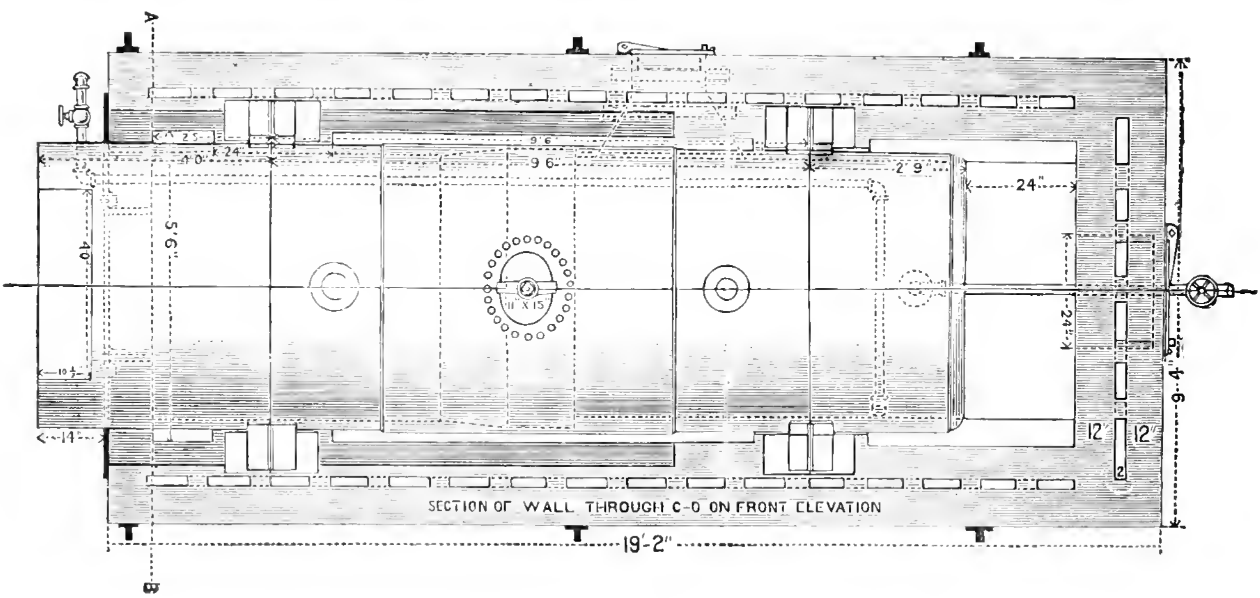


Fig. 3.

Tubes of greater diameter than 3 inches may be used with good results; all depends upon their proper arrangement. The Hartford Steam Boiler Inspection and Insurance Co. furnishes plans and specifications for both boilers and settings for its patrons, and will supervise the settings if desired. It also prepares plans for boiler-houses and chimneys. Hundreds of boilers are now in use which have been built and set from its plans and specifications.

Inspectors' Reports.

JUNE, 1882.

The one hundred and eighty-ninth monthly summary of the reports of the Company's Inspectors is given below, and will well repay a careful perusal. From it we learn that 2,142 visits of inspection were made and 4,535 boilers were examined. The number of thorough annual internal inspections reaches a total of 1,803, and 364 boilers were proved by hydrostatic pressure.

The whole number of defects found which were considered sufficiently serious to be reported, was 2,898, of which number 661 were considered to be of so grave a nature as to impair the safety of the boilers in which they were found. The number of boilers condemned, was 44. The usual analysis of defects is given below.

Nature of defects.	Whole number.	Dangerous.
Cases of deposition of sediment,	311	56
Cases of incrustation and scale,	442	43
Cases of internal grooving,	26	12
Cases of internal corrosion,	109	21
Cases of external corrosion,	160	49
Broken and loose braces and stays,	88	58
Settings defective,	87	15
Furnaces out of shape,	105	27
Fractured plates,	174	70
Burned plates,	72	39
Blistered plates,	311	36
Cases of defective riveting,	297	48
Defective heads,	38	26
Leakage around tubes,	214	81
Leakage at seams,	164	18
Water-gauges defective,	64	8
Blow-out defective,	22	10
Cases of deficiency of water,	9	4
Safety-valves overloaded,	31	7
Safety-valves defective in construction,	18	8
Pressure-gauges defective,	154	25
Boilers without pressure gauges,	2	0
Total,	2,898	661

The matter of *defective settings*, as well also as the proper design for a boiler setting originally, is one that is every day becoming of greater importance. As competition in different branches of manufacturing industry becomes each succeeding year closer, every avenue of waste must be closed as far as it is possible to do so, and manufacturers find themselves obliged to economize in all things. This being the case, it will readily be seen that users of steam power are interested to the greatest possible extent in everything that tends to the economy of fuel; for the item of coal in any manufacturing establishment running by steam power must necessarily be a very important one.

It is very difficult to imagine conditions more unfavorable to the stability and durability of brickwork generally, than those which obtain in the case of the ordinary externally fired horizontal tubular boiler. One part of the setting is exposed to a very intense heat, while other parts are always exposed to draughts of cold air, and in many cases which have come under the writer's observation, every shower or snow storm caused a complete deluge of the brickwork with cold water. Under such circumstances masonry must give way, walls will crack open, and settle down, and bulge out, and general disarrangement of steam and water connections must inevitably result. Of course some of this action is unavoidable, from mere changes of temperature, but the extent of it depends to a great extent upon the manner in which the work is done originally.

As much, perhaps, depends upon the design, as upon the quality of the workmanship as far as the durability of the setting and economy of the boiler is concerned. The side walls and back end wall of a boiler setting should always be closed in to the shell a few inches below the normal water line. This is absolutely essential to the safety of the boiler. Under no conditions should the top of the shell be exposed to the direct action of the heated products of combustion. Serious trouble will always arise when this is allowed. The sheets are burned, fractures occur, the seams are loosened, and a boiler in nine cases out of ten will be reduced to an absolutely dangerous condition in a comparatively short time.

One of the commonest defects to which boilers set with a flush front setting are liable, is the burning and breaking off of the shell on the lower side just forward of the front tube-sheet. This is caused by the fire-brick arch over the furnace door becoming loose and tumbling down, thus exposing the dry portion of the shell to the direct action of the intense heat of the furnace fire. When this is the case a very short time only suffices to heat the shell at this point red hot, and the expansion is in itself sufficient to fracture it. While this defect is not necessarily dangerous, it is apt to so strain the joint between the shell and the flange on the tube-sheet, that persistent leakage, resulting in corrosion at this point, is the consequence.

Another important point to which we would call the attention of boiler owners is the method of supporting the shells of boilers. They should always have strong, substantial brackets, riveted, not bolted, on the side of the shell, and should have a strong pier of fire brick built up to take the weight of the boiler. These piers should be about 2 feet long and should be perpendicular on their face. A cast iron plate extending nearly their whole length should be laid on top of them to distribute the weight of the boiler over the whole pier as much as possible. Of course the brackets at back end of boiler should rest on rolls so that the resistance to contraction and expansion shall be as little as possible.

The thickness of the side and end walls of boiler settings should not be too much scrimped. Where a battery of boilers are set together, the distance between the shells should be two feet at least. The walls between any two adjacent boilers need not have an air space, but they should not be tied together; they should be laid up independently of each other, but close together. The advantages of this plan will be apparent when it is wished to lay any one boiler in the battery off. Then the liability of cracking the wall is much reduced if they are laid up separately.

The outside walls, both of the side and back ends of the setting, should always be laid up double, with a good air space between. The thickness of the air space should be not less than two inches, and that of the outer wall not less than 8″; that of the inner wall a foot at least. For a 60-inch boiler it should be about 14 inches at top of grate and should batter outwards to a line 3 inches from the shell of the boiler at the height, where the wall is closed in. The plans of boiler and setting in this issue show the proper method of setting boilers.

If attention be given to the above points, and the mason does his work properly the repairs on the setting will be reduced to a minimum.

The Locomotive.

HARTFORD, AUGUST, 1882.

In our examinations of boilers we not infrequently find a strange disregard of all rules and regulations for the safe management of boilers. We say strange, for it hardly seems possible that intelligent men would encourage or allow a disregard of rules that are known to be safe. We can account for it only on the ground that the desire to meet every demand for his product blinds the manufacturer to the danger of overworking his boilers. We have of late found safety-valves overweighted 15 and 20 pounds. When the engineer was asked why he had changed the weight on the safety-valve, his reply was that his employer wanted more steam and had ordered him to increase the weight on the valve. These men would feel very much aggrieved to be accused of dishonesty. But suppose the boiler had exploded in the meantime and killed several persons. Would these men have stood up and said, "We increased the load on the safety-valve and are responsible for this disaster." Probably they would have kept very quiet and thrown the responsibility on the insurance company or on the inspector. Men sometimes have two kinds of morality — one for church and the family and another for business. If men will take the responsibility of their own acts and not endeavor to throw it on to others when disaster comes there will be a higher tone of morality in business.

Another difficulty is the desire to use old boilers at excessive pressures. "We must have more steam," is the cry. Why not get new boilers constructed for the pressure you want? Then you could do your work easily and safely. This penny-wise policy of working boilers beyond their safe limit is a strange phenomenon. And how men reputed to be wise and prudent can be so short-sighted is the mystery.

They sometimes get very much disturbed because we will not assent to their demands. Oftentimes they pay no attention to the condition of their boilers, and know nothing of the rules for casting the safe working pressure of boilers, but they want so much steam, and they are going to have it. We give them the limit that we are willing to be responsible for, and say if you want more you must take the responsibility and we will withdraw our certificate; and we have withdrawn it in a number of instances lately. We hope those who have taken the responsibility will go through unharmed, but if accident should occur their reflections will not be cheerful.

We say to all steam users, Don't presume to overwork old boilers, nor work any boilers beyond a safe pressure. If your business demands more steam get new boilers, and you will do your work easier and have a clearer conscience.

We have just received the Report of Mr. Michael Longridge, Chief Engineer of the *Engine, Boiler, and Employers' Liability Insurance Company*, Manchester, England, for the year 1882. It contains very full and complete accounts of Boiler Explosions in England during the past year; a very interesting report of the trial of a pair of compound engines; many specimens of indicator diagrams taken by the company's engineers, and which illustrate queer practices in the use of steam, and a good amount of very sensible information regarding the construction and management of engines and boilers generally.

Wrought Iron Welded Tubes for Gas, Steam, or Water.

TABLE OF STANDARD DIMENSIONS. (*Morris, Tasker & Co., Limited.*)

1¼″ and below, butt welded }
1½″ and above, lap welded } Proved to 300 lbs. per sq. inch by hydraulic pressure.

Nominal Size.	Actual Inside Diameter.	Actual Outside Diameter.	Thickness.	Internal Circumference.	External Circumference.	Internal Area.	External Area.	Length of pipe per sq. ft. of inside surface.	Length of pipe per sq. ft. of outside surface.	L'gth of pipe containing 1 cu. ft.	Weight per foot of length.
Inch's	Inches.	Inches.	Inch's.	Inches.	Inches.	Square In.	Sq're In.	Feet.	Feet.	Feet.	Pounds.
⅛	.27	.405	.068	.848	1.272	.0572	.129	14.15	9.44	2,500.	.243
¼	.364	.54	.088	1.144	1.696	.1041	.229	10.50	7.075	1,385.	.422
⅜	.494	.675	.091	1.552	2.121	.1916	.358	7.67	5.657	751.5	.561
½	.623	.84	.109	1.957	2.652	.3048	.554	6.13	4.502	472.4	.845
¾	.824	1.05	.113	2.589	3.299	.5333	.866	4.635	3.637	270.	1.126
1	1.048	1.315	.134	3.292	4.134	.8627	1.357	3.679	2.903	166.9	1.670
1¼	1.38	1.66	.140	4.335	5.215	1.496	2.164	2.768	2.301	96.25	2.258
1½	1.611	1.9	.145	5.061	5.969	2.038	2.835	2.371	2.01	70.65	2.694
2	2.067	2.375	.154	6.494	7.461	3.355	4.430	1.848	1.611	42.36	3.667
2½	2.468	2.875	.204	7.754	9.032	4.783	6.491	1.547	1.328	30.11	5.773
3	3.067	3.5	.217	9.636	10.996	7.388	9.621	1.245	1.091	19.49	7.547
3½	3.548	4.0	.226	11.146	12.566	9.887	12.566	1.077	.955	14.56	9.055
4	4.026	4.5	.237	12.648	14.137	12.730	15.904	.949	.849	11.31	10.728
4½	4.508	5.	.247	14.153	15.708	15.939	19.635	.848	.765	9.03	12.492
5	5.045	5.563	.259	15.849	17.475	19.990	24.299	.757	.629	7.20	14.564
6	6.065	6.625	.28	19.054	20.813	28.889	34.471	.63	.577	4.98	18.767
7	7.023	7.625	.301	22.063	23.954	38.737	45.663	.544	.505	3.72	23.410
8	7.982	8.625	.322	25.076	27.096	50.039	58.426	.478	.444	2.88	28.348
9	9.001	9.688	.344	28.277	30.433	63.633	73.715	.425	.394	2.26	34.077
10	10.019	10.75	.366	31.475	33.772	78.838	90.762	.381	.355	1.80	40.641
11	11.224	12.	.388	35.261	37.699	98.942	113.097	.340	.318	1.455	47.727
12	12.180	13.	.41	38.264	40.840	116.535	132.732	.313	.293	1.235	54.655
13	13.136	14.	.432	41.268	43.982	134.582	153.938	.290	.273	1.069	61.940
14	14.092	15.	.454	44.271	47.124	155.968	176.715	.271	.254	.923	70.008
15	15.048	16.	.476	47.274	50.265	177.867	201.062	.254	.238	.809	78.269
16	16.004	17.	.498	50.278	53.407	201.162	226.980	.238	.225	.715	87.120
17	16.960	18.	.520	53.281	56.548	225.907	254.469	.225	.212	.638	96.379
18	17.916	19.	.542	56.284	59.690	252.096	283.529	.213	.201	.571	106.067
19	18.872	20.	.564	59.288	62.832	279.720	314.160	.202	.191	.515	116.214
20	19.828	21.	.586	62.291	65.973	308.771	346.361	.192	.183	.466	126.760

NUMBER OF THREAD PER INCH OF SCREW.

⅛ inch pipe, ...	27 threads per inch.
¼ inch and ⅜ inch pipe, ...	18 " " "
½ " " ¾ " "	14 " " "
1 " 1¼ inch, 1½ inch, and 2 inch pipe, ...	11½ " " "
All sizes larger than 2 inch, ...	8 " " "

For sizes above 10 *inch diameter flanges are recommended instead of screwed ends.*

TAPER OF THREADS PER INCH OF SCREW.

⅛ inch to 8 inch pipe, inclusive, $\frac{1}{32}$ inch per inch in length of screw.
9 inch to 20 " " " $\frac{1}{64}$ " " " " " " "

Lap Welded American Charcoal Iron Boiler Tubes.

STANDARD DIMENSIONS. (*Table of Morris, Tasker & Co., Limited.*)

External Diam.‡	Internal Diam.†	Standard Thickness.*	Internal Circumference.	External Circumference.	Internal Area.	External Area.	Length of tube per sq. foot of Inside Surface.‡	Length of tube per sq. foot of Outside Surface.‡	Weight per Lineal foot.
Inches.	Inches.	Inches	Inches.	Inches.	Square Ins.	Square Ins.	Feet.	Feet.	Pounds.
1	.856	.072	2.689	3.142	.575	.785	4.460	3.819	.708
1¼	1.106	.072	3.474	3.927	.960	1.227	3.455	3.056	.9
1½	1.334	.083	4.191	4.712	1.396	1.767	2.863	2.547	1.25
1¾	1.560	.095	4.901	5.498	1.911	2.405	2.448	2.183	1.665
2	1.804	.098	5.667	6.283	2.556	3.142	2.118	1.909	1.981
2¼	2.054	.098	6.484	7.069	3.314	3.976	1.850	1.698	2.238
2½	2.283	.109	7.172	7.854	4.094	4.909	1.673	1.528	2.755
2¾	2.533	.109	7.957	8.639	5.039	5.940	1.508	1.390	3.045
3	2.783	.109	8.743	9.425	6.083	7.069	1.373	1.273	3.333
3¼	3.012	.119	9.462	10.210	7.125	8.296	1.268	1.175	3.958
3½	3.262	.119	10.248	10.995	8.357	9.621	1.171	1.091	4.272
3¾	3.512	.119	11.033	11.781	9.687	11.045	1.088	1.018	4.590
4	3.741	.130	11.753	12.566	10.992	12.566	1.023	.955	5.32
4½	4.241	.130	13.323	14.137	14.126	15.904	.901	.849	6.01
5	4.720	.140	14.818	15.708	17.497	19.635	.809	.764	7.226
6	5.699	.151	17.904	18.849	25.509	28.274	.670	.637	9.346
7	6.657	.172	20.914	21.991	34.805	38.484	.574	.545	12.435
8	7.636	.182	23.989	25.132	45.795	50.265	.500	.478	15.109
9	8.615	.193	27.055	28.274	58.291	63.617	.444	.424	18.002
10	9.573	.214	30.074	31.416	71.975	78. 40	.399	.382	22.19
11	10.560	.22	33.175	34.557	87.479	95.033	.361	.347	25.489
12	11.542	.229	36.26	37.699	103.749	113.097	.330	.318	28.516
13	12.524	.238	39.345	40.840	123.187	132.732	.305	.293	32.208
14	13.504	.248	42.414	43.982	143.189	153.938	.282	.272	36.271
15	14.482	.259	45.496	47.124	164.718	176.715	.263	.254	40.612
16	15.458	.271	48.562	50.265	187.667	201.062	.247	.238	45.199
17	16.432	.284	51.662	53.407	212.227	226.980	.232	.224	49.902
18	17.416	.292	54.714	56.548	238.224	254.469	.219	.212	54.816
19	18.400	.3	57.805	59.690	265.903	283.529	.207	.200	59.479
20	19.360	.32	60.821	62.832	294.373	314.159	.197	.190	66.765
21	20.320	.34	63.837	65.973	324.311	346.361	.188	.181	73.404

* The thickness of Tubes can be varied to order.

† It is impossible to make Tubes of *exact* internal diameter.

‡ In estimating the effective steam-heating or boiler surface of Tubes, the surface in contact with air or gases of combustion (whether internal or external to the tubes) is to be taken.

For heating liquids by steam, superheating steam, or transferring heat from one liquid or gas to another, the mean surface of the Tubes is to be taken.

MAGNESIA BRICKS AND MOULDERS' SAND.—Magnesia obtained by decomposing chloride of magnesium, as free from silica as possible, is formed into briquettes and heated to a white heat, then ground and mixed with a little water or tar, and made into bricks, and again burned to a white heat. As magnesium bricks shrink greatly in burning, Mr. S. G. Thomas places in the kiln an occasional layer of lime bricks as a binding layer, and is thus able to build them up much higher without fear of their falling while being burnt. The briquettes above mentioned, ground, are stated to be an excellent substitute for moulders' sand, as they are quite infusible, and do not stick to steel castings.—*Boston Journal of Commerce.*

Properties of Saturated Steam.

Pressure per Steam-gauge.	Temperature per Fahrenheit Thermometer.	Heat required to raise one pound of water from 32° to temp. of evaporation.	Latent heat in one pound of steam.	Total heat in one pound of steam.	Density or weight of one cubic foot of steam.	Volume of one pound of steam.	Cubic feet of steam from one cubic foot of water.
Lbs.p'rSq.In	Degrees.	Heat Units.	Heat Units.	Heat Units.	Pounds.	Cubic Feet.	Cubic Feet.
0	212.0	180.9	965.7	1,146.6	.03797	26.336	1,642
5	227.2	196.3	955.0	1,151.2	.05	20.	1,246
10	239.4	208.7	946.3	1,154.9	.0619	16.16	1,008
15	249.8	219.2	938.9	1,158.1	.0736	13.59	847
20	258.8	228.4	932.5	1,160.9	.0852	11.74	732
25	266.8	236.6	926.8	1,163.3	.0967	10.34	645
30	274.0	243.9	921.6	1,165.5	.1081	9.27	577
35	280.6	250.7	916.9	1,167.5	.1195	8.37	521
40	286.7	256.9	912.5	1,169.4	.1308	7.65	477
45	292.4	262.7	908.4	1,171.1	.142	7.04	439
50	297.7	268.2	904.6	1,172.7	.1531	6.53	407
55	302.6	273.2	901.1	1,174.2	.1643	6.09	380
60	307.3	278.0	897.7	1,175.7	.1753	5.70	356
65	311.8	282.6	894.4	1,177.0	.1863	5.37	335
70	316.0	286.9	891.4	1,178.3	.1973	5.07	316
75	320.0	291.1	888.4	1,179.5	.2082	4.80	299
80	323.9	295.1	885.6	1,180.7	.2192	4.56	282
85	327.6	298.9	883.0	1,181.9	.23	4.35	271
90	331.2	302.6	880.4	1,182.9	.2409	4.15	259
95	334.6	306.1	877.9	1,184.0	.2517	3.97	248
100	337.9	309.5	875.5	1,185.0	.2625	3.81	238
105	341.1	312.8	873.15	1,186.0	.2732	3.66	228
110	344.2	316.0	870.9	1,186.9	.2839	3.52	220
115	347.2	319.1	868.7	1,187.8	.2946	3.39	212
120	350.1	322.1	866.6	1,188.7	.3053	3.28	204
125	352.9	325.0	864.5	1,189.6	.3160	3.17	197
130	355.6	327.8	862.5	1,190.4	.3266	3.06	191
135	358.3	330.6	860.6	1,191.2	.3372	2.97	185
140	360.9	333.3	858.6	1,192.0	.3478	2.88	179
145	363.4	335.9	856.75	1,192.7	.3584	2.79	174
150	365.9	338.5	855.0	1,193.5	.3689	2.71	169
155	368.3	341.0	853.25	1,194.3	.3791	2.64	164
160	370.7	343.5	851.5	1,195.0	.3899	2.56	160
165	373.0	345.9	849.8	1,195.7	.4004	2.50	156
170	375.2	348.2	848.2	1,196.4	.4109	2.43	152
175	377.4	350.5	846.6	1,197.1	.4213	2.37	148
180	379.6	352.8	845.0	1,197.7	.4318	2.32	144
185	381.7	355.0	843.4	1,198.4	.4422	2.26	141
190	383.8	357.2	841.8	1,199.0	.4526	2.21	138
195	385.8	359.2	840.4	1,199.6	.4630	2.16	135
200	387.8	363.3	836.9	1,200.2	.4734	2.11	132

Rule for Ascertaining the Cubic Contents of Masses, Broken, Rough, and of Irregular Form.

It not unfrequently occurs in the experience of those who have to do with small castings of brass, silver, iron, and even larger castings, together with carved work of stone or marble, or irregular and broken lumps of any material, that some convenient rule for ascertaining the cubic contents of the same, in mass or singly, would be very desirable. Some thirty years ago the writer settled a dispute over the cubic contents of a very irregular broken piece of stone to the entire satisfaction of both the disputants, neither of whom was right. I give the process for the benefit of our readers. A tub was secured of sufficient depth to allow the irregular mass to be entirely submerged when placed on the bottom of the tub, and the tub filled with water to the brim. By small copper wires, which had been previously attached to the irregular piece of stone, it was carefully lifted out so as not to spill any of the water. This done, the cubic contents of the water in the tub was ascertained, also the cubic contents of the tub. The difference between these two results was the cubic contents of the irregular piece of broken stone. To make this plainer if possible, I will suppose that we have a lump of broken coal as large as one's two fists, more or less, the cubic contents of which we wish to ascertain. First secure a tin pail with straight sides. (I say straight, because the contents of the pail can be more easily cast), ascertain the cubic contents of this by the following rule: Multiply the square of the diameter in inches by the decimal .7854, and this result by the depth of the pail in inches. The last result will be the cubic contents of the pail in inches. Now place the lump of coal in the pail, having fastened a small copper wire to it, and fill the pail to the brim. Remove the coal carefully by means of the copper wire. Then ascertain the number of cubic inches in the water remaining in the pail by multiplying the square of the diameter of the pail in inches, by the decimal .7854 (as above), and this result by the *depth of water* in inches. Subtract this last result from the cubic contents of the pail, and you have the cubic contents of the lump of coal. By this process the cubic contents of bent and twisted pieces of metal can be easily ascertained, also pieces which are turned into fantastic shapes. A square, water-tight box may be used instead of a circular vessel or pail. The cubic contents of such a vessel is easily ascertained by multiplying the internal length, breadth, and depth together. To ascertain the cubic inches in the water when the box is only partially full, multiply the length, breadth, and depth of the body of water together.

Some very vexing problems can be easily solved by this simple rule.

J. M. A.

Superheated Water.

We republish the following article from our issue of January, 1880, believing it will be of interest at the present time. It is an extract from an article published some years ago in the *American Artisan*. It was written by Mr. A. Guthrie, formerly U. S. Supervising Inspector General, and the ten experiments seem to include about all the methods of de-aërating water that are likely to occur in the use of steam boilers.

"In the *American Artisan* of the 20th inst. (page 45), I was pleased to find some communications from correspondents of your valuable paper in reference to boiler explosions being caused by de-aërated and 'superheated' water. This theory — that water deprived of its natural proportion of air can ever be heated above a boiling point due to the pressure, and in consequence becoming explosive — has in my humble opinion, gone far enough to meet a positive contradiction. A theory advanced by M. Donny, an obscure chemist, as long back perhaps as 1770, being of itself simply ridiculous, has found advocates up to the present day. That this theory has been copied into many works on chemistry and science, and assented to by learned men during one hundred years, excites my wonder; but that it has not found its refutation in its own absurdity seems to me still more singular. I am glad to see that at least one of your correspondents, Mr. Geo. B. Brayton, has the boldness to contradict it.

"I have made many experiments to satisfy myself of the truthfulness of this theory, and have endeavored to conduct them with perfect fairness and impartiality, and with all the care that my feeble abilities would permit. I am entirely satisfied that there is not a shadow of truth in the Donny theory, that water deprived of air boils at a higher temperature or at any different temperature than water not so deprived; nor is there any foundation whatever for the statement that such water has the slightest explosive tendency more than any other water. I mean exactly, that it will boil at 212° Fahrenheit when other water does, and that it will come to a point of ebullition without a particle of tendency to explosion, no more than any other water, just this, exactly.

"I concede that Prof. Tyndall has in his lectures in a manner given credit to this theory; but the moment after and before concluding he declaims his belief in it so plainly that he need not be misunderstood.

"I admit that Brand and Taylor in their work on 'Chemistry' (which, by the bye, is a work of exceeding value), with many other distinguished writers, have adopted this theory as the true one; but I am led to think it has been adopted without reflection and without investigation. It may appear to be great presumption in me to contradict this theory with the positiveness I do; but did I not suppose I had given it the fullest investigation, with just as good means to give it a fair trial as any one, I should not venture to contradict.

"In the first place, I assume as true that all natural water has a small percentage (say two and a half) of atmospheric air mixed with it; in this I believe we all agree. Now, then, I assume that this air may be expelled in the process of congelation; by boiling for a given time; by distillation out of contact of air; by placing it *in vacuo;* and by being absorbed in fish or water-breathing animals in their kind of respiration. I suppose there is little difference of opinion upon these points.

"(1.) In my experiments, I first procure a sample of water from the boiler of an ordinary condensing engine; here, of course, in addition to being subjected to long-continued boiling, it had passed through the vacuum.

"(2.) I procured a sample from the ordinary high-pressure non-condensing engine boiler, which before entering the boiler had passed the heater at 210°.

"(3.) I procured some clean snow and dissolved it under oil, so that there was no contact with the air.

"(4.) I froze some water in a long upright tube, using only the lower end of the ice when removed from the tube, and dissolved under oil.

"(5.) I placed a bottle of water under a powerful vacuum pump worked by steam, for two hours; agitating the water from time to time to displace any air that might possibly be confined in it, then closed it by a stop-cock, so that no air could possibly return.

"(6.) I boiled water in an open boiler for several hours, and filled a bottle half-full, closed and sealed it up, so that when it became cool it would in effect be under a vacuum; agitating it as often as it seemed necessary.

"(7.) Another bottle was filled with the same, and sealed.

"(8.) I next took some clean, solid ice, dissolved it under oil, and brought it to a boil, which was continued for an hour or more, after which it was tightly corked.

"(9.) I procured a bottle of carefully distilled water, after long boiling and having been perfectly excluded from air during the distillation.

"(10.) I obtained a large number of small fish, placed them in pure, clean water in an open-headed cask in a moderately cold night, so that very soon it became frozen over, consequently excluding the air, the fish breathing up the air in the water, so that (if I am correct in this theory) a water freed from air would be the result; but in *some* of these different processes, if not in all, I was likely to free the water from air, if it could ever possibly occur in the ordinary course of operating a steam boiler.

"Having procured a good supply of glass boilers adapted to my purpose, and so made that the slightest changes could be noted, and using as delicate thermometers as I could obtain, I took these samples one after another, and brought them to the boiling point; and every one with no variation whatever, boiled effectually and positively at 212° Fahrenheit or *under;* nor was there the slightest appearance of explosion to be observed."

Misapplying the Steam Jacket.

The object of applying steam jackets to steam engines is to keep the steam doing work from artificial condensation by the external temperature as long as possible. In other words, to keep its vital heat at the temperature at which it entered the cylinder, less that lost necessarily by doing useful work. There have been differences of opinion upon the utility of jacketing steam cylinders, and able engineers have not hesitated to state their disbelief in them. In such cases there may have been causes operating similar to those here related:

A writer in the recent number of the *Engineering* relates that he had occasion to believe that the steam jacket applied to compound marine engines was seldom used, or if used at all, improperly. His observations are divided into five classes. He found thirteen vessels where the jackets were used as follows: The engineers said:

"I work the jacket with the outlet to the condenser or hot well full open, and temper the live steam supply to the jacket by the valve. I prefer this plan because there is then no trouble with the water."

On three steamers the engineers said: "I use the jacket on starting only, to warm up the cylinder, and keep the steam from condensing during stopping and starting. When under way I shut off the jacket, because there is no use in it when the cylinders are well lagged."

On two steamers the engineers said: "I work with the steam inlet full open, but keep the drain cock shut, and blow the water out once on a watch."

On three steamers the engineers said: "I dinna trouble meself much aboot the jecket, for I canna see what difference it can make."

On two steamers the engineers said: "I keep the live steam on all the while, and regulate the drain so as to keep the water out without wasting steam."

By this testimony, which in some respects is ludicrous, it will be seen that it is easy to make out that a jacket is or is not economical, according as it is used. It also shows the risk attending taking testimony upon the merits of economical apparatus without absolute certainty as to the manner in which the same was treated.—*Mechanical Engineer.*

Weight of a Million Dollars.

Mr. E. B. Elliott, the Government Actuary, has computed the weight of a million dollars in gold and silver coin as follows:

The standard gold dollar of the United States contains of gold of nine-tenths fineness, 25.8 grains, and the standard silver dollar contains of silver of nine-tenths of fineness, 412.5 grains. One million standard gold dollars, consequently, weigh 25,800,000 grains, or 53,750 ounces troy, or 4,479 1-6 pounds troy, of 5,760 grains each, or 3,685.71 pounds avoirdupois of 7,000 grains each, or 1 843-1,000 "short" tons of 2,000 pounds avoirdupois each, or 1 645-1,000 "long" tons of 2,240 pounds avoirdupois each. One million standard silver dollars weigh 412,500,000 grains or 859,375 ounces troy, or 71,-614.58 pounds troy, or 58,928.57 pounds avoirdupois, or 29 464-1,000 "short" tons of 2,000 pounds avoirdupois each, or 26 307-1,000 "long" tons of 2,240 pounds avoirdupois each. In round numbers the following table represents the weight of a million dollars in the coin named:

Description of coin.	*Tons.*
Standard gold coin	$1\frac{7}{8}$
Standard silver coin	$26\frac{4}{5}$
Subsidiary silver coin	25
Minor coin, 5 cent nickel	100

—*Scientific American.*

Things Worth Remembering About Air.

[Condensed from D. K. Clark's Manual of Rules, Tables, and Data.]

The mean pressure of the atmosphere at the level of the sea is equal to:

14.7 pounds per square inch, or
2,116.4 " " " foot.

This pressure is equivalent to a column of air at 32° F. of *uniform density*, (equal to that at the level of the sea.) 27,801 feet high, or

A column of mercury at 32° F.=29.922 inches high.
" " 62° F.=30. " "
" water 32° F.=33.913 feet " (Freezing point.)
" " 39° F.=33.909 " " (Maximum density.)
" " 62° F.=33.947 " " (Standard temperature.)

A pressure of one pound per square inch is equal to:

A column of air at 32° F., of uniform density as above, 1,891 feet high, or,
" mercury at 32° F.=2.035 inches high.
" " 62° F.=2.04 " "
" water 32° F.=27.684 " "
" " 39° F.=27.68 " "
" " 62° F.=27.72 " "

A pressure of one pound per square foot is equal to:

A column of air at 32° F., of uniform density as above, 13.13 feet high.
" mercury at 32° F.= .0141 inch high.
" " 62° F.=.01417 " "
" water 32° F.=.19225 " "
" " 39° F.=.19222 " "
" " 62° F.=.1925 " "

The density or weight of one cubic foot of pure air, under a pressure of one atmosphere or 14.7 pounds per square inch is:

At 32° F.=.080728 pound, or 1.29 ounce, or 565.1 grains.
" 62° F.=.076097 " 1.217 " 532.7 "

The weight of air compared with that of water at three notable temperatures, and at 52.3° F., under one atmosphere, is as follows:

Weight of water at 32° F.=773.2 times the weight of air at 32° F.
" " 39.1° F.=773.27 " " " 32° F.
" " 62° F.=772.4 " " " 32° F.
" " 62° F.=819.4 " " " 62° F.
" " 52.3 F.=820. " " " 62° F.

The volume of one pound of air, at 32° F., and under one atmosphere of pressure, is 12.387 cubic feet. The volume at 62° F. is 13.141 cubic feet.

The specific heat of water being 1:—
" " " air under constant pressure is .2377.
" " " " " volume is .1688.

Or in other words, if we enclose air in a cylinder provided with a piston moving freely, so that when the air is heated it can expand, and the pressure remain the same, then the quantity of heat necessary to raise the temperature of one pound of water one degree from 39.1° to 40.1° will raise the temperature of 4.207 pounds of air one degree. And, if we enclose air in the cylinder and secure our piston so that the air cannot expand when it is heated, then the quantity of heat which will raise the temperature of one pound of water one degree, from 39°.1 to 40.°1 will raise the temperature of 5.924 pounds of air one degree.

The following rules will be found to be practically useful.

RULE 1. When the volume of any given weight of air at any given temperature is known, to find its volume at any other temperature, the pressure remaining the same, *Multiply the given volume by the temperature at which the volume is required* + 461, *and divide the product by the given temperature* + 461; *the quotient is the required volume.*

EXAMPLE. The volume of one pound of air at 32° F., under one atmosphere of pressure is 12.387 cubic feet; required its volume at 212° F., at the same pressure.

12.387 × (212 + 461) = 8336.45 and 8336.45 ÷ (32 + 461) = 16.91 nearly = the volume of one pound of air at 212°, and under one atmosphere of pressure.

RULE 2. When the pressure of any given weight of air at any given temperature and volume is known, to find its pressure for any other temperature and volume.

Multiply the given pressure by the given volume, and this product again by the temperature for which the pressure is required + 461; *divide this last product by the product of the new volume multiplied by the given temperature* + 461.

EXAMPLE. The pressure of one pound of air at a temperature of 32° F., at a volume of 12.387 cubic feet is 14.7 pounds per square inch; what is its pressure at a temperature of 212° and volume of 20 cubic feet?

14.7 × 12.387 × (212 + 462) = 122545.8297 and 122545.8297 ÷ 20 × (32 + 461) = 12.428 the required pressure.

The Locomotive Industry.

In a recent number of the *Railway Age* there is published an article on the locomotives in the United States, in which some figures relating to the locomotive industry and its prospects for the future are given that are likely to be of interest to our readers:

The number of locomotives on the 104,325 miles of railway in the United States at the commencement of the present year is stated by Poor's Manual as 20,116, an increase of 2,167 over the number reported one year previous. In our issue of December 8, 1881, we estimated the number of engines manufactured during the year at private works and railway shops as about 3,000, of which probably 1,000 would take the place of machines worn out and retired. This would give a net increase of about 2,000, which nearly corresponds with the actual figures given in the Manual, whose statistics, however, it must be remembered, do not come within the exact bounds of the calendar year, as they are made up from the railway reports, which terminate at various periods. It is interesting to note that, taking the Manual's totals of railway mileage and number of engines for the last two years, they give nearly the same average number of miles per engine, that for 1880 being 5.21 miles, and that for 1881 being 5.18 miles showing a slight and not unnatural falling off in the average, as the roads opened into new country do not at first require as large equipment as those upon which business is developed. Had the average of 1880 continued, the increase for last year would have been only 93 locomotives more than that actually reported. The number of engines added this year is likely to be somewhat less than that built in 1881, as orders were, in many cases, curtailed when the temporary depression of last winter and spring came, and the lost time cannot be recovered, even if the demand greatly increases, as it seems certain to do. The 15 locomotive works in the United States, however, appear to be fairly busy, and some we know have orders ahead sufficient to run them through the year. Most of them have increased their productive capacity, and one or two new works are being constructed. The buildings are being erected for one of these near Chicago, but the works are not likely to be finished in time to offer much competition this year.

Prices of locomotives have fallen somewhat. The fact is, they were higher last year than necessary to afford a good profit, but as the manufacturers had all that they wanted to do, and the railways must have the engines at any price, it is not strange that as high as $13,500 was asked and paid for an eight-wheel passenger engine. The locomotive builders made money enough last year to enable them to stand a little lower prices, although they are in no danger of suffering this year. The railways will have a heavy business, the country is prosperous, and the manufacturers are as much entitled to share in the general prosperity as are the farmers, many of whom will grow rich with a single year's harvest. — *Mechanics.*

Regenerative Gas Burners.

At a recent meeting of the Glasgow Philosophical Society, Scotland, Mr. William Foulis read a paper on the Siemens regenerative gas burner. He said that the general principle of this burner was the heating of the gas and air supplies before they reached the point of combustion. This idea was suggested by Professor Faraday as early as 1843. The luminosity of a flame is due to the incandescence of the small particles of carbon, which, by the ordinary method of burning gas, are dissociated from the hydrogen gas in the earlier stages of the process of combustion. The important points to consider in connection with the question of the economical consumption of gas are (1) that the separation of the particles of carbon should be as complete as possible, and (2) to have the greatest available number of these particles disseminated throughout the flame. The limit of the separation of the solid particles was the point at which the flame began to smoke, and the stage of the combustion process at which the greatest degree of luminosity took place was just the point before the emission of smoke began. Another consideration was that the higher the quality of the gas, the sooner did the point arrive at which it began to smoke. In order to insure a perfect separation of the carbon particles the gas should be burned at a very low pressure; and moreover, the temperature of the flame should be as high as possible, in order that the carbon particles may be very highly heated, and also that a greater number of them may be maintained in the state of incandescence. In the Siemens burner the gas is heated to a temperature of from 600° to 700° F., and thus the flame temperature greatly increased. — *Mechanics.*

The End of the World.

"I had a horrible dream the other night," said George Freeman, of New York, to a party of friends the other evening. "Tell us about it," said one. "Well, I dreamed that while sitting in my office and looking out on Broad street I saw an unusual excitement on the sidewalk. I leaned out and asked 'What's the matter?' 'The world is coming to an end,' said one excited man as he ran for his life. Just then in walked William H. Vanderbilt, and says I, 'Billy, what can you do to save us?' 'Oh, that's all right; you stay by me and you'll pull through all right. You see I've got the Celestial branch of the New York Central put through, and when the final bust comes we'll get aboard the special train and be all right.' 'Just hold the train a minute, will you, till I send up town for my wife and children.' 'Certainly,' says William, and I immediately called my son, who looked very queer as he walked in, and no wonder, for his head was covered with a fungus growth of chessmen, knights, queens, kings, and pawns scattered all over his head in a wonderful manner. 'How did you come by those?' 'Don't know,' said he; 'they came on all of a sudden last night.' 'Well, never mind; go up town and get your mother and family and bring them down quick as possible.' The dutiful boy left. In a few minutes I had a telephone message from the house from my son, saying that 'mother is down at Macy's. What shall I do?' 'Great heavens,' I cried, 'that woman is always at Macy's.' 'Go after her,' I yelled, and began packing up my valuable papers. Meantime William H. was pacing up and down the office with an anxious look upward to the sky. 'Ah,' he murmured,' here she comes.' 'What comes?' said I. 'The Celestial branch train,' he replied, complacently. I looked up and saw about a hundred miles in the zenith a long train of Pullman sleepers plowing down through space with comet-like velocity. The train then stopped and several balloons immediately descended corner of Broad and Wall streets. There was a great scramble for seats, but William H. had engaged a squad of the 'finest' to beat the crowd back. My wife having arrived with her bundles from Macy's, we got on the car and shot up to the train. William H. did the square thing by giving us all a through ticket, and we were soon bowling through space at the rate of 42,005 miles a second. At the end of the first second after starting we heard a fizz like a wet fire-cracker, and looking down we saw that the world had really come to an end, like an ignited torpedo. We had traveled but a few winks more and had come in sight of the pearly gates, when a terrific roar was heard and the whole train evaporated. The boiler had exploded. I instinctively grasped my wife's back hair to save her life, and we both fell down through space like a rocket-stick. The next thing I heard was my wife's voice saying: 'Good land! George, what are you doing there on the floor? Come back to bed and don't act like a fool.' I went 'back,' and, I forgot how I acted, but I remember crawling under the sheet all covered with goose pimples and a horrible taste in my mouth. — *The Review.*"

A Super-Sensitive Thermometer.

Since the days when Mr. Edison brought out his microtasimeter, which proved so sensitive to heat, until now, we have had no instrument devised for measuring extremely delicate changes of temperature. Such an apparatus has, however, been recently devised by M. Michelson, and brought, at least, in its experimental form, before the French Physical Society. It is based on the principle of bi-metallic thermometers, but ebonite or hard caoutchouc is chosen instead of one metal. Hard rubber is ten times more dilatable than platinum under heat, and a spring composed of platinum on one side, and ebonite on the other, will curve under the least increase of temperature. At the extremity of the spring is fixed a small glass stem forming an elbowed lever which abuts against a light mirror suspended by a silk fibre. When the spring curves or straightens, the mirror is deflected, and a ray of light from a lamp reflected from its surface to a scale that moves up or down the divisions of the scale. By giving to the spring and lever a relatively great length, this instrument can be made very sensitive, and the inventor hopes to be able to measure the thousandth of a degree centigrade. — *Engineering.*

English and American Machinery in Russia. — Reporting upon the trade of Odessa in the year 1881, Consul Stanley directs special attention to the strong demand which exists in the south of Russia for agricultural machinery. Few villages, he states, are without at least one agricultural steam engine, and as there is only one manufactory of these engines in Russia — viz., that of Maltzof — they are largely imported. Notwithstanding the great extra cost of English engines, due to freight, insurance, and duty — an extra cost, which on an engine sold in England for £240 may, Consul Stanley estimates, be placed at £100 — the Russians are willing to pay the higher price, because of the greater durability and better working of our machines. English plows and threshing machines also are, he states, preferred to all others; "but the Americans supply at a cheaper rate better horse-rakes, mowers, and reapers, with or without self-binders. As these are exempt from duty, Russia does not attempt to enter into competition. It may seem strange," Consul Stanley goes on to say, "that the American makers should so completely drive the English out of the field in this business. An explanation given to me is that they are content with a smaller profit than English makers, and that the iron and wood work, while sufficiently strong, is lighter and better. English manufacturers could, I am told, make an equally good article, and the rate of skilled wages being less in England than in America, the cost of making them ought to be less; but English makers, apparently, do not care to sell them at the price taken here for such articles of American make." — *Iron, London.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. III. HARTFORD, CONN., SEPTEMBER, 1882. No. 9.

An Explosion Without Any Mystery.

The explosion illustrated in this number of the LOCOMOTIVE occurred some years ago in one of the southern cities. A short account of the accident appeared in the LOCOMOTIVE at the time, and we reproduce it here with an additional illustration, which shows more clearly the cause of the disaster, believing it will afford a timely warning to workmen who have occasion to make repairs to boilers, as well, also, as to illustrate certain important points regarding the proper construction and arrangement of safety-valves.

FIG. 1.

The exploded boiler was one of a battery of two horizontal boilers, 48 inches in diameter by 31 feet long. Each boiler had two flues 16 inches in diameter by 27 feet long. The thickness of the shell plates was $\frac{5}{16}$ of an inch. They were provided with domes 20 inches in diameter, to the top of which the steam-pipes and safety-valves were connected as shown in Fig. 2. Each boiler was provided with its own safety-valve, with no stop-valve between it and the boiler. The two boilers were run in connection with each other, and were connected with each other by a steam pipe provided with a stop-valve, which could be closed when it was desired to use but one of the boilers. The working pressure allowed was 60 pounds per square inch.

The boiler which exploded was known as No. 2. Repairs being necessary, this boiler was laid off, and the stop-valve between it and No. 1 was closed. This valve leaked slightly, and the steam coming through from No. 1 was condensed in the pipe and dripping down through the opening in the dome and annoyed the workmen who were making the repairs (and who were inside the boiler), so one of them made a pine plug to fit the hole in the steam-nozzle, and drove it into the nozzle from the inside, as shown in Fig. 2, and went on with his work. When the repairs were completed, the workmen of course got out of their uncomfortable quarters as quickly as possible, and, what was very natural under the circumstances, forgot all about the plug, it being at the top of the dome out of sight. They then put on the man-hole plate, and pronounced the boiler ready for use.

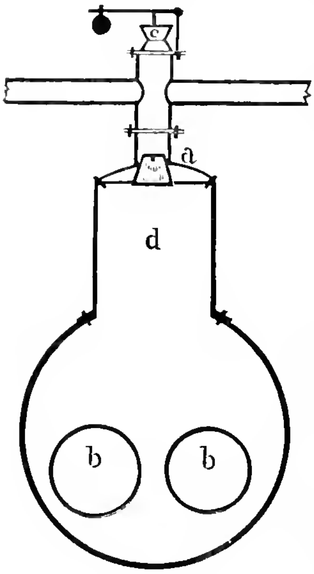


FIG. 2.

Thus it will be seen that the only outlet for the steam was securely closed, and the safety-valve rendered useless.

The boiler was filled with water and the fire started under it. Four hours afterward it exploded with great violence, demolishing everything in the immediate vicinity, killing one man and injuring several others. The damage to property was estimated at not less than 15,000 dollars.

A study of the top of the dome of the exploded boiler is very interesting. The crown of the dome was of cast iron and was $1\frac{3}{8}$ inches thick. It was convex outwardly, and the steam nozzle was cast with and formed a part of it. It will readily be seen that the force required to produce the rupture must have been enormous. The surface of the iron through the line of fracture shows it to be sound and of good quality. The portion of the plug left projecting into the dome by the workmen was about 8 inches long, and $3\frac{1}{4}$ inches in diameter. It was completely shattered or "broomed" by the force of the expanding steam. It appears as though the steam, under the immense pressure just preceding the explosion, had permeated the fiber of the wood, and filled every pore, and its sudden expansion when the boiler burst and the pressure on it was relieved, was sufficient to completely shatter the projecting portion. It has the same appearance as portions of a tree have which has been struck by lightning, and the moisture in it suddenly converted into steam of sufficient tension to splinter the trunk.

Workmen cannot be too careful when making repairs on steam boilers, or any changes in steam connections, to be perfectly sure, the last thing they do before putting on the man-hole cover, to see that the outlet to the safety-valve is free from all obstructions. The importance of this cannot be overestimated. Under no circumstances should it be plugged up as it was in the above case, for there is always a chance that it may be forgotten to remove the plug, and then serious consequences are sure to follow. The most careful workman is apt to forget to do so in the rush and hurry under which such repairs are generally made, and therefore *the risk of doing so should never be incurred.*

It is also very bad practice to make the safety-valve part of a cluster of fixtures or mounting, as it was in this case. It should always be an independent fixture, and have its own independent connection with the boiler. Then the risk of accidents like the above will be reduced to a minimum. Had the safety-valve on the above boilers been *properly constructed*, the accident would never have occurred.

Inspectors' Reports.

JULY, 1882.

The summary of the one hundred and ninetieth monthly report of the Inspection Corps is given below, and has more than the ordinary amount of interest to boiler owners and users. From it we learn that the inspectors of the company made 2,071 visits of inspection, and examined altogether 4,838 boilers. 2,523 of these were complete internal and external inspections, while 373 were subjected to hydrostatic pressure.

The number of defects found foot up 3,081, of which number 455, or about $14\frac{3}{4}$ per cent. were considered dangerous. The number of boilers condemned was 54. Below is a tabular view of the number of defects of each class found.

Nature of defects.	Whole number.	Dangerous.
Cases of deposition of sediment,	335	35
Cases of incrustation and scale,	585	19
Cases of internal grooving,	17	11
Cases of internal corrosion,	113	20
Cases of external corrosion,	200	29
Broken and loose braces and stays,	48	13
Defective settings,	106	15
Furnaces out of shape,	98	18
Fractured plates,	158	66
Burned plates,	68	17
Blistered plates,	332	36
Cases of defective riveting,	311	38
Defective heads,	33	15
Cases of leakage around tubes,	205	25
Cases of leakage at seams,	163	35
Water-gauges defective,	64	9
Blow-outs defective,	21	10
Cases of deficiency of water,	6	5
Safety-valves overloaded,	32	8
Safety-valves defective in construction,	12	5
Pressure gauges defective,	174	26
Total	3,081	455

It seems strange that in the present advanced state of the mechanic arts, there can be found men who will fit up safety-valves in the manner in which we sometimes find them. In many cases the grossest ignorance of the first principles which should govern the construction and arrangement of apparatus of this sort is displayed. In other cases it would be hard to determine whether ignorance, carelessness, or cupidity is responsible for some of the astonishing work which we run across.

One favorite way of running the escape pipes of safety-valves where boilers are situated in buildings not over one story high, is to run it straight up through the roof of the building. This is perhaps well enough if the connections are properly made and the pipes properly drained, but unless they *are* furnished with a properly arranged drip-pipe, the arrangement is positively dangerous, and should never be allowed under any pretense whatever. In fact no escape-pipe should *rise* in the slightest degree after it leaves the valve-chamber without being provided with a drip-pipe. It will invariably fill with water if it does, and this will, of course, increase the load on the valve, and the water which so collects, not only corrodes the valve and its fittings, but it is very liable to become frozen in the winter season, and disaster is sure to follow if it does.

One of the most damaging explosions on record occurred a few years ago from this cause. The pipe run out through the side of the building and some distance beyond. It became filled with water, which froze up solid, in consequence of which the boiler blew up from failure of the safety-valve to relieve the pressure.

Another way of putting up escape pipes from safety-valves is to run them into the chimney or the flue which leads to the chimney. This is frequently resorted to when the chimney power is deficient and the reason given for it is that "it improves the draft." It is difficult for a disinterested person to see how this device operates to "help the draft" unless the valves are blowing off steam, and we confess our inability to see why the draft should be improved at that time. However, we suppose a poor apology is sometimes better than none at all.

One potent reason why safety-valves should never be put up this way is this: It is impossible to tell when a valve is tight when it is connected. It may leak, and become a source of great waste, without anyone knowing anything about it. A valve should never be put up so that any leakage of steam will fail to make itself manifest immediately.

Safety-valves should never have an "escape-pipe" attached to them. They should be allowed to blow freely into the boiler-room. The objections to this plan are fast disappearing among intelligent steam users and engineers, and in the very best arranged boiler-houses that have been built lately, the safety-valves are put up in this manner. This arrangement is not only the best, but it is also the *cheapest*, as all the extra pipe-fittings and useless labor are saved.

There can be little doubt that it would have been a blessing if the ordinary lever safety-valve had never been invented. If the inventor's design had been to make something possessing every facility for being tampered with, instead of making a safety-valve, he could not have succeeded in a more admirable manner. The lever offers every facility for overweighting at the caprice of an ignorant or careless boiler attendant. If more steam is wanted, if, from any cause, the demand for steam is irregular, so that much care is required to prevent often blowing off, or, if the valve leaks, the sovereign remedy is to slide the weight out farther on the lever, or attach all manner of junk to save trouble. And observe how admirably the thing is contrived to produce much overweighting with little effort. The multiplying principle of the lever is brought into requisition so that a pound on the end of it may be equal to anywhere from five to ten pounds on the valve, and the effect of hanging a few old bricks, gears, pulleys, or pieces of anything that has weight, on the end of the lever, would be equal to a whole junk shop if placed directly on the valve. And the lever is such an inviting place to hang scraps of all kinds, that many boiler attendants are simply unable to resist the temptation to do so on the slightest provocation.

A really good safety-valve should possess the following qualities in the highest possible degree:

First: It should be of the "dead weight" type of construction. No steelyard lever should be allowed in its construction, it would then require much more weight placed on it to produce a dangerous degree of overloading.

Second: Its construction should be such it would be no easy matter to place extra weight upon it, and such that any extra weight could be readily seen by anyone.

Third: It should be connected to the boiler so as to be easily accessible, and no escape pipe should be connected to it, and it should be arranged so as to be easily lifted once or twice a day by the attendant.

Fourth: It should always be an independent fixture, attached directly to the boiler, and should have no connection whatever with any of the other fittings on the boiler.

The Locomotive.

HARTFORD, SEPTEMBER, 1882.

Comparatively few people except those particularly interested in natural science are aware of the important work which is being accomplished by the United States Fish Commission.

Its object is to thoroughly investigate and study the sea fauna of the waters of our coast. In the winter season its labors are mainly confined to our southern waters, while in the summer its investigations are extended to and largely confined to the New England coast. Its summer station is at Woods' Hole, Mass., the southern point of the promontory that divides Buzzard's Bay from Vineyard Sound. Here may be found the Laboratories, Aquaria, and manipulating rooms of the commission, while at an adjoining wharf is a large steamer named "The Fish Hawk," which is used exclusively by the commissioner for dredging in the adjacent or more remote waters for "life beneath the waters." The steamer is provided with very complete apparatus for dredging in deep waters, and sometimes the "catch" comprises beautiful and rare specimens. These dredgings are not unfrequently made in waters 800 fathoms deep. From these great depths fish unheard of before are often brought to the surface, and it is interesting to note that their eyes are generally undeveloped, little more than rudimentary — apparently sightless — showing that very little light penetrates these great depths, and yet there is animal life, a fact which these and similar investigations have established, though until within a few years it was thought impossible for animal life to exist so far below the surface. When the "catch" is brought in it is examined and distributed in the several aquaria, where the habits of the various species can be studied.

The rare ones are then preserved in alcohol and prepared to enrich the already large and rare collection in the National Museum of the Smithsonian Institute at Washington. The work of this commission has settled many important questions bearing upon the fish supply of our coast, their habits and feeding grounds, and the intelligent and scientific manner in which the work has been done, has given it high rank among similar commissions of other nations. It is highly creditable to our national goverment that it provides liberally for such investigations.

This commission is under the direction of Prof. Spencer F. Baird, Secretary of the Smithsonian Institute. His name at the head is a guaranty that all the investigations will be conducted in the most scientific manner. Prof. Baird is not merely a figure-head: he is on the ground and supervises every detail. He is ably assisted by an enthusiastic corps of naturalists, among whom are Profs. Verrill and Smith of Yale Scientific school, Prof. Smith of New York, Prof. Rathbun of the Smithsonian Institute, Dr. Kidder, and many others. Captain Tanner is commander of the "Fish Hawk." He is not only highly competent in nautical science, but enters with enthusiasm into the whole work of the commission. It has been our privilege to spend more or less time with these gentlemen, each season for several years, and we esteem it one of the great privileges of our lives, it opens a wide field for thought, and gives new impressions and views of the handiwork of that ever active Providence that provides for all His creatures.

WE are glad to notice that the American Railway Master Mechanics' Association has taken the first step towards abolishing the use of that trade idiocy known as wire and sheet metal gauges. How anything of the sort ever was originated is a complete puzzle to us, and now that instruments for measuring with precision are everywhere used, an adherence to anything of the sort shows still greater stupidity. The only way that we can explain the existence of the abomination is on the supposition that people always used to measure in the same manner as the laborer, who, when given a two-foot rule and told to go and measure a certain dimension, returned with the information that it was "twict the length of the rule, the thickness of two bricks and 'a small bit of a schtick,' the breadth of two fingers, and half the distance from his 'fisht' to his elbow." Appearances indicate that wire gauges originated from some such standard as this.

THE list of horrors traceable directly to the use of a poor quality of kerosene oil is so great that few people have any idea until they have made investigations. Accidents by burning are really the most terrible which can happen to people, and those who suffer most from the use of poor oil are those whose sensibilities are the keenest, the accidents usually happening to women and children. We think there is little need of an oil accident of any kind when a good quality of oil is used. Unfortunately, public taste, when oil first came into the market, was made the sole judge of its excellence. People had been in the habit of burning camphene and other similar substances which were "water white." Without knowing what constituted a good oil, people at once began to demand a white kerosene, because they "didn't like the looks" of the yellow oil. In England even the better qualities of American oils have on more than one occasion been condemned by consumers as being bad, simply on account of their dark color and great specific gravity. Our manufacturers were actually sending them an oil that was too good. It was heavy, and consequently when the reservoir became partly empty, the wick had difficulty in lifting it to the flame. In their ignorance they wanted something which was lighter, which burned easier, and was of course more dangerous. — *Mechanics.*

Standard for Exact Measurement.

The committee appointed by the American Society of Mechanical Engineers at the meeting held in Philadelphia April last to investigate the method adopted by the Pratt & Whitney company for the establishment of a standard for exact measurement, and which met recently at the works of the company, was composed of the following gentlemen: Henry Morton, Ph.D., president of the Stevens Institute, Hoboken, N. J., chairman; J. Sellers Bancroft, of William Sellers & Co., Philadelphia, secretary; Professor Robinson of Ohio state university; Oberlin Smith, president of the Ferracute Machine company, Bridgeton, N. J.; William Betts of the Betts Machine company, Wilmington, Del.; George Stetson of Morse Twist Drill company, New Bedford; Ambrose Swasey of Warner & Swasey, Cleveland, O.; Edward Parkes of the Brown & Sharp Manufacturing company, Providence, R. I., and Charles T. Porter of the Southwark Foundry and Machine company, Philadelphia. Their report is to be submitted at the next meeting of the mechanical engineers' society, to be held at New York in November.

A very favorable report has already emanated from the committee appointed by the car builders' association of the United States, resulting in the adoption by them of the United States standard thread gauges produced by the Pratt & Whitney company. The subject of exact measurement has been most carefully considered by the company during the past three years, and has been carried out from a scientific foundation to a practical working standard irrespective of what has been done by others, the British imperial yard being the only reference, an accurate transfer of which is in the hands of the company. A complete and detailed description of the work and apparatus employed, with reports, etc., will soon be published. This comparator meets a long-felt want among machinists and will probably be universally adopted. The scientific work in obtaining the necessary transfers and the determination of the co-efficients of expansions was performed by Professor W. A. Rogers of Harvard observatory, Cambridge, Mass., and his plans were originally carried out in the construction of the comparator now in use by the Pratt & Whitney company. Mr. George W. Bond has been in charge of the work throughout — a work which appears to have given satisfaction to the scientific gentlemen who have had the privilege of seeing it in operation. — *Hartford Post.*

A London Anaconda.

A few years ago an immense anaconda, or water-boat, was received at the Gardens in Regent's Park, brought in a barrel on board a steamer from Central America to Liverpool, and fowarded thence by rail. This reptile is the largest of the serpent tribe, inhabiting the swamps of tropical America, and sometimes attaining a length of thirty or forty feet, it may be much more. It is one of the constrictors — that is to say, it is non-venomous, and kills its prey, like the boa and python, by crushing it within the convolutions of its powerful body. In the British Museum there is a fine stuffed specimen, about thirty feet long, represented in the act of seizing, though not constricting, a peccary. The subject of my tale measured twenty-three feet in length, and in girth was equal to the circumference of a man's thigh — a formidable customer, capable of swallowing a sheep. Prepared for his reception, with the floor duly graveled, and a tank with water, Den No. 3, on the left-hand side of the reptile-house, counting from the entrance door, was allotted to him; and within the cage is a stunted tree, up which these large serpents are wont to climb. The top of the cask unscrewed, the creature was allowed to find his way into the cage through the small aperture behind.

Roaming about in the full enjoyment of his new-found liberty, he presently turned round between the tree and front of the cage — a space of several feet — in such a way that the bight of his body — to use a seafaring expression — lay within this space. Here, feeling the contact of the glass on one side and the wood on the other, he suddenly expanded his coil, probably in the sheer luxury of being able to stretch himself, and pushed the front of the cage out! Not simply the glass, itself, which was not broken, but the heavy framework in which it is fixed, was forced away from its connection with the surrounding beams. Hereupon several of the spectators had the presence of mind to rush forward and catch the sash before it could fall to the floor. In this way they supported it as well as they could with hands and knees until fresh assistance arrived, for the weight was to great for them to lift it back into position again; while the reptile inside, excited by the shouting and commotion, was dashing about furiously in all directions. This scattered the gravel about; and it was then found impossible to return the frame into its proper place, as the groove was choked with the small stones. Mr. Frank Buckland, aided now by a number of men from all parts of the gardens, still kept the glass from descending, while the keeper and carpenter, who got into the cage from behind, having thrown some blankets over the snake and pushed him into a corner, proceeded to scrape away the gravel. But the anaconda, now thoroughly enraged, contrived to extricate his head from the covering, and before the men could escape, flew at the carpenter and seized him by the shoulder. The keeper courageously turned, gripped the serpent by the throat, and forced him to let go, but not until the unfortunate man's arm was terribly lacerated by the powerful lancet-like teeth.

Luckily, the door of the reptile-house had been locked when the first *contretemps* took place, so that no casual visitors were witnesses of the scene; otherwise fainting women and horror stricken-men would doubtless have added to its confusion. By this time the groove was clear, and the frame temporarily secured, so that the carpenter made good his exit, while the keeper watching his opportunity, flung the creature from him and jumped out.

But it afterwards became very tame and tractable, and I established very friendly relations with it. Many a time have I stood at the door with Holland, the keeper, and allowed it to rear its great black-spotted head out of the tank till it flickered its tongue against my face, while I patted its shining scales with my hand. Towards Holland it was most affectionate, and would always come up to the grated ventilator to see him when he was sweeping out the passage behind, though it took no notice of the people in front. Snakes take strong likes and dislikes to people, often unaccountably. Holland was one of the kindest and most intelligent keepers that ever handled a reptile, and could generally win anything's confidence; yet there was — and probably is still — a West African python, some sixteen feet long, in the house, that positively conceived a murderous hatred of him. Why this should be so, neither he nor any one else could ever understand: but it is a fact that this python at feeding-times would sit up close to the door and wait, not for the ducks and rabbits, but for him! — *Chambers' Journal.*

LONDON FIRE SERVICE. — Capt. Eyre M. Shaw, Chief of the London Fire Department, now visiting this country, gives a number of interesting facts with regard to the system and material for fire protection in use in London.

The area to be protected is 121 square miles. The force employed numbers 536 men and officers of all grades, one-third of the number doing duty by day, and two-thirds by night, each set working twelve hours. The equipment of the department comprises 53 land fire engines, 121 fire escape engines, 3 floating steam fire engines, 11 movable land stations, 4 floating stations, 3 large land fire engines, 35 small steam land fire engines, 2 steam tugs, 4 barges, 29 hose-carts, 15 vans, and two trollies.

The movable land stations are large vans that are taken to a designated spot every night at eight o'clock, each one drawn by four horses. The horses are then returned to the engine-house to which they belong. They are sent the next morning at eight o'clock to fetch the vans back. In each van is an engine and a number of men who are always ready to attend a fire in the immediate neighborhood where the van is stationed. The department is forced to use these movable stations on account of the cost of building permanent stations. The engine does not leave its place, but depends upon its length of hose to reach a fire.

The system of telegraph alarms has fifty-three telegraph lines with forty-four "call points," or alarm-boxes, and seven telephone lines. The intention is to replace all the telegraph lines with telephone lines. The city is divided iuto four sections or fire districts, each with a central office, communicating with headquarters. The area covered is so great that a single system, like that of New York, would not answer.

Captain Shaw was greatly interested with the method employed in this city of loosing the horses from their stalls by electricity on the sounding of an alarm, and the automatic harnessing. The London horses stand in their stalls harnessed. All the London fireman are given a two months' course of instruction and systematic drilling before they are sent out for actual service. The department has discarded rubber hose entirely and use "fabric hose," which is much lighter, costs one-third as much, and last three times as long. It is manufactured at Dundee. — *Scientific American.*

Table Showing the Number of Rivets in 100 Pounds.

DIAMETERS.

Length.	$\frac{3}{8}$ inch.	$\frac{7}{16}$ inch.	$\frac{1}{2}$ inch.	$\frac{9}{16}$ inch.	$\frac{5}{8}$ inch.	$\frac{11}{16}$ inch.	$\frac{3}{4}$ inch.	$\frac{7}{8}$ inch.
$\frac{3}{4}$	1965	1419	1092	944	665			
$\frac{7}{8}$	1848	1335	1027	846	597			
1	1692	1222	940	763	538	450		
$1\frac{1}{8}$	1512	1092	840	726	512	415		
$1\frac{1}{4}$	1437	1036	797	691	487	389	356	228
$1\frac{3}{8}$	1368	988	760	653	460	370	329	211
$1\frac{1}{2}$	1300	949	730	624	440	357	280	180
$1\frac{5}{8}$	1260	924	711	596	420	340	271	174
$1\frac{3}{4}$	1200	900	693	553	390	325	262	169
$1\frac{7}{8}$	1156	840	648	532	375	312	257	165
2	1100	789	608	511	360	297	243	156
$2\frac{1}{8}$	1031	744	573	502	354	289	237	152
$2\frac{1}{4}$	999	721	555	491	347	280	232	149
$2\frac{1}{2}$	945	682	525	475	335	260	220	141
$2\frac{3}{4}$	900	650	500	443	312	242	208	133
3	828	598	460	411	290	224	197	127
$3\frac{1}{4}$	779	562	433	379	267	212	180	115
$3\frac{1}{2}$	743	536	413	352	248	201	169	108
$3\frac{3}{4}$	715	513	395	341	241	192	160	102
4				326	230	184	158	99
$4\frac{1}{4}$				312	220	177	150	96
$4\frac{1}{2}$				298	210	171	146	94
$4\frac{3}{4}$				284	200	166	138	89
5				270	190	161	135	87
$5\frac{1}{4}$				256	180	156	130	84
$5\frac{1}{2}$				244	172	151	124	80
$5\frac{3}{4}$				233	164	145	120	77
6				223	157	140	115	74
$6\frac{1}{4}$				215	150	138	111	71
$6\frac{1}{2}$				207	146	134	107	69
$6\frac{3}{4}$				203	143	129	104	67
7				198	140	125	100	64

The length of rivets required for *hand driving* = the length of the hole + $1\frac{1}{2}$ times the diameter of the rivet.

The length of rivets required for *machine driving* = $1\frac{1}{4}$ times the length of the hole + $1\frac{1}{2}$ times the diameter of the rivet.

The weight of a pair of rivet heads is about as follows:

Diameter of rivet, ...	$\frac{5}{8}''$,	$\frac{11}{16}''$,	$\frac{3}{4}''$,	$\frac{7}{8}''$.
Weight of two heads, . . .	$\frac{1}{6}$	$\frac{1}{5}$	$\frac{1}{4}$	$\frac{2}{5}$ of a pound.

A SINGULAR SUBJECT.—The question whether our heads are smaller than those of our grandfathers has been attracting particular attention in European scientific circles during the last few weeks. The subject was first agitated by writers for *Nature*, London, one of whom, Mr. F. F. Tuckett, insists that the average size of hats has decreased one size within the last twenty-five years, which means, if the criterion is to be trusted, a diminution of three-eights of an inch in average circumference. As Mr. Tuckett adduces in evidence of his assertion the testimony of leading hatters in London, he is probably right, says the New York *Times*, so far as that part of the case is concerned. But there are, as Mr. Charles Roberts explains, in a rejoinder to Mr. Tuckett, various reasons for the average decrease in size of hats, without accepting that gentleman's view of the cause. In the first place, men wear their hair cropped more closely than they did years ago; and in the second, the fashion now is to wear one's hat on the top of the head, instead of pulling it down over the ears, as was done by men of the last generation. Again, the tall hat is now worn by a large class of persons who are uniformly small-headed, such as clerks and shopmen, who formerly did not effect such a luxury; while on the other hand, many persons of the large-headed class, clergymen and others, who wore tall hats only years ago, have now given them up, and prefer the soft felt to the uncomfortable section of stovepipe once in vogue. The only way to get at the truth would be to examine the statistics of each class separately, and to make an allowance of a quarter of an inch for the present mode of wearing the hat and of cropping the hair. But if Mr. Tuckett's view is to be accepted, then, while the head has lost in size, there has been a general gain in weight and vigor of body; for, comparing the statistics of factory children in 1833 with those of 1873, in England, it is found that children of ten years of age now are as tall of statue and as heavy as children of eleven years of age were forty years ago. There is great variety, however, in the size of heads among the intellectual classes in England. According to Mr. Tuckett, Lord Chelmsford wears a $6\frac{1}{2}$ hat only; and the sizes of some prominent people he gives as follows: The late Dean Stanley, $6\frac{3}{4}$; Lord Beaconsfield, 7; the Prince of Wales, 7; Charles Dickens, $7\frac{1}{8}$; Lord Selbourne, $7\frac{1}{8}$; John Bright, $7\frac{1}{8}$; Lord Russell, $7\frac{1}{4}$; Macaulay, the historian, $7\frac{3}{8}$; Mr. Gladstone, $7\frac{3}{8}$; Thackeray, $7\frac{5}{8}$; Louis Philippe, $7\frac{3}{4}$; M. Julien, the celebrated musical conductor, $7\frac{3}{4}$; and the Archbishop of York, 8. The prelate must possess a head of nearly 24 inches in circumference, while that of Dickens was average, that of Thackeray beyond the average, and the pumpkin-head of Louis Philippe was very large.— *Exchange.*

VISITORS to ancient wine vaults or damp coal pits are sometimes astonished by the curious fungi which drape the walls with gruesome tapestry; but every instance of this kind is thrown into the shade by the extraordinary growths which have recently been discovered in some of the deserted Mexican silver mines of Nevada. The dank, warm timber galleries and drifts of these old workings abandoned to themselves for years, have silently given birth to a monstrous brood of morbid vegetation which, apparently, has no parallel in the regions of the sunlight and the upper air. In general they are all of a snowy whiteness, and some of the hooded masses rise up several feet from the ground like sheeted ghosts. Others, in the distance take the form of bearded goats or sleeping owls. Here great bunches of long, white hair hang down from the roof; and there huge, pulpy masses encumber the floor like brimstone coral. The latter appear to have sprung miraculously from some spilled upon the rocks in past days, while the former seem to have crystallized like hoar-frost from the atmosphere itself. Some of the round masses have acutally lifted up from the floor blocks of stone weighing ten, fifty, and even one hundred pounds to a height of three feet. In the higher level of the mines, where the air is drier, the fungi are far less bulky then below, and much firmer in texture. The shapes here are, however, more beautiful. One kind grows in a twisted spiral like a ram's horn to a length of five feet, and hangs from the rafters like a trophy of the chase, or rather, like a serpent suspended by the tail. Another sort sends out a stem the thickness of a pencil to a height of one or two feet where it blossoms into a bulbous knob something like a flower. Nothing like the toadstool or the common mushroom is to be found, and the wondrous growths have all the aspect of being called into a special being by the peculiarities of their environment.— *Exchange.*

Table of Inches and Sixteenths Reduced to Decimals of a Foot.

The following table will be found of very great use to draughtsmen and others who have a variety of computations to make:

Inch.	Feet.	Inch.	Feet.	Inch.	Feet.	Inch.	Feet.	Inch.	Feet.	Inch.	Feet.
0	.0000	2	.1667	4	.3333	6	.5000	8	.6667	10	.8333
	.0052		.1719		.3385		.5052		.6719		.8385
$\frac{1}{8}$	.0104	$\frac{1}{8}$	.1771	$\frac{1}{8}$	.3438	$\frac{1}{8}$	.5104	$\frac{1}{8}$	.6771	$\frac{1}{8}$	.8438
	.0156		.1823		.3490		.5156		.6823		.8490
$\frac{1}{4}$	.0208	$\frac{1}{4}$	.1875	$\frac{1}{4}$	.3542	$\frac{1}{4}$	.5208	$\frac{1}{4}$	.6875	$\frac{1}{4}$	.8542
	.0260		.1927		.3594		.5260		.6927		.8594
$\frac{3}{8}$	.0313	$\frac{3}{8}$	.1979	$\frac{3}{8}$	.3646	$\frac{3}{8}$	.5313	$\frac{3}{8}$	.6979	$\frac{3}{8}$	.8646
	.0365		.2031		.3698		.5365		.7031		.8698
$\frac{1}{2}$	.0417	$\frac{1}{2}$	.2083	$\frac{1}{2}$	.3750	$\frac{1}{2}$	.5417	$\frac{1}{2}$	.7083	$\frac{1}{2}$	.8750
	.0469		.2135		.3802		.5469		.7135		.8802
$\frac{5}{8}$	.0521	$\frac{5}{8}$	.2188	$\frac{5}{8}$	.3854	$\frac{5}{8}$	.5521	$\frac{5}{8}$	.7188	$\frac{5}{8}$	.8854
	.0573		.2240		.3906		.5573		.7240		.8906
$\frac{3}{4}$	.0625	$\frac{3}{4}$	.2292	$\frac{3}{4}$	.3958	$\frac{3}{4}$	.5625	$\frac{3}{4}$	.7292	$\frac{3}{4}$	.8958
	.0677		.2344		.4010		.5677		.7344		.9010
$\frac{7}{8}$	.0729	$\frac{7}{8}$	.2396	$\frac{7}{8}$	.4063	$\frac{7}{8}$	.5729	$\frac{7}{8}$	.7396	$\frac{7}{8}$	.9063
	.0781		.2448		.4115		.5781		.7448		.9115
1	.0833	3	.25	5	.4167	7	.5833	9	.7500	11	.9167
	.0885		.2552		.4219		.5885		.7552		.9219
$\frac{1}{8}$	.0938	$\frac{1}{8}$	.2604	$\frac{1}{8}$	.4271	$\frac{1}{8}$	.5938	$\frac{1}{8}$	.7604	$\frac{1}{8}$	.9271
	.0990		.2656		.4323		.5990		.7656		.9323
$\frac{1}{4}$	.1042	$\frac{1}{4}$	.2708	$\frac{1}{4}$	.4375	$\frac{1}{4}$	.6042	$\frac{1}{4}$	.7708	$\frac{1}{4}$	.9375
	.1094		.2760		.4427		.6094		.7760		.9427
$\frac{3}{8}$	.1146	$\frac{3}{8}$	.2813	$\frac{3}{8}$	.4479	$\frac{3}{8}$	.6146	$\frac{3}{8}$	.7813	$\frac{3}{8}$	.9479
	.1198		.2865		.4531		.6198		.7865		.9531
$\frac{1}{2}$	.1250	$\frac{1}{2}$	.2917	$\frac{1}{2}$	.4583	$\frac{1}{2}$	.6250	$\frac{1}{2}$	.7917	$\frac{1}{2}$	.9583
	.1302		.2969		.4635		.6302		.7969		.9635
$\frac{5}{8}$	.1354	$\frac{5}{8}$	.3021	$\frac{5}{8}$	.4688	$\frac{5}{8}$	.6354	$\frac{5}{8}$	.8021	$\frac{5}{8}$	.9688
	.1406		.3073		.4740		.6406		.8073		.9740
$\frac{3}{4}$	.1458	$\frac{3}{4}$	.3125	$\frac{3}{4}$	.4792	$\frac{3}{4}$	.6458	$\frac{3}{4}$	.8125	$\frac{3}{4}$	.9792
	.1510		.3177		.4844		.6510		.8177		.9844
$\frac{7}{8}$	.1563	$\frac{7}{8}$	.3229	$\frac{7}{8}$	.4896	$\frac{7}{8}$	.6563	$\frac{7}{8}$	.8229	$\frac{7}{8}$	.9896
	.1615		.3281		.4948		.6615		.8281		.9948

THE annual expense of running a locomotive engine and tender, averaging 75 miles a day for 267 days in the year, or 20,000 miles annually, is given as follows by Trautwine:

Fuel, say $2\frac{1}{4}$ cords wood per 75 miles, at \$3.50 per cord, \$7.87$\frac{1}{2}$ per day,	\$2,100
Repair, at 9 cts. per mile run,	1,800
Engineer, 12 months, at \$90 per month,	1,080
Fireman, 12 months, at \$50 per month,	600
Oil and waste, at 1 ct. per mile run,	200
Sawing and loading wood, at $1\frac{1}{2}$ ct. per mile run,	300
Supplying water, at 1 ct. per mile run,	200
Putting away, cleaning, and getting out, say,	120
Locomotive superintendence,	100
Total,	\$6,500

Equal to 34 cts. per train mile; \$24.35 per running day, or \$17.81 for every day in the year.

A CORRESPONDENT writing from Bayreuth, in describing a fire, says:—The night I arrived I had the unexpected pleasure of seeing a comedy. It was a genuine German comedy, too. Its subject-matter was the efforts of the Bayreuth fire brigade to put out a fire. I was awakened from a sound sleep by the loud beating of a drum under my windows. I could hear drums beating in various parts of the city, the church bells were ringing, there was a heavy tramp of soldiers through the street, people rushing about and shouting "Fire"—in fact every indication of a fire, except the noise of fire engines. A house a little way down the street was burning. A crowd had gathered there. I found the infantry guarding a patch of beans, the cavalry stationed about the potato patch with flashing sabres, and the artillery drawn up around a pear tree. The flames were crackling merrily among the beams. At last, around the corner appeared six big Germans carrying a small ladder, and, after them, six small Germans carring a big ladder. These twelve Germans wore green suits and brass helmets. When they had managed to place the big ladder against the front of the house they ran away again. After a while we heard a rattling as though a dog with a tin can tied to his tail was running through the next street. The twelve Germans again turned the corner, drawing after them what looked like a tin box on wheels. It was the fire engine—an open tin box with a hand pump. A hose was attached. A fireman mounted the ladder. Another fireman carried the hose up to him. Meanwhile, women with large wooden paniers strapped to their backs brought water from the neighboring fountain and emptied it into the engine. Finally, everything was ready, and the pumping began. Several large streams of water came from the joints of the hose and wet the bystanders. A small stream came from the nozzle. The fire was such a trifle that they really managed to get it pretty well under control. Then they consulted as to whether they should adjourn then and there and get some beer or go on until the fire was completely out. They decided to adjourn. In about an hour they came back and finished their work. I heard one Bayreuther say to another that after all the Bayreuth fire brigade was the best in the world. The next day the city council voted a resolution of thanks and a compensation of 12½ cents to the women who carried the water from the fountain to the engine. During the "Parsifal" performances the firemen are distributed through the theater. This seems to me unnecessary—the building could burn down without their assistance.

EFFECT OF EXPLOSIVES.—In their sixth annual report, Colonel Majendie and Major A. Ford, the inspectors of explosives, say:—"Experiments conducted by us appear to establish very satisfactorily that the effect of small charges of dynamite, and similar explosives, upon masonry structure, is essentially local. Where the charge is in contact with an external portion of the structure, any effect which may be produced is almost entirely confined to a complete or partial penetration of the structure at the spot where such contact occurs; while, if the charge be not in contact with any part of the structure, the result, in the case of an external explosion, is either wholly or nearly negative, while, if occurring in the interior of a building, any effect which may be produced is limited to the more or less complete demolition of the chamber or portion of the structure in, or in the immediate neighborhood of which the explosion was effected. General, or even partial, destruction of a public building, or of a substantial dwelling-house, could not be accomplished except by the use of very much larger charges of dynamite and similar substances than could usually be brought to bear without attracting observation, and the effect of a single 'infernal machine' containing a few pounds of explosive would be structurally insignificant."—*Mechanical World.*

THE RAZOR-BACK HOG. — To the traveler through Texas one of the strangest and most peculiar features of landscape is the razor-back hog. He is of Swiss cottage style of architecture. His physical outline is angular to a degree unknown outside of a text book on the science of geometry. The country razor-back prowls around in the woods and lives on acorns, pecannuts, and roots; when he can spare time he climbs under his owner's fence and assists in harvesting the corn-crop. In this respect he is neighborly to a fault, and, when his duty to the owner's crop will allow, he will readly turn in and assist the neighbors, even working at night rather than see his crop spoil for want of attention. Crossing the razor-back with blue-blooded stock makes but little improvement. The only effective way to improve him is to cross him with a railroad train. He then becomes an imported Berkshire or Poland-China hog, and if he does not knock the train off the track, the railroad company pays for him at the rate of $1 a pound, for which they are allowed the mournful privilege of shoveling the remains off the track. The ham of the razor-back is more juicy than the hind leg of an iron fire-dog, but not quite so fat as a pine knot. — *Exchange.*

A MUSEUM of relics collected by Mr. D. W. Sawyer, cashier of a bank at Boothbay, Maine, contains, among other curious things, a piece of worm-eaten plank found in a codfish, and a watch-chain taken from a cod on the Banks. A brown jug in the collection has this curious fish story. One of the crew of the schooner *Willie G.*, at Southport, accidently broke the handle from a jug and threw it overboard. Four weeks afterwards, in that locality, while cleaning a codfish just drawn in, the fisherman exclaimed; "Wal, by gracious now, if I don't believe that here's the handle of my jug;" and, sure enough, the piece found in the cod fitted completely, and both are here to verify it. — *Exchange.*

TO CLEANSE A SOILED CHAMOIS LEATHER. — Make a solution of weak soda and warm water, rub plenty of soft soap into the leather, and allow it to remain in soak for two hours; then rub it well until it is quite clean. Afterwards rinse it well in a weak solution composed of warm water, soda, and yellow soap. If rinsed in water only, it becomes hard when dry, and unfit for use. The small quantity of soap left in the leather allows the finer particles of the leather to separate and become soft like silk. After rinsing, wring it well in a rough towel, and dry quickly; then pull it about and brush it well, and it will become softer and better than most new leathers. — *Boston Journal of Commerce.*

Notes and Queries.

W. H. W., Jr., Westville, Conn., asks: (1) Can you give me a correct rule for determining the size of water-cylinder for pumps to supply a given size of automatic engine? (2) What kind of grate bars are most suitable for burning wood and sawdust; the single, the double, or the sectional? (3) If it is a fact (and I think it is) that a steam boiler evaporates more water some days than others to do the same amount of work, why is it?

Ans. (1) From the known dimensions, speed of engine, point of cut off, and pressure of steam used, calculate the amount of feed-water required per minute to supply dry steam for the engine; and then so proportion the pump that it will be capable of delivering at least $2\frac{1}{2}$ times this quantity in a minute, if required. The manner of making the calculation is best shown by the following

Example. Engine with cylinder 30″ diameter, 60″ stroke of piston, cut-off at $\frac{1}{4}$ of stroke, clearance 5 per cent., steam pressure 80 pounds above the atmosphere, 60 revolutions per minute.

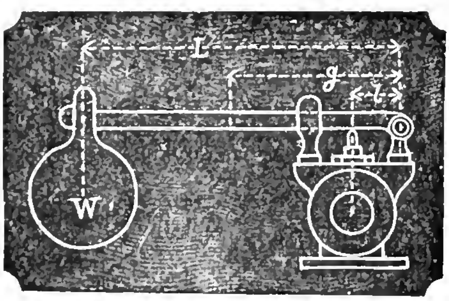
Area cylinder 30″ diameter, =4.91 square feet, 5 feet stroke of piston. Then $4.91 \times 5 = 24.55$ cubic feet displaced by the piston at each stroke. If we divide this by 4 because the engine cuts off at one-fourth, and add the clearance, which is 5 per cent. of 24.55, we obtain $(24.55 \div 4) + (24.55 \times .05) = 7.365$ cubic feet of steam consumed by the engine at each stroke. Multiplying 7.365 by 120, the number of strokes per minute, we obtain 883.8 cubic feet of steam used per minute by the engine. Now one cubic foot of water will make 282 cubic feet of steam at 80 pounds pressure (See LOCOMOTIVE, August, 1882, page 120), therefore we divide 883.8 by 282, and obtain 3.135 cubic feet of feed-water which must be supplied to the boiler every minute to supply the engine with dry saturated steam.

But steam from a boiler is rarely perfectly dry, more or less water is always carried off with the steam — there is always some condensation in pipes and cylinders, and always more or less steam lost by leakage, and water lost by blowing off; these quantities are variable and cannot be calculated, therefore it is necessary to have a pump large enough to supply more than the above quantity. Practice shows that it should be capable of delivering at least $2\frac{1}{2}$ times the above quantity. Hence, $3.135 \times 2.5 = 7.8375$ cubic feet as the capacity of the pump per minute. The size of the water cylinder of such a pump is quite arbitrary, and depends upon the speed at which it is run, and also whether it is single or double-acting. Good American practice would be to make the diameter of the water cylinder for a double-acting pump about $4\frac{1}{4}$ inches, length of stroke about 8 inches, and run it from 120 to 125 strokes per minute. If this is a plunger pump, the suction may be throttled down so it will deliver the required quantity of water to the boiler. If it is a direct acting steam pump, the speed of which can be varied at will, the cylinder might be reduced in size, say $3\frac{1}{4}$ or $3\frac{1}{2}$ inches in diameter, and 7-inch stroke.

(2) The sectional.

(3) The increased evaporation is probably due to the influence of the atmospheric moisture upon the various belts and machines about the establishment, by which they require an increased amount of power to drive them.

J. C. A., New York, asks: For a rule for ascertaining the necessary weight and length of lever for safety-valves on stationary boilers.



Ans. Referring to the Fig.,

W denotes the weight at end of lever in pounds.

L " " distance between center of weight and fulcrum in inches.

w denotes the weight of the lever itself in pounds.

g " " distance between center of gravity of lever and fulcrum in inches.

l denotes the distance between center of valve and fulcrum in inches.

V denotes the weight of the valve and its spindle in pounds.

A " " area of valve in square inches.

P " " pressure in pounds per square inch at which the valve commences to blow.

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

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

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

Divide l by L and call the quotient c.

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

Example. Diameter of valve = 4″. Distance from fulcrum to center of weight = 36″. Distance from fulcrum to center of valve = 4″. Weight of lever = 7 pounds. Distance from fulcrum to center of gravity of lever = 15½″. Weight of valve = 3 pounds.

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

Area 4″ valve = 12.566 square inches.

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

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

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

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

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

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

Area 4″ valve = 12.566 square inches.

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

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

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

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

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

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

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

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

F. S. K., St. Louis, Mo. Your figures are right so far as they go. You should take into account the weight of lever and also the weight of the valve itself. See answer to J. C. A., above.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. III. HARTFORD, CONN., OCTOBER, 1882. No. 10.

A Defective Mud-Drum and what it Teaches Us.

Apparently trifling mechanical details which may easily be overlooked unless unusual care is exercised by the constructor, sometimes have great influence on the efficiency and durability of structures. This is especially true of steam boilers and their connections. A seam in the wrong place; a single rivet in some particular place, badly driven; a plate unduly strained in some spot; or an indentation in some portion of a boiler shell, may, under certain conditions, which may develop in practice, but which may have been more or less difficult to foresee, produce the most serious results.

The following communication lately received from Mr. J. H. Cooper of Philadelphia, affords a very good illustration of what sometimes occurs when some little detail of a boiler is badly arranged, either through carelessness or otherwise.

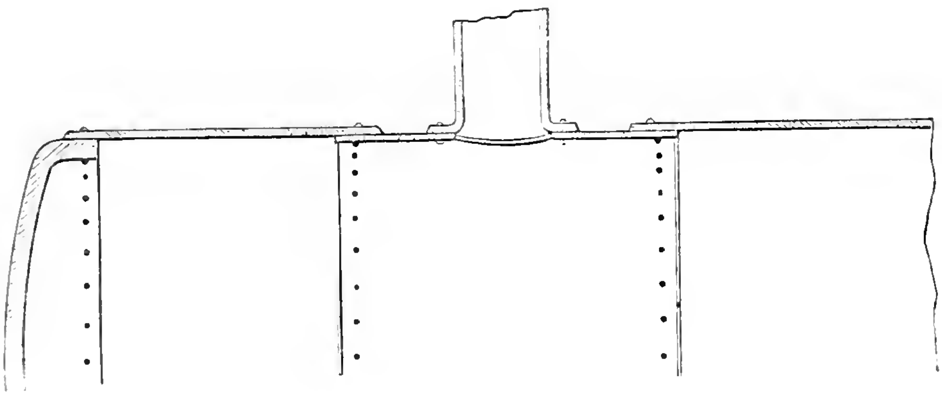


FIG. 1.

Editor Locomotive:—I have recently noticed a mud-drum which has been removed, and which shows evident marks of burning at the tops of the outside courses of plates. (See Fig. 1.) These places were so badly burned that they leaked, and were patched on the outside. This, of course, increased the difficulty two-fold, and only rendered the patch liable to more rapid destruction, which proved the case. It soon raised a blister and led to removal of drum.

The destruction of the iron in this drum is so distinctly marked that my attention was drawn to it in walking past simply. I thought the drum was condemned on account of internal corrosion and pitting, which perhaps it was, but the top burning from confined steam was sufficient to reject this member at once.

It would be better to make these drums without circular seams, or with middle ring outside of the others. Yours respectfully, J. H. COOPER.

The accompanying cuts illustrate the above point. Fig. 1 is a section of the drum which was burned on the top of the two outside courses of plates. It will readily be seen that when the drum is filled with water, a portion of the contained air will be trapped in the space at either end below the top of the inside course of plates. When the fires are started, the air contained in the feed-water will gradually be expelled by the heat, and will rise and entirely fill these spaces. Thus the sheets at these points will be unprotected by water, and, being exposed to the full heat of the furnace, will become highly overheated, and be sure to buckle or blister, and be destroyed in time. After steam commences to form, these places will be filled with a mixture of air and steam, which effectually prevents contact of water with the plates as long as the fires are kept up.

Fig. 2 shows the proper construction. Here, the neck connecting the drum with the boiler is located at the highest point of the drum, and no collection of steam and air is possible. It is also well, where mud-drums are used, to watch them closely and not allow one end to settle appreciably below the other end, or the same trouble will be experienced.

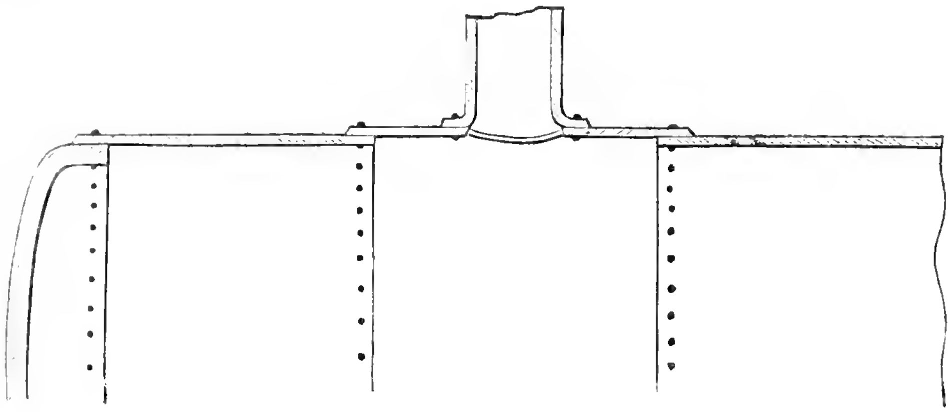


FIG. 2.

Some kinds of boilers having an internal furnace or combustion chamber, are so constructed that they are peculiarly liable to the above defect. When they are provided with a handhole at the lower side of the front end (as they always should be), opening into the water space between shell and furnace, it becomes necessary, to gain room for the handhole when the water space is narrow, to bend the furnace-plate upward. This is generally done in such a manner that it forms a "bump" in the furnace sheet at its lowest point. This bump makes an excellent steam trap, and we find that it invariably blisters and burns out in a short time. The proper method of construction in such a case, would be to flatten the furnace sheet instead of making a hollow place in it. This would be equally easy to construct, and would entirely obviate the above-mentioned difficulty.

The action of the air and steam in the above cases, may be very prettily shown as follows. Fill an ordinary kettle, or other similar vessel, with cold water, and invert a deep watch glass in it. The watch glass must be inverted while it is entirely submerged, so that no air will remain under it. Let it be fixed by means of any suitable apparatus, so that it is three or four inches from the bottom of the kettle, and heat applied. Air bubbles will soon begin to collect on the sides of the kettle and glass. At about 150 degrees F. the small air bubbles on the under or concave side of the glass will begin to run together quite rapidly, and form one large bubble at the highest point of the glass before the boiling point is reached. When the water begins to boil, steam rapidly collects beneath the glass, and usually a few seconds suffice to entirely expel the water from it. After this small puffs of steam escape from beneath the glass at irregular intervals, but never enough to allow the water to enter the glass to any appreciable extent.

This experiment represents exactly what occurs in a steam-boiler, whenever there is an inverted "pocket" of any sort below the water level. It will readily be seen that where the convex side of the pocket or lump is exposed to the furnace heat, as is the case with a mud-drum, or where it is at the bottom of a furnace or combustion chamber, it must inevitably become burned and destroyed.

Inspectors' Reports.

AUGUST, 1882.

During the month of August last, there were made by the Inspectors of this Company, 2,026 visits of inspection. The total number of boilers examined was 4,309, of which number 1,660 were thoroughly examined, both externally and internally; the remaining 2,649 were quarterly inspections or "externals" as they are denominated by the inspectors, made while the boilers are under steam; for the purpose of testing pressure gauges, ascertaining the condition of safety valves, water gauges, blow-off connections. feed connections, and making suggestions in management relative to economy or safety. The number of boilers which were tested by hydrostatic pressure was 402, principally new ones tested in the yards of their makers for the purpose of ascertaining the quality of their workmanship, etc. The number of boilers condemned was 25. The whole number of defects found foot up 2,637, of which 519 were considered to be of such a serious nature as to impair the safety of the boilers in which they were found. The usual tabular statement of defects is given below.

Nature of defects.	Whole number.	Dangerous.
Cases of deposition of sediment,	193	38
Cases of incrustation and scale,	324	33
Cases of internal grooving,	24	17
Cases of internal corrosion,	111	23
Cases of external corrosion,	147	41
Broken and loose braces and stays,	48	26
Defective settings,	93	19
Furnaces out of shape,	57	10
Fractured plates,	139	62
Burned plates,	86	34
Blistered plates,	191	33
Cases of defective riveting,	445	46
Defective heads,	43	10
Cases of leakage around tubes,	278	18
Cases of leakage at seams,	178	19
Water gauges defective,	53	14
Blow-outs defective,	30	5
Cases of deficiency of water,	12	9
Safety-valves overloaded,	19	13
Safety-valves defective in construction,	23	13
Pressure gauges defective,	139	35
Boilers without pressure gauges,	4	1
Total,	2,637	519

The large number of broken and loose braces which we find every month is a pretty sure indication that there is abundant room for improvement in workmanship on the part of some boiler-makers. If a brace is properly made and attached to a boiler, there is no more reason why it should ever break or get loose than there is for a plate in the shell to become loose and fall into the furnace. But that they do break, and get so loose that they might as well be broken, is very certain.

The ways in which braces fail are various, and depend upon the construction of the brace itself, as much as anything else. One of the commonest faults to be met with, is a deficiency in the size of the eye, where the brace is attached to angle or T irons. We have actually seen braces an inch in diameter, with the eye part not over one-half an inch square, and this merely bent so as to form a hook instead of being bent around and welded as it should have been. As might be expected under the circumstances, the hook was well straightened out, and the head of the boiler badly bulged.

One of the best forms of brace is made by welding a crow-foot to the end of the brace which is attached to the tube sheet, and riveting the whole thing rigidly to shell and head. If one could be sure that the weld were always sound, this would be a first class brace for parts of a boiler that are exposed to the fire; but unfortunately this is not the case. All experiments that have been made show that the strength of a welded joint is a very uncertain thing, and cannot be depended upon to be much more than one-half the strength of the solid part of the bar.

A very common way of attaching braces is to rivet two angle irons to the tube sheet, make the brace with a single eye, and fasten with a pin. The objection to this method is that the angle irons cover too much of the plate, and the space between them forms a lodging-place for sediment, which is apt to give trouble if it is used on surfaces exposed to the fire. In addition to this, the claw-hammer strain on the heads of the rivets in the angle irons is apt to loosen it so that the braces become slack.

The best method of connecting braces is to rivet T irons to the tube sheet and attach the brace by a pin and double eye, taking care to make the double eye of such a size that its strength shall be at least equal to the body of the brace. The T irons should be riveted radially to tube sheet, and the braces also arranged radially. In this manner all oblique strains are avoided, as well also as all twisting of the brace to make the attachment to the shell. For surfaces exposed to the direct action of the fire, however, the plain crow-foot brace is to be preferred.

The model brace for all parts of a boiler will not probably be designed until we can obtain mild steel castings which can be depended upon every time. Then a simple crow-foot with a *double eye* may be cast, and the body of the brace made simply of a flat piece of iron with a hole drilled near the end, and fastened to the crow-foot with a straight pin. This would seem to be the most simple and reliable form of brace that could be desired.

An Eighty-Pound Hailstone.—Considerable excitement was caused in our city last Tuesday evening by the announcement that a hailstone weighing eighty pounds had fallen six miles west of Salina, near the railroad track. An inquiry into the matter revealed the following facts: A party of railroad section men were at work Tuesday afternoon several miles west of the town, when the hailstorm came upon them. Mr. Martin Ellwood, the foreman of the party, relates that near where they were at work hailstones of the weight of four or five pounds were falling, and that returning towards Salina the stones increased in size, until his party discovered a huge mass of ice weighing, as near as he could judge, in the neighborhood of eighty pounds. At this place the party found the ground covered with hail as if a wintry storm had passed over the land. Besides securing the mammoth chunk of ice, Mr. Ellwood secured a hailstone something over a foot long, three or four inches in diameter, and shaped like a cigar. Mr. W. J. Hagler, the North Santa Fé merchant, became the possessor of the larger piece, and saved it from dissolving by placing it in sawdust at his store. Crowds of people went to see it, and many were the theories concerning the mysterious visitor. At evening its dimension were 29×16×2 inches.—*Salina (Kansas) Journal.*

Liverpool ranks as the most important port in the world, with an annual tonnage of 2,647,372; London stands second, with a tonnage of 2,330,688; Glasgow third, with 1,432,364; New York fourth, with a tonnage of 1,153,676. As a manufacturing city, New York leads the world.—*Knowledge.*

The Locomotive.

HARTFORD, OCTOBER, 1882.

Phosphorus in Iron and Steel.

The question is sometimes asked, How much phosphorus is allowable in iron from which good boiler-plate can be made? We were favored recently with a call from Col. J. F. Black, Sup't of the Shelby Iron Works, Alabama, and inquired of him as to his experience in the matter. He said, "Our product is all charcoal iron. In 100 analyses of the ore from which our iron is made, the highest percentage of phosphorus was 0.4 of one per cent. This iron has been used by the Ewald Manufacturing Company, of Nashville, Tenn., and is reported to have made a superior quality of plate iron.

Phosphorus, even in small quantities, has a decided effect upon the malleability and strength of iron at ordinary temperatures, causing "cold shortness," or a tendency to break short off when cold. While this is true at ordinary temperatures, when hammered or rolled at high temperatures no such effect would be produced. Karsten thought that iron was not materially affected when the phosphorus did not exceed 0.5 per cent., and up to 0.3 per cent. it only hardened, but did not diminish the tenacity. When iron contains 0.6 per cent. of phosphorus it will often bend at right angles but will not stand the breaking test. Its value decreases very rapidly with the increase of phosphorus, and with more than 1 per cent. it is extraordinarily "cold-short."

The highest limit for phosphorus in iron for making steel, we are informed, is 0.1 per cent. In the process of puddling dephosphorization takes place, and a large percentage of the phosphorus is eliminated. In steel low in carbon 0.1 per cent. renders it very brittle, and almost unfit for any use.

It will be seen from the foregoing that great care is necessary in manufacturing iron and steel plates for boilers. It not unfrequently happens that an inferior plate will find its way, by accident or otherwise, into a boiler manufacturer's order. Its inferiority will manifest itself in flanging, punching, or some of the processes of boiler construction, and such a plate should be rejected at once. The practice of "peening" up skin cracks and deeper cracks, caused in flanging, is pernicious. Such cracks show that either the material or the workmanship, or both, are inferior. A good piece of flange work will show neither cracks, flaws, or hammer marks. The flanges of boiler-heads are, as a rule, turned at too sharp an angle. They should not be turned on a radius of less than 2 inches; $2\frac{1}{2}$ inches would be better.

Manufacturers often purchase second-hand boilers because they are cheap. Now this may be well enough if, upon examination, they are found to be in fair condition, and are to be used only at low pressures for heating water, heating buildings, or some such purpose. But it very often happens that when the boiler or boilers are secured they are connected with the engine and used at ordinary boiler pressure, and if a "drive" in business comes the owners immediately run the pressure up excessively, and complain and fume if an inspector objects to such pressure. If parties engaged in any manufacturing business which has prospect of growth need additional power, we advise them to get new boilers. Don't take any chances on second-hand boilers for power because they are cheap. If you do they will very likely give out at a time when you can least afford to stop. We speak from knowledge of many cases. See that your boiler-room is fitted up with good boilers, sufficient in number for your work, and furnished with all the attachments required for convenient handling and safety. It is false economy to neglect this department of the establishment, for upon its efficiency depends in a great measure the success of your enterprise. In your eagerness to see a handsome product going out from the front of the mill, don't forget the rear end, where is the power that sets all the machinery in motion. Second-hand boilers are good in their place, but not to be used, as a rule, as though they were new, nor can they be safely rated at the same pressures.

THE Hartford Steam Boiler Inspection and Insurance Company has just completed the setting of four boilers of its own design for the Otis Company of Ware, Mass. The boilers were built by R. F. Hawkins & Co., of Springfield, Mass.

It has also recently set three boilers of an improved design of the Drop-flue type, for The Colt Patent Fire Arms Company of this city. These boilers were built by Peter Amerman of Hartford.

It has also set boilers for The Pratt & Whitney Company, of the Water-front Tubular type, built by H. B. Beach & Son of this city.

Boilers have also been designed and set for Smith, Northam & Robinson of this city, including plans for boiler-house and chimney; and for the East Hampton Rubber Thread Company, including boiler-house and chimney; also for the Otis Company's Mills at Three Rivers, Mass.

The boilers in the new mill of The Clark Thread Company of New Jersey were built and set from plans furnished by this company through its New York branch, R. K. McMurray its Chief Inspector.

Boilers built and set from the company's plans are extensively used throughout the country.

A VISIT to the Fair of the New England Manufacturers' and Mechanics' Institute, now being held in Boston, reveals a rich collection of the treasures of Art and Industry. Every variety of the steam engine, and all machinery connected with the manufacture of cotton and woolen fabrics are here, and most of them in actual operation. The exhibit of electric lighting apparatus is exceptionally fine, the entire building being so lighted. The most prominent systems are the Edison, the Weston, and the Thomson-Houston. The lighting of the Art Galleries by the Edison system produces a most brilliant effect. The display of minerals and woods by the southern railroads is very fine. Many magnificent specimens of iron and copper ore, and coal are to be seen. No one, who has an opportunity, should fail to spend a day or two at this fair.

Dr. Siemens' Address.

For the past few weeks the daily papers have been filled with the most nonsensical stuff imaginable, the burden of which is: "the Steam Engine is doomed." The immediate cause of this unusual commotion in the quasi scientific world was the inaugural address of Dr. C. W. Siemens, the President of the British Association, at Southampton, England, on the 23d day of August last. For the benefit of those of our readers who have had no chance to obtain the entire address in printed form, we reproduce from *Engineering* that portion of it which relates more particularly to the electric transmission of power; and gas vs. electric lighting. We may be grossly mistaken, but to us it seems to be nothing but a very shrewdly-framed argument for the benefit of the gas companies. That portion of the address which relates to the substitution of gas engines for steam engines is very interesting reading, but unfortunately only one side of the question is stated, and that but imperfectly. We have no space for extended comments, so we will call attention to but one point. The learned Doctor says that the efficiency of any heat engine depends upon the range of temperature through which it works. This is true. But the range of temperature through which the steam or any other heat engine works, is, in practice, limited by, and only by, the materials of which the engine is made, therefore it is difficult to see how gas can have any advantage over steam. Admit, however, for the sake of argument, that the efficiency of the gas engine is double that of the steam engine; that is, the steam engine converts into useful work one-eighth of the heat due to the combustion of the coal in the boiler furnace; while the gas engine converts into useful work one-fourth of the heat due to the combustion of the gas used. Then we must bear in mind that this gas is only to be obtained *from coal*, and from *three to four pounds* of coal are necessary to the production of one pound of gas. The argument that the by-products of gas manufacture are worth more than the value of the coal used has very little weight, for in the majority of places where *steam* is used they would be worthless. Further comment seems unnecessary. We would be willing to wager any sum that a hundred years hence, instead of being supplanted by any other motor, the steam engine will be only more firmly established in public favor than it is now.

The address is, however, very interesting, and we strongly advise every one to read it carefully.

Electricity is the form of energy best suited for transmitting an effect from one place to another; the electric current passes through certain substances—the metals—with a velocity limited only by the retarding influence caused by electric charge of the surrounding dielectric, but approaching probably under favorable conditions that of radiant heat and light, or 300,000 kilometres per second; it refuses, however, to pass through oxidized substances, glass, gums, or through gases except when in a highly rarefied condition. It is easy therefore to confine the electric current within bounds, and to direct it through narrow channels of extraordinary length. The conducting wire of an Atlantic cable is such a narrow channel; it consists of a copper wire, or strand of wires, 5 mm. in diameter, by nearly 5,000 kilometres in length, confined electrically by a coating of gutta-percha about 4 mm. in thickness. The electricity from a small galvanic battery passing into this channel prefers the long journey to America in the good conductor, and back through the earth, to the shorter journey across the 4mm. in thickness of insulating material. . . . .

Regarding the transmission of power to a distance, the electric current has now entered the lists in competition with compressed air, the hydraulic accumulator, and the quick running rope as used at Schaffhausen to utilize the power of the Rhine fall. The transformation of electrical into magnetical energy can be accomplished with no further loss than is due to such incidental causes as friction and the heating of wires; these in a properly designed dynamo-electric machine do not exceed 10 per cent., as shown by Dr. John Hopkinson, and, judging from recent experiments of my own, a still nearer approach to ultimate perfection is attainable. Adhering, however, to Dr. Hopkinson's determination for safety's sake, and assuming the same percentage in reconverting the current into mechanical effect, a total loss of 19 per cent. results. To this loss must be added that through electrical resistance in the connecting line wires, which depends upon their length and conductivity, and that due to heating by friction of the working parts of the machine. Taking these as being equal to the internal losses incurred in the double process of conversion, there remains a useful effect of 100 — 38 = 62 per cent. attainable at a distance, which agrees with the experimental results, although in actual practice it would not be safe at present to expect more than 50 per cent. of ultimate useful effect, to allow for all mechanical losses.

In using compressed air or water for the transmission of power the loss cannot be taken at less than 50 per cent., and as it depends upon fluid resistance it increases with distance more rapidly than in the case of electricity. Taking the loss of effect in all cases as 50 per cent., electric transmission presents the advantage that an insulated wire does the work of a pipe capable of withstanding high internal pressure, which latter must be more costly to put down and to maintain. A second metallic conductor is required, however, to complete the electrical circuit, as the conducting power of the earth alone is found unreliable for passing quantity currents, owing to the effects of polarization; but as this second conductor need not be insulated, water or gas pipes, railway metals or fencing wire, may be called into requisition for the purpose. The small space occupied by the electro-motor, its high working speed, and the absence of waste products, render it specially available for the general distribution of power to cranes and light machinery of every description. A loss of effect of 50 per cent. does not stand in the way of such applications, for it must be remembered that a powerful central engine of best construction produces motive power with a consumption of two pounds of coal per horse power per hour, whereas small engines distributed over a district would consume not less than five; we thus see that there is an advantage in favor of electric transmission as regards fuel, independently of the saving of labor and other collateral benefits. . . . .

In the electric railway first constructed by Dr. Werner Siemens, at Berlin, in 1879, electric energy was transmitted to the moving carriage or train of carriages through the two rails upon which it moved, these being sufficiently insulated from each other by being placed upon well-creosoted cross sleepers. At the Paris Electrical Exhibition the current was conveyed through two separate conductors making sliding or rolling contact with the carriage, whereas in the electric railway now in course of construction in the north of Ireland (which when completed will have a length of twelve miles) a separate conductor will be provided by the side of the railway, and the return circuit completed through the rails themselves, which in that case need not be insulated; secondary batteries will be used to store the surplus energy created in running down hill, to be restored in ascending steep inclines, and for passing roadways where the separate insulated conductor is not practicable. The electric railway possesses great advantages over horse or steam power for towns, in tunnels, and in all cases where natural sources of energy, such as waterfalls, are available; but it would not be reasonable to suppose that it will in its present condition compete with steam propulsion upon ordinary railways. The transmission of power by means of electrical conductors possesses the further advantage over other means of transmission that, provided the resistance of the rails be not very great, the power communicated to the locomotive reaches its maximum when the motion is at its minimum—that is, in commencing to work, or when encountering an exceptional resistance—whereas the utmost economy is produced in the normal condition of working when the velocity of the power-absorbing nearly equals that of the current-producing machine. . . . .

Electric energy may also be employed for heating purposes, but in this case it would obviously be impossible for it to compete in point of economy with the direct combustion of fuel for the attainment of ordinary degrees of heat. Bunsen and St. Claire De Ville have taught us, however, that combustion becomes extremely sluggish when a temperature of 1,800 deg. C. has been reached, and for effects at temperatures exceeding that limit the electric furnace will probably find advantageous applications. Its specific advantage consists in being apparently unlimited in the degree of heat attainable, thus opening out a new field of investigation to the chemist and metallurgist. Tungsten has been melted in such a furnace, and 8 pounds of platinum have been reduced from the cold to the liquid condition in 20 minutes.

. . . .

The principal argument in favor of the electric light is furnished by its immunity from products of combustion which not only heat the lighted apartments, but substitute carbonic acid and deleterious sulphur compounds for the oxygen upon which respiration depends; the electric light is white instead of yellow, and thus enables us to see pictures, furniture, and flowers as by daylight; it supports growing plants instead of poisoning them, and by its means we can carry on photography and many other industries at night as well as during the day. The objection frequently urged against the electric light, that it depends upon the continuous motion of steam or gas engines, which are liable to accidental stoppage, has been removed by the introduction into practical use of the secondary battery; this, although not embodying a new conception, has lately been greatly improved in power and constancy by Plante, Faure, Volckmar, Sellon, and others, and promises to accomplish for electricity what the gas-holder has done for the supply of gas and the accumulator for hydraulic transmission of power.

It can no longer be a matter of reasonable doubt, therefore, that electric lighting will take its place as a public illuminant, and that even though its cost should be found greater than that of gas, it will be preferred for the lighting of drawing-rooms and dining-rooms, theaters and concert-rooms, museums, churches, warehouses, show-rooms, printing establishments and factories, and also the cabins and engine-rooms of passenger steamers. In the cheaper and more powerful form of the arc light, it has proved itself superior to any other illuminant for spreading artificial daylight over the large areas of harbors, railway stations, and the sites of public works. When placed within a holophote the electric lamp has already become a powerful auxiliary in effecting military operations both by sea and land.

The electric light may be worked by natural sources of power, such as waterfalls, the tidal wave, or the wind, and it is conceivable that these may be utilized at considerable distances by means of metallic conductors. Some five years ago I called attention to the vastness of those sources of energy, and the facility offered by electrical conduction in rendering them available for lighting and power supply.

. . . .

Assuming the cost of electrical light to be practically the same as gas, the preference for one or other will in each application be decided upon grounds of relative convenience, but I venture to think that gas lighting will hold its own as the poor man's friend.

Gas is an institution of the utmost value to the artisan; it requires hardly any attention, is supplied upon regular terms, and gives with what should be a cheerful light a genial warmth, which often saves the lighting of a fire. The time is, moreover, not far distant, I venture to think, when both rich and poor will largely resort to gas as the most convenient, the cleanest, and the cheapest of heating agents, and when raw coal will be seen only at the colliery, or the gas-works. In all cases where the town to be supplied is within, say, thirty miles of the colliery, the gas works may with advantage be planted at the mouth, or still better at the bottom of the pit, whereby all haulage of fuel would be avoided, and the gas in its ascent from the bottom of the colliery, would acquire an onward pressure sufficient probably to impel it to its destination. The possibility of transporting combustible gas through pipes for such a distance has been proved at Pittsburg, where natural gas from the oil district is used in large quantities.

The quasi monopoly so long enjoyed by gas companies has had the inevitable effect of checking progress. The gas being supplied by meter, it has been seemingly to the advantage of the companies to give merely the prescribed illuminating power, and to discourage the invention of economical burners, in order that the consumption might reach a maximum. The application of gas for heating purposes has not been encouraged, and is still made difficult in consequence of the objectionable practice of reducing the pressure in the mains during daytime to the lowest possible point consistent with prevention of atmospheric indraught. The introduction of the electric light has convinced gas managers and directors that such a policy is no longer tenable, but must give way to one of technical progress; new processes for cheapening the production and increasing the purity and illuminating power of gas are being fully discussed before the Gas Institute; and approved burners, rivalling the electric light in brilliancy, greet our eyes as we pass along the principal thoroughfares.

Regarding the importance of the gas supply as it exists at present, we find from a Government return that the capital invested in gas works in England, other than those of local authorities, amounts to £30,000,000; in these 4,281,048 tons of coal are converted annually, producing 43,000 million cubic feet of gas, or about 2,800,000 tons of coke; whereas the total amount of coal annually converted in the United Kingdom may be estimated at 9,000,000 tons, and the by-products therefrom at 500,000 tons of tar, 1,000,000 tons of ammonia liquor, and 4,000,000 tons of coke, according to the returns kindly furnished me by the managers of many of the gas works and corporations. To these may be added, say, 120,000 tons of sulphur, which up to the present time is a waste product.

Previous to the year 1856—that is to say before Mr. W. H. Perkin had invented his practical process, based chiefly upon the theoretical investigations of Hoffman, regarding the coal-tar bases and the chemical constitution of indigo—the value of coal-tar in London was scarcely a halfpenny a gallon, and in country places gas-makers were glad to give it away. Up to that time the coal-tar industry had consisted chiefly in separating the tar by distillation into naphtha, creosote, oils, and pitch. A few distillers, however, made small quantities of benzine, which had been first shown—by Mansfield, in 1849—to exist in coal-tar naphtha mixed with toluene, cumene, etc. The discovery, in 1856, of the mauve or aniline purple gave a great impetus to the coal-tar trade, inasmuch as it necessitated the separation of large quantities of benzine, or a mixture of benzine and toluene, from the naphtha. The trade was further increased by the discovery of the magenta or rosaniline dye, which required the same products for its preparation. In the meantime, carbolic acid was gradually introduced into commerce, chiefly as a disinfectant, but also for the production of coloring matter.

The next most important development arose from the discovery by Græbe and Lieberman that alizarine, the coloring principle of the madder root, was allied to anthracine, a hydro-carbon existing in coal-tar. The production of this coloring matter from anthracene followed, and is now one of the most important operations connected with tar distilling. The success of the alizarine made in this manner has been so great that it has almost entirely superseded the use of madder, which is now cultivated to only a comparatively small extent. The most important coloring matters recently introduced are the azo-scarlets. They have called into use the coal-tar hydro-carbons, xylene and cumene. Napthalene is also used in their preparation. These splendid dyes have replaced cochineal in many of its applications, and have thus seriously interfered with its use. The discovery of artificial indigo by Professor Baeyer is of great interest. For the preparation of this coloring matter tuluene is required. At present artificial indigo does not compete seriously with the natural product; but should it eventually be perpared in quantity from tuluene, a further stimulus will be given to the coal-tar trade.

The color industry utilizes even now practically all the benzine, a large proportion of the solvent naphtha, all the anthracene, and a portion of the naphthaline resulting frem the distillation of coal-tar; and the value of the coloring matter thus produced is estimated by Mr. Perkins at £3,350,000.

The demand for ammonia may be taken as unlimited, on account of its high agricultural value as a manure; and, considering the failing supply of guano, and the growing necessity for stimulating the fertility of our soil, an increased production of ammonia may be regarded as a matter of national importance. for the supply of which we have to look almost exclusively to our gas works. The present production of 1,000,000 tons of liquor yields 95,000 tons of sulphate of ammonia; which, taken at £20 10*s.* a ton, represents an annual value of £1,947,000.

The total annual value of the gas works' by-products may be estimated as follows:

Coloring matter, ...	£3,350,000
Sulphate of ammonia, ...	1,947,000
Pitch (325,000 tons), ...	365,000
Creosote (25,000,000 gallons), ...	208,000
Crude carbolic acid (1,000,000), ...	100,000
Gas coke, 4,000,000 tons (after allowing 2,000,000 tons consumption working the retorts) at 12*s.*, ...	2,400,000
Total, ...	£8,370,000

Taking the coal used, 9,000,000 tons, at 12*s.*, equal £5,400,000, it follows that the by-products exceed in value the coal used by very nearly £3,000,000.

In using raw coal for heating purposes these valuable products are not only absolutely lost to us, but in their stead we are favored with those semi-gaseous by-products in the atmosphere too well known to the denizens of London and other large towns as smoke. Professor Roberts has calculated that the soot in the pall hanging over London on a winter's day amounts to fifty tons, and that the carbonic oxide, a poisonous compound, resulting from the imperfect combustion of coal, may be taken as at least five times that amount. Mr. Aitken has shown, moreover, in an interesting paper communicated to the Royal Society of Edinburgh, last year, that the fine dust resulting from the imperfect combustion of coal is mainly instrumental in the formation of fog; each particle of solid matter attracting to itself aqueous vapor; these globules of fog are rendered particularly tenacious and disagreeable by the presence of tar vapor, another result of imperfect combustion of raw fuel, which might be turned to much better account at the dye-works. The hurtful influence of smoke upon public health, the great personal discomfort to which it gives rise, and the vast expense it indirectly causes through the destruction of our monuments, pictures, furniture, and apparel, are now being recognized, as evinced by the success of recent Smoke Abatement Exhibitions. The most effectual remedy would result from a general recognition of the fact that wherever smoke is produced fuel is being consumed wastefully, and that all our calorific effects, from the largest down to the domestic fire, can be realized as completely and more economically, without allowing any of the fuel employed to reach the atmosphere unburnt. The most desirable result may be effected by the use of gas for all heating purposes with or without the addition of coke or anthracite.

The cheapest form of gas is that obtained through the entire distillation of fuel in such gas producers as are now largely used in working the furnaces of glass, iron, and steel works; but gas of this description would not be available for the supply of towns, owing to its bulk, about two-thirds of its volume being nitrogen. The use of water-gas, resulting from the decomposition of steam in passing through a hot chamber filled with coke, has been suggested, but this gas also is objectionable, because it contains, besides hydrogen, the poisonous and indorous gas, carbonic oxide, the introduction of which into dwelling-houses could not be effected without considerable danger. A more satisfactory mode of supplying heat separately from illuminating gas would consist in connecting the retort at different periods of the distillation with two separate systems ot mains for the delivery of the respective gases. Experiments made some years ago by Mr. Ellisen, of the Paris gas works, have shown that the gases rich in carbon, such as olefiant and acetylene, are developed chiefly during an interval of time, beginning halt an hour after the commencement and terminating at half the whole period of distillation, whilst during the remainder of the time, marsh gas and hydrogen are chiefly developed, which, while possessing little illuminating power, are most advantageous for heating purposes. By resorting to improved means of heating the retorts with gaseous fuel, such as have been in use at the Paris gas works for a considerable number of years, the length of time for effecting each distillation may be shortened from six hours, the usual period in former years, to four, or even three hours, as now practiced at Glasgow and elsewhere. By this means a given number of retorts can be made to produce, in addition to the former quantity of illuminating gas of superior quality, a similar quantity of heating gas, resulting in a diminished cost of production and an increased supply of the valuable by-products previously referred to. The quantity of both ammonia and heating gas may be further increased by the simple expedient of passing a streamlet of steam through the heated retorts towards the end of each operation, whereby the ammonia and hydro-carbon still occluded in the heated coke will be evolved, and the volume of heating gas produced be augmented by the products of decomposition of the steam itself. It has been shown that gas may be used advantageously for domestic purposes with judicious management even under present conditions, and it is easy to conceive that its consumption for heating would soon increase, perhaps tenfold, if supplied separately at say 1 shilling a thousand cubic feet. At this price gas would be not only the cleanest and most convenient, but also the cheapest form of fuel, and the enormous increase of consumption, the superior quality of the illuminating gas obtained by selection, and the proportionate increase of by-products, would amply compensate the gas company or corporation for the comparatively low price of the heating gas.

The greater efficiency of gas as a fuel results chiefly from the circumstance that a pound of gas yields in combustion 22,000 heat units, or exactly double the heat produced in the combustion of a pound of ordinary coal. This extra heating power is due partly to the freedom of the gas from earthy constituents, but chiefly to the heat imparted to it in effecting its distillation. Recent experiments with gas burners have shown that in this direction also there is much room for improvement.

. . . .

In the production of mechanical effect from heat, gaseous fuel also presents most striking advantages, as will appear from the following consideration. When we have to deal with the question of converting mechanical into electrical effect, or *vice versâ*, by means of a dynamo-electrical machine, we have only to consider what are the equivalent values of the two forms of energy, and what precautions are necessary to avoid losses by the electrical resistance of conductors and by friction. The transformation of mechanical effect into heat involves no losses except those resulting from imperfect installation, and these may be so completely avoided that Dr. Joule was able by this method to determine the equivalent values of the two forms of energy. But in attempting the inverse operation of effecting the conversion of heat into mechanical energy we find ourselves confronted by the second law of thermo-dynamics, which says that whenever a given amount of heat is converted into mechanical effect, another but variable amount descends from a higher to a lower potentatial, and is thus rendered unavailable.

In the condensing steam engine this waste heat comprises that communicated to the condensing water, whilst the useful heat, or that converted into mechanical effect, depends upon the differences of temperature between the boiler and condenser. The boiler pressure is limited, however, by considerations of safety and convenience of construction and the range of working temperature rarely exceeds 120 deg. Cent., except in the engines constructed by Mr. Perkins, in which a range of 160 deg. Cent., or an expansive action commencing at 14 atmospheres, has been adopted with considerable promise of success, as appears from an able report on this engine by Sir Frederick Bramwell. To obtain more advantageous primary conditions we have to turn to the caloric or gas engine, because in them the coefficient or efficiency expressed by $\frac{T-T'}{T}$, may be greatly increased. This value would reach a maximum if the initial absolute temperature T could be raised to that of combustion, and T′ reduced to atmospheric temperature, and these maximum limits can be much more nearly approached in the gas engine worked by a combustible mixture of air and hydro-carbons than in the steam engine.

Assuming, then, in an explosive gas engine a temperature of 1,500 deg. Cent. at a pressure of four atmospheres, we should, in accordance with the second law of thermodynamics, find a temperature after expansion to atmospheric pressure of 600 deg. Cent., and therefore a working range of 1,500 deg. — 600 deg. = 900 deg., and a theoretical efficiency of $\frac{900}{1500+274}$ = about one-half, contrasting very favorably with that of a good expansive condensing steam engine, in which the range is 150 — 30 = 120 degrees Cent., and the efficiency $\frac{120}{150+274} = \frac{2}{7}$.

A good expansive steam engine is therefore capable of yielding as mechanical work two-seventh parts of the heat communicated to the boiler, which does not include the heat lost by imperfect combustion, and that carried away in the chimney. Adding to these, the losses by friction and radiation in the engine, we find that the best steam engine yet constructed does not yield in mechanical effect more than one-seventh part of the heat energy residing in the fuel consumed. In the gas engine we have also to make reductions from the theoretical efficiency, on account of the rather serious loss of heat by absorption into the working cylinder, which has to be cooled artificially in order to keep its temperature down to a point at which lubrication is possible; this, together with frictional loss, cannot be taken at less than one-half, and reduces the factor of efficiency of the engine to one-fourth.

It follows from these conditions that the gas or caloric engine combines the conditions most favorable to the attainment of maximum results, and it may reasonably be supposed that the difficulties still in the way of their application on a large scale will gradually be removed. Before many years have elapsed we shall find in our factories and on board our ships engines with a fuel consumption not exceeding 1 pound of coal per effective horse power per hour, in which the gas producer takes the place of the somewhat complex and dangerous steam boiler. The advent of such an engine and of the dynamo-machine must mark a new era of material progress at least equal to that produced by the introduction of steam power in the early part of our century.

From 40,000 to 50,000 slate pencils are manufactured at the pencil mill daily, at Castleton, Vt., and sent to New York, whence they go far and near through this and other countries. Thirty persons are employed in the mill and quarry, and are paid promptly every month. Three from one family in the village are paid $80 a month for labor. Four men with machines point 40,000 pencils a day.—*Industrial Journal.*

A Simple Method of Keeping Correct Time.

It is not generally known that there is available to every one a most simple and accurate method of regulating a clock or watch, when access to Standard Time at short intervals is inconvenient or impossible. It consists simply in observing the time at which any particular star sets, or passes the range of two fixed objects, on different nights. It is necessary to have the correct clock time to *start* with; after that, a clock may be kept within a very few seconds of Standard Time for any number of years without any difficulty.

The Sun cannot be used for this purpose for the reason that there are only two days in a year when it is on the meridian of a place at noon *by clock time.* It may be as much as 14½ minutes fast, or 16¼ minutes slow on different days; and besides, the determination of its altitude with any degree of accuracy, requires the use of special instruments, and much skill in observation.

To determine the time by observation of a star, on the contrary, is a matter of great ease, and no instruments are necessary. The mode of operation is a follows. Select two fixed points for a range of observation. If a westerly window can be chosen which faces any building anywhere more than 25 to 30 feet distant, we have as good a post of observation as we can desire. Drive a nail, or stick a pin into the window jamb; or, if anything more substantial is wanted, fix a thin piece of metal, with a *very small* hole in it to sight through, in any convenient place, so that you can observe the time any star sets, or sinks below the roof of the adjacent building, or whatever may be chosen as the more remote sight. Then choose some well-defined star, the brighter the better, and with your timepiece set right, (to start with,) observe the time it passes the range of your sights. The exact time, as well also, as the date of this observation should *be recorded*, then to find out at any subsequent time, how much your watch has varied from correct time, observe the same star, and recollect that *it sets just 3 minutes and 55.90944 seconds earlier on any given night than it did the preceding night.* Thus if our first observation was taken some night when the star set at 9 hours 15 minutes, and 23 seconds; and at our second observation, taken just one week later, it set at 8 hours, 47 minutes, and 52 seconds, we would know that our watch had kept correct time. If it had set at 8 hours, 45 minutes, and 52 seconds, we would know that our watch or clock had *lost* 2 minutes during the week. And similarly for any other variation. If the time at which it had set had been 8 hours, 49 minutes, 52 seconds, we should see that our watch had *gained* 2 minutes, and so on.

If the location of our sights admits of it, we should select a star 90°, as nearly as possible, from the pole star, for its apparent motion will be greater than that of one near the pole, and the liability of error will be diminished. If a suitable selection can be made, the error need not be more than three or four seconds, and it will not be accumulative.

From the fact that any given star sets nearly four minutes earlier each night, it is evident that it will after a while, begin to set during daylight. Before this occurs it will be necessary to transfer the time to some other star, which sets later. Thus we see that the later in the evening our first observation is taken, the longer the same star may be used. To transfer the time, of course is very simple, you merely have to observe the star you have been using, note the time, and also the error and rate of variation of your watch; then as late as convenient the same evening, select the new star, observe its time, and from the data of the first observation, calculate the exact time of its setting, or passing the range of your sights. This is a very simple matter and requires no explanation. Then use the new star as long as possible, and transfer to another, and so on.

To facilitate observation and calculation, the following table from *Trautwine's Pocket Book* is inserted.

TABLE SHOWING HOW MUCH EARLIER A STAR PASSES A GIVEN RANGE ON EACH SUCCEEDING NIGHT.

Night.	Min.	Sec.	Night.	Hour.	Min.	Sec.	Night.	Hour.	Min.	Sec.
1	3	55.91	11	...	43	15.01	21	1	22	34.11
2	7	51.82	12	...	47	10.92	22	1	26	30.02
3	11	47.73	13	...	51	6.83	23	1	30	25.93
4	15	43.64	14	...	55	2.74	24	1	34	21.84
5	19	39.55	15	...	58	58.65	25	1	38	17.75
6	23	35.46	16	1	2	54.56	26	1	42	13.66
7	27	31.37	17	1	6	50.47	27	1	46	9.57
8	31	27.28	18	1	10	46.38	28	1	50	5.48
9	35	23.19	19	1	14	42.29	29	1	54	1.39
10	39	19.10	20	1	18	38.20	30	1	57	57.30
							31	2	1	53.21

H. F. S.

Notes and Queries.

W. H. W. JR., WESTVILLE, CONN., ASKS:

1st. In introducing a boiler compound into the feed-water in order to prevent it forming scale, is there danger of the sediment passing off in the steam, and injuring the valve seats and cylinder, or will it remain in solution until blown off?

2d. When feeding a boiler by an inspirator, with impure water, through a heater which heats it to 212°, will it form a deposit in the pipes between heater and boiler, which will, in time, fill them up?

3d. If a boiler is covered with fire clay for a non-conductor of heat, will it injure the iron?

Ans. 1st. The sediment will remain in the boiler unless the boiler primes, in which case some of it would be carried over into the cylinder. Some kinds of compounds, however, contain ingredients which are volatilized by heat, and pass off with the steam and are capable of doing much damage to valves and cylinders.

2d. If the water contained much sulphate of lime the feed-pipe would fill up in time.

3d. No, not unless moisture has access to it.

J. A. H., NEW YORK, INQUIRES:

Why is the compound engine more economical in the use of steam than the single engine?

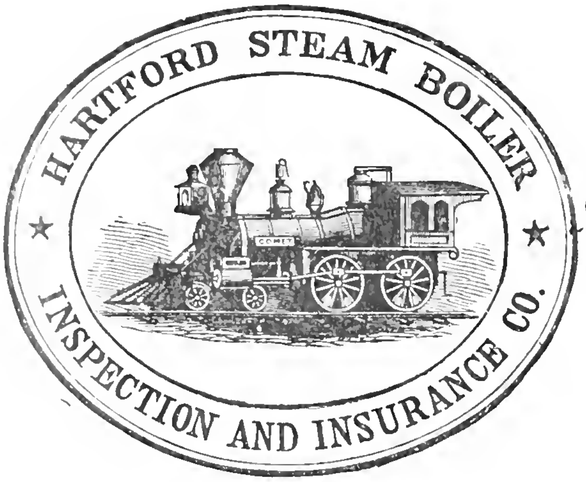
Ans. First, because a greater expansion can be obtained; second, the cylinder condensation for any given ratio of expansion is reduced, in consequence of the expansion being divided between the two or more cylinders, so that the variation of temperature in the cylinders when expansion takes place, is less than in the single cylinder engine.

G. H. B., DES MOINES, IOWA, ASKS:

What is the highest duty that has ever been attained by the steam engine, and what was the nature of the work performed?

Ans. The highest duty we have any record of is: 1 H. P., with a consumption of $1\frac{52}{100}$ pounds coal per hour, the work, pumping water.

Incorporated 1866.



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The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. III. HARTFORD, CONN., NOVEMBER, 1882. No. 11.

Upright Tubular Boilers.

In our articles on boiler construction in previous numbers of THE LOCOMOTIVE, we have uniformly urged the necessity of so planning and constructing boilers that there should be every reasonable opportunity for thorough inspection. In upright tubular boilers it is impossible to make an internal examination with the same care and thoroughness that an inspection can be made of a boiler where internal access can be had. Hence, for this reason, everything should be done that is possible to enable an inspector to examine the interior through suitable hand holes. The trouble with boilers of this type is usually with the furnace sheets, the lower tube sheet, and the tube ends. If sediment collects in the water leg, and on the lower tube sheet, the furnace sheets and lower tube ends will most certainly be burned. Boilers of this type are often constructed as shown in the following Figure.

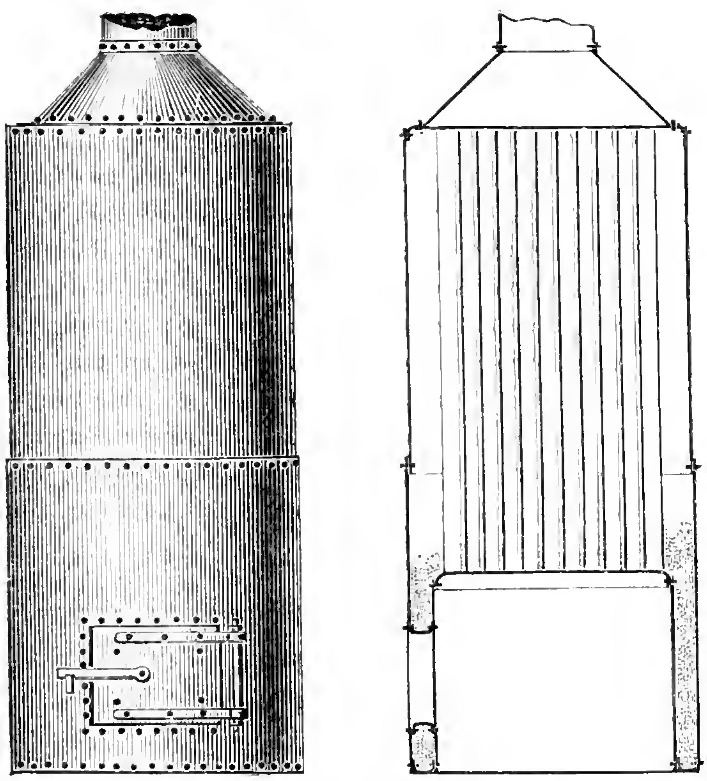


FIG. 1.

It will be seen that there is no provision for cleaning the boiler, and the water leg in time, particularly if water carrying impurities is used, is filled solidly full, and often the sediment covers the lower tube sheet to a greater or less depth, enclosing the tubes. These portions are exposed to the greatest heat, and being unprotected by water must of necessity become over heated and greatly weakened. Every boiler of this type should have three or four hand-holes at the bottom of the water leg, and at least four just above the lower tube sheet, as shown in the following figure.

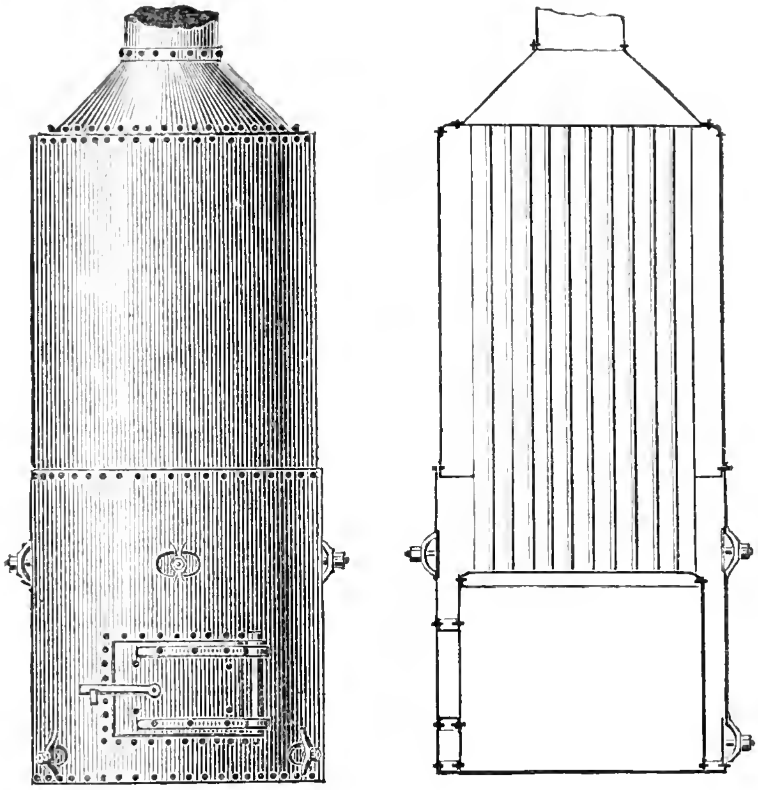
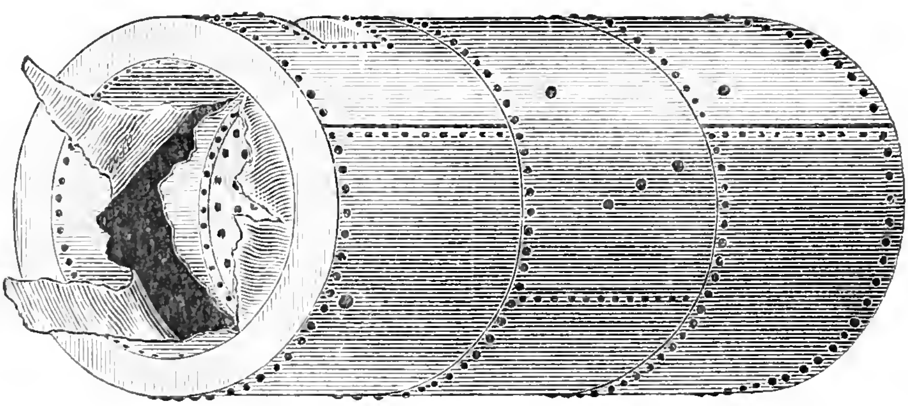


FIG. 2.

With these provisions the sediment can be easily and frequently removed, by use of a bent iron cleaner constructed for the purpose. Another matter which should not be overlooked is the proper stay-bolting of the water leg. Boilers of this type, particularly those of smaller diameters, are very often constructed without any stay-bolts. The builders will say that the inner furnace sheet is so short that it is supported sufficiently by the flanging at the top and bottom. But suppose the sheet becomes overheated and softened. What is to prevent its collapsing or fracturing? Or suppose from some disarrangment of the safety valve it becomes inoperative, and an unusual pressure accumulates in the boiler. What then? Such contingencies are liable to arise, and every boiler should be so constructed as to have ample margin for such contingencies. The following figure shows the rupture of the furnace sheet of such a boiler, that had no staying. The boiler was 30 inches in diameter, and the accident occurred from over pressure, the safety valve having been overloaded.

FIG. 3.



In some cities where inspection laws are in operation, the rule applied for ascertaining the resistance of cylindrical furnace sheets to collapsing is the same as that used for cylindrical flues—Fairbairn's Rule—and boilers made for such markets could not be approved without proper staying of the furnace sheets. Upright Tubular Boilers are very generally used where small power is required. They will be found in our business blocks, for job printing offices and small mechanical shops, therefore those who purchase and use them should be sure that they are well and properly constructed.

Inspectors' Reports.

SEPTEMBER, 1882.

The number of visits of inspection made during the month of September last, was 2,486. The total number of boilers examined was 4,798, of which 1,696 were complete internal and external inspections. The number of boilers tested by hydrostatic pressure was 438.

The number of defects found which were sufficiently serious to be reported was 3,127, of which number 648, or 20.7 per cent., were considered dangerous. The number of boilers condemned was 37.

The following is a statement of the defects in detail:

Nature of defects.	Whole number.	Dangerous.
Cases of deposit of sediment,	262	32
Cases of incrustation and scale,	370	42
Cases of internal grooving,	13	9
Cases of internal corrosion,	72	9
Cases of external corrosion,	140	37
Broken and loose braces and stays,	29	17
Defective settings,	115	22
Furnaces out of shape,	77	12
Fractured plates,	88	36
Burned plates,	73	21
Blistered plates,	155	20
Cases of defective riveting,	786	139
Defective heads,	53	11
Cases of leakage around tubes,	462	135
Cases of leakage at seams,	196	36
Water gauges defective,	45	7
Blow-outs defective,	17	10
Cases of deficiency of water,	5	3
Safety-valves overloaded,	10	6
Safety-valves defective in construction,	14	5
Pressure gauges defective,	142	37
Boilers without pressure gauges,	3	2
Total,	3,127	648

One of the most important parts of a steam boiler is the blow-off. It is also one that is subject to more abuse in its construction, location, and use than almost any other fixture pertaining to the boiler. The most peculiar ideas seem to prevail in regard to its construction and position on the boiler. Some put it at the front end, some at the back end, and some put it in the middle of the shell. The great majority also, instead of putting it on the bottom of the shell, where it belongs, insert it through the heads of the boiler, anywhere from 2 to 6 inches above the bottom of the shell, thus rendering it impossible to entirely empty the boiler when desired, and greatly impairing its efficiency for any purpose.

The only place for a blow-off pipe to enter a horizontal externally-fired boiler is through the bottom of the shell within a foot or so of the back head. The boiler should be set slightly lower at the back end than at the front, say three-fourths of an inch for a boiler 15 feet long. Then it may be entirely emptied by simply opening the blow-off valve, and all syphoning of water out through hand holes is obviated.

This however is not the most important reason for locating the blow-off at the back end of the boiler. In a horizontal externally-fired boiler the application of the heat, and the resulting circulation of the water, is such that the sediment is always deposited at the back end to a much greater extent than in any other part of the boiler. Obviously, then, this is the place for the blow-off. It is true that most boiler-makers now place it there, but there are many who still persist in placing it at the front end.

The proper method of constructing and attaching the blow-off pipe to the ordinary horizontal boiler is as follows: First, the pipe should be 2 inches in diameter. A circular piece of boiler plate about 8 inches in diameter should be riveted on the bottom of the shell, with its center not over 12 inches from the back head. The hole for the pipe had better not be made until after this piece is riveted on, and then it should be drilled. If, however, facilities are not available for doing the job in this way, it may be drilled before it is put on. The hole should then be tapped, when it is ready for the pipe. The rivet holes on the inside of the shell should always be countersunk, and the heads of the rivets driven flush with the inner surface of the plate. If this is done there are no projecting rivet heads to assist in the collection of sediment at this point. A blow-off attached in this manner and provided with a straight away valve outside the setting will always give perfect satisfaction if properly cared for. In many cases however, where the water is bad, they are not opened often enough, and the inevitable consequence is that they soon become filled up with scale and sediment. When this occurs it may always be regarded as the best possible proof that it is located in just the right place, and, if properly attended to, will prove most effective in keeping the boiler free from scale and sediment.

YESTERDAY afternoon an employee of William Michaeles, a dentist at 82 East Fourth street, put three sets of teeth into a vulcanizer to harden them. The vulcanizer is a copper boiler $3\frac{1}{2}$ inches in diameter by 7 inches long. The process requires the teeth to be placed in small flasks. The flasks are put in the boiler, and the boiler is filled with water. The top of the boiler is screwed on, and a gas jet raises the temperature to 320 degrees. Before the right temperature was reached yesterday, the boy, while looking through the laboratory door, saw the safety plug blow out, and then the boiler went through the ceiling of the room. The windows were broken, and the furniture injured to the extent of $50. One of the flasks was broken open by the explosion, and no trace of the teeth has been found.—*Sun*, Nov. 10, 1882.

TOWER CITY, Dakota, has a water supply from a remarkable artesian well. When the earth was penetrated 569 feet salt water was obtained. Twenty feet further down a gravelly stream was struck, which yielded salt water also. When a depth of 604 feet had been reached, fresh water mixed with quicksand came up. At a depth of 675 feet a flow of pure water was obtained, and the quantity is steadily increasing.

The Locomotive.

HARTFORD, NOVEMBER, 1882.

We have frequently warned manufacturers against using open heaters, especially where the water was heated by exhaust steam from the engine. The oil contained in the exhaust steam is very liable to make trouble, especially if the feed-water is impure, or contains carbonate of lime or magnesia, or organic matter in any considerable quantity. The oil or grease combines with these substances, and forms a conglomerate mass that is sometimes especially troublesome. We have not unfrequently found the fire sheets of boilers greatly overheated from this cause, and their strength destroyed. A deposit which would naturally fall down as a fine powder and be easily blown out, soon mixes with the grease, forming a pasty substance which adheres to the plates, and when the boilers are blown down it at once bakes on to the hot plates and is removed with no little difficulty. We have removed this deposit from boilers when the amount of organic matter was large, and when dried it burned readily on being put into a gas flame. The amount of oil daily used by engineers in the cylinder of an engine varies considerably. For instance, in eighty H. P. engines we have known the quantity to vary from one-half pint to more than a pint, and the larger quantity makes the most trouble. These difficulties have been remedied by substituting coil or tubular heaters. Another trouble which occasionally occurs in the use of condensed water is this. The drip or condensation from cotton mill slashers and dressers is sometimes returned to the boiler. We have found in some cases that the boilers at once began to show internal corrosion. A recent case,—two nearly new boilers had been running since placed in position with good results. The condensed water from the slashers was subsequently fed to the boilers and signs of internal corrosion began to appear.

The cause of this we attribute to the steam having been in contact with the copper drying cylinders, large and small. This theory is not fully established in our minds, but from the cases which we have seen, we believe corrosion has occurred from this cause. The quality of water, however, may have had much to do with it.

Mr. Francis B. Allen, who has been connected with the New York Department of the Hartford Steam Boiler Inspection and Insurance Company for the past eleven years, has been transferred to the Home Office in Hartford, to act in the capacity of Supervising General Agent. Mr. Allen is by profession a mechanical engineer, was an engineer in the Navy during the war, which together with his experience with this company, especially fit him for his new position.

Our enterprising contemporary, which has been so long and favorably known as the *Boston Journal of Commerce*, has changed its name to *Cotton, Wool, and Iron*, which more clearly indicates the character of its contents. Cotton, Wool, and Iron are the three great industrial staples, and, being their accredited representative, our contemporary has fairly earned the right to its new title.

The November number of the *Manufacturer and Builder* has a timely article on fatal accidents with electric light wires. It shows the difficulties and dangers of splicing "live wires," giving an account of the manner in which it is done. Few persons not familiar with the electric light are aware of the dangers attending its care and successful operation.

Unclassified Data.

BY J. H. COOPER.

"With good wrought-iron, the permanent set is so slight for loads below the limit of ten to twelve tons per square inch, or about one-half the breaking weight, as not to be sensibly felt in a boiler shell."—*Wilson on Steam Boilers*, p. 214.

"To allow for contingencies the *elastic limit* should not be taken at more than two-fifths the breaking strength of the joints, which is the limit of test pressure to which a new boiler should be strained. This may also be applied to an old boiler."—*Wilson*, p. 215.

"The working pressure of new boilers whose condition is known and regularly ascertained at intervals of six to twelve months, a factor of safety of five or even less may be used."—*Wilson*, p. 216.

"A boiler that has been at work for some time and has thus in a manner proved its capability of bearing a given pressure may be considered safe if it will stand a test of one and a half times its working load."—*Wilson*, p. 225.

D. K. Clarke. Rules, Tables, and Data for Mechanical Engineers. London, 1877. Page 640:

CONCLUSIONS ON THE STRENGTH OF RIVET JOINTS IN IRON PLATES.—"It may be concluded that the tensile strength of iron plates of good quality is not materially impaired by punching, when done under proper conditions. Also, that the shearing section of rivets should not in any case exceed the net section of plate; and that the maximum strength of joint is attainable when the shearing section is from ninety to one hundred per cent. of the net section of plate. In the order of strength the joints proportioned on this principle range thus:

Solid plate, - - - - - - -	100 per cent.
Double riveted lap joint, - - - - -	72 per cent.
Single riveted lap joint, - - - - -	60 per cent.

These percentages are to be accepted for plates not more than seven-sixteenths thick. For boilers they give wider pitches than are usually practiced, but they are nevertheless right."

Mr. W. S. Hall gives the following table* of proportions, which may be taken as a guide, not as a hard and fast rule:

PROPORTIONS OF RIVET JOINTS.	Double Riveted Zigzag Joints.	Single Riveted Joints.
Thickness of Plate, - - - -	1.0	1.0
Diameter of Rivet, - - - -	1.7	1.7
Breadth of Lap, - - - - -	8.3	5.4
Pitch of Rivets in Line, - - - -	7.1	4.6
Distance apart of Pitch Lines, - - -	2.8	
Distance from Edge to Plates, - - -	2.7	

"Mr. Paul Havrez gives a table of proportions of single rivet joints, embracing average good practice in France," from which we select a few examples:

Thickness of Plates.	Diameter of Rivets.	Pitch of Rivets.	Lap of Joint.
.236	.551	1.69	1.73
.276	.630	1.89	1.97
.315	.669	2.01	2.13
.354	.748	2.13	2.20

* The above table is somewhat blind, but as we understand it the thickness of the plate is the basis of the calculation. The results do not fully accord with recent American practice.—ED. LOCOMOTIVE.

D. K. Clarke, Tables and Rules, p. 625:

"Wrought Iron.—For bars and plates, five tons per square inch of net section is taken as the safe tensile stress; for bar iron of extra quality, six tons, and for steam boilers the 'factor of safety' is taken at one-fourth to one-eighth." Mr. Roebling says: "Long experience has proved beyond the shadow of a doubt that good iron, exposed to tensile strain not above one-fifth of the ultimate strength, and not subject to strong vibration or torsion may be depended upon for a thousand years."*

Mr. Rankine gives the following data as factors of strength:

	Dead Load.	Live Load.
Perfect materials and work, - - - - -	2	4
Good ordinary materials and work, - - - -	3	6

Dead loads are such as are put on quietly and remain.

Live loads are such as are put on suddenly, accompanied with vibration.

Humber, London 1870, p. 70, in his work on bridges, repeats *the same factors* as above.

For the maximum working strength of the material of a boiler and the joints, the proportion of one-fifth of the ultimate strength may safely be adopted. In selecting this proportion we are fortified by the practice of wrought iron bridge engineers, who adjust the lower members of such bridges to a working tensile strain of four to five tons per square inch; the metal so employed being of Staffordshire manufacture, supposed to have an ultimate tensile strength of twenty tons per inch.

The ultimate and working tensile strengths taken at one fifth the ultimate are placed together for reference in the following table:

Description.	Low Moor.			Staffordshire.		
	Strength per cent.	Ultimate Strength.	Working Strength.	Strength per cent.	Ultimate Strength.	Working Strength.
Entire Plate, - -	100	56,000	11,200	100	44,800	8,960
Double Rivet Lap, -	72	40,320	8,064	72	32,480	6,496
Single Rivet Lap, -	60	33,600	6,720	60	26,880	5,376

For the strength of the joints of the best American plates, allow *one-half* more than for best Staffordshire plates; for ordinary American plates, *one-third* more, and for cast steel, *double*. The contents of the table are correct for three-eighth inch plates, and for thinner plates.

In round numbers the working strengths of best boiler plates are as follows:

Yorkshire, per square inch of entire section, - - -	11,000 lbs.
Staffordshire, per square inch of entire section, - - -	9,000 lbs.
American, per square inch of entire section, - - -	14,000 lbs.
American (ordinary), per square inch of entire section, - -	12,000 lbs.
Cast Steel Plates, per square inch of entire section, - -	18,000 lbs.

Mr. Clarke gives the working pressures in an extended table, from which we take the following for a 54-inch boiler;

Thickness of Plates.	Single Riveted.	Double Riveted.
One-fourth inch, - - - - - -	62 lbs.	74 lbs.
Five-sixteenths inch, - - - - - -	77 lbs.	92 lbs.
Three-eighths inch, - - - - - -	92 lbs.	111 lbs.

The bursting pressure is five times the working pressure.

* The reader will be careful to note that the conditions enumerated here do not apply to engines or boilers under ordinary conditions of practice.—Ed. Locomotive.

Useful Notes on Lead, Copper, and Brass in Various Forms.

(Tables from *Trautwine's Pocket Book.*)

ROLLED LEAD, COPPER, AND BRASS IN SHEETS AND BARS.

Thick'ss of Sheet, Side of Square, or Diam. of Round Bar	LEAD.			COPPER.			BRASS.			Thick'ss of Sheet, Side of Square, or Di. R'd Bar.
	Sheets per Sq. Foot.	Sq. Bars per Lin'al Ft.	R'nd Bars per Lin'al Ft.	Sheets per Sq. Foot.	Sq. Bars per Lin'al Ft.	R'd Bars per Lin'l Ft.	Sheets per Sq. Foot.	Sq. Bars per Lin'al Ft.	R'd Bars per Lin'al Ft.	
Inches.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Inches.
1/32	1.86	.005	.004	1.44	.004	.003	1.36	.004	.003	1/32
1/16	3.72	.019	.015	2.89	.015	.012	2.71	.014	.011	1/16
3/32	5.58	.044	.034	4.33	.034	.027	4.06	.032	.025	3/32
1/8	7.44	.078	.061	5.77	.060	.047	5.42	.056	.044	1/8
5/32	9.30	.121	.095	7.20	.094	.074	6.75	.088	.069	5/32
3/16	11.2	.174	.137	8.66	.135	.106	8.13	.127	.100	3/16
7/32	13.0	.237	.187	10.1	.184	.144	9.50	.173	.136	7/32
1/4	14.9	.310	.244	11.5	.240	.189	10.8	.226	.177	1/4
5/16	18.6	.485	.381	14.4	.376	.295	13.5	.353	.277	5/16
3/8	22.3	.698	.548	17.3	.541	.425	16.3	.508	.399	3/8
7/16	26.0	.950	.746	20.2	.736	.578	19.0	.691	.543	7/16
1/2	29.8	1.24	.974	23.1	.962	.755	21.7	.903	.709	1/2
9/16	33.5	1.57	1.23	26.0	1.22	.955	24.3	1.14	.900	9/16
5/8	37.2	1.94	1.52	28.9	1.50	1.18	27.1	1.41	1.11	5/8
11/16	40.9	2.34	1.84	31.7	1.82	1.43	29.8	1.70	1.34	11/16
3/4	44.6	2.79	2.19	34.6	2.16	1.70	32.5	2.03	1.60	3/4
13/16	48.3	3.27	2.57	37.5	2.55	1.99	35.2	2.38	1.87	13/16
7/8	52.1	3.80	2.98	40.4	2.94	2.31	37.9	2.76	2.17	7/8
15/16	56.0	4.37	3.42	43.3	3.38	2.65	40.6	3.18	2.49	15/16
1	59.5	4.96	3.90	46.2	3.85	3.02	43.3	3.61	2.84	1
1 1/8	66.9	6.27	4.92	52.0	4.87	3.82	48.7	4.57	3.60	1 1/8
1 1/4	74.4	7.75	6.09	57.7	6.01	4.72	54.2	5.64	4.43	1 1/4
1 3/8	81.8	9.37	7.37	63.5	7.28	5.72	59.6	6.82	5.37	1 3/8
1 1/2	89.3	11.2	8.77	69.3	8.65	6.80	65.0	8.12	6.38	1 1/2
1 5/8	96.7	13.1	10.3	75.1	10.2	7.98	70.4	9.53	7.49	1 5/8
1 3/4	104.	15.2	11.9	80.8	11.8	9.25	75.9	11.1	8.68	1 3/4
1 7/8	112.	17.5	13.7	86.6	13.5	10.6	81.3	12.7	9.97	1 7/8
2	119.	19.8	15.6	92.3	15.4	12.1	86.7	14.4	11.3	2

In connection with the above table it will be found useful to memorize the following points:

A piece of sheet lead one foot square and one inch thick weighs, in round numbers, 60 pounds, or just one-half more than a sheet of iron of the same dimensions, the iron being taken in round numbers at 40 pounds.

A similar piece of copper weighs, in round numbers, 46 pounds, and one of brass, 43 pounds. For the requirements of approximate calculation, it will be near enough, in most cases, to call both copper and brass 45 pounds, which is easily remembered from the fact of its being three-fourths of the weight of lead; or one-eighth more than that of iron.

The weight of a square bar of lead 1 inch square and one foot long is, in round numbers, 5 pounds; and that of a round bar of the same metal, 1 inch diameter, and 1 foot long, 4 pounds, nearly.

The weight of a square bar of either copper or brass, 1 inch square and 1 foot long, may, without much error, be taken at 3¾ pounds; and a round bar of the same materials 1 inch in diameter and 1 foot long, may be taken equal to 3 pounds.

The weight of round bars of any given length varies directly as the square of their diameters and that of square bars as the square of their sides.

WEIGHT OF LEAD PIPES PER LINEAL FOOT.

Inside diameter of Pipe.	THICKNESS OF METAL IN INCHES.											
	1/16	1/8	3/16	1/4	5/16	3/8	7/16	1/2	5/8	3/4	7/8	1 inch.
Inches.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.	Lbs.
1/4	.305	.724	1.28	1.95	2.74	3.65	4.53	5.84	8.52	11.7	15.3	19.5
5/16	.366	.845	1.47	2.20	3.05	4.02	4.96	6.33	9.14	12.4	16.2	20.5
3/8	.427	.967	1.65	2.44	3.35	4 38	5.39	6.82	9.76	13.2	17.0	21.5
7/16	.488	1.09	1.83	2.69	3.66	4.75	5.82	7.31	10.4	13.9	17.9	22.4
1/2	.548	1.21	2.01	2.93	3.96	5.11	6.24	7.79	11.0	14.6	18.7	23.4
5/8	.670	1.46	2.38	3.42	4.57	5.85	7.10	8.77	12.2	16.1	20.4	25.4
3/4	.791	1.70	2.74	3.90	5.18	6.58	7.96	9.75	13.4	17.6	22.1	27.3
7/8	.911	1.95	3 11	4.39	5.79	7.31	8.82	10.7	14.6	19.1	23.9	29.3
1	1.03	2.19	3.47	4.88	6.40	8.04	9.67	11.7	15.8	20.5	25.6	31.2
1/8	1.16	2.44	3.84	5.37	7.01	8.77	10 5	12.7	17.1	22.0	27.3	33.2
1/4	1.28	2.69	4.21	5.85	7.62	9.50	11.4	13.7	18.3	23.4	29.0	35.1
3/8	1.40	2.94	4.58	6.34	8.23	10.3	12.3	14.7	19.5	24.9	30.7	37.1
1/2	1.52	3.18	4.94	6.83	8.84	11.0	13.1	15.6	20.7	26.3	32.4	39.0
5/8	1.64	3.43	5.31	7.32	9.47	11.7	14.0	16.6	22.0	27.8	34.1	41.0
3/4	1.76	3.67	5.67	7.81	10.1	12.4	14.8	17.6	23.2	29.3	35.8	42.9
7/8	1.89	3.92	6.04	8.30	10.7	13.2	15.7	18.6	24.4	30.8	37.6	44.9
2	2.01	4.16	6.40	8.78	11.3	13.9	16.5	19.5	25.6	32.2	39.3	46.8
1/4	2.25	4.65	7.13	9.76	12.5	15.4	18.2	21.5	28.1	35.1	42.7	50.7
1/2	2.49	5.14	7.86	10.7	13.7	16.8	20.0	23.4	30.5	38.0	46.1	54.6
3/4	2.73	5.63	8.59	11.7	14.9	18.3	21.7	25.4	32.9	41.0	49.5	58.5
3	2.98	6.12	9.32	12.7	16.1	19.7	23.4	27.3	35.4	43.9	52.9	62.4
1/4	3.22	6.61	10.1	13.7	17.4	21.2	25.1	29.3	37.8	46.8	56.4	66.4
1/2	3.46	7.10	10.8	14.6	18.6	22.7	26.8	31.3	40.3	49.7	59.8	70.3
3/4	3.71	7.59	11.5	15.6	19.8	24.1	28.5	33.2	42.7	52.7	63.2	74.2
4	3.95	8.08	12.2	16.6	21.0	25.6	30.2	35.2	45.2	55.6	66.6	78.1

WEIGHT OF LEAD, COPPER, BRASS, AND IRON BALLS.

Diameter of Ball.	Cast Lead.	Cast Copper.	Cast Brass.	Cast Iron.	Diameter of Ball.	Cast Lead.	Cast Copper.	Cast Brass.	Cast Iron.
Inches.	Lbs.	Lbs.	Lbs.	Lbs.	Inches.	Lbs.	Lbs.	Lbs.	Lbs.
1/4	.0032	.0026	.0024	.0021	4 3/4	22.7	17.9	15.9	14.6
1/2	.026	.021	.019	.017	5	26.0	20.8	18.6	17.0
3/4	.088	.070	.063	.058	5 1/4	30.1	24.1	21.5	19.8
1	.209	.167	.148	.136	5 1/2	34.7	27.7	24.7	22.7
1 1/4	.408	.325	.290	.266	5 3/4	39.6	31.7	28.3	25.9
1 1/2	.705	.562	.501	.460	6	45.0	36.0	32.0	29.4
1 3/4	1.12	.893	.795	.731	6 1/2	57.2	45.8	40.8	37.4
2	1.67	1.33	1.19	1.07	7	71.5	57.2	50.9	46.8
2 1/4	2.38	1.90	1.69	1.55	7 1/2	88.0	70.3	62.6	57.5
2 1/2	3.25	2.60	2.32	2.13	8	106.	85.3	76.0	69.8
2 3/4	4.34	3.47	3.09	2.83	8 1/2	127.	102.	91.2	83.7
3	5.63	4.50	4.01	3.68	9	151.	121.	108.	99.4
3 1/4	7.15	5.72	5.10	4.68	9 1/2	178.	143.	127.	117.
3 1/2	8.94	7.14	6.36	5.85	10	208.	167.	148.	136.
3 3/4	11.0	8.79	7.83	7.19	10 1/2	241.	193.	172.	158.
4	13.4	10.7	9.50	8.73	11	277.	222.	198.	182.
4 1/4	16.	12.8	11.4	10.5	11 1/2	317.	253.	226.	207.
4 1/2	18.9	15.2	13.5	12.4	12	360.	288.	257.	236.

From the last table we observe that the weights of balls 1 inch in diameter are as follows:

Cast lead,	.209	pounds.
" copper,	.167	"
" brass,	.148	"
" iron,	.136	"

The cubical contents, and therefore the weight of balls, varies directly as the cubes of their diameters. Hence, it is only necessary to cube the diameter of a ball of any given size, and multiply by the weight of a ball of the same substance 1 inch in diameter to obtain its weight. It will be found useful, therefore, to commit the weights of 1-inch balls to memory.

Or to find the weight in round numbers:

For lead,	cube the diam.	and	*divide by*	5.
" copper,	"	"	"	6.
" brass,	"	"	"	$6\frac{3}{4}$.
" iron,	"	"	"	$7\frac{1}{2}$.

Lead may be hardened by alloying it with various other metals. From $\frac{1}{2}$ to $3\frac{2}{3}$ per cent. of antimony will generally render lead so hard as to be unfit for many of its applications. Lead for bullets for smooth-bored guns should be hardened by the addition of from one-fourth to one-fifth of its weight of antimony. Rifle bullets should be made of very soft lead. Common type metal consists of 4 parts lead and 1 part antimony. Stereotype metal, which is somewhat more fusible, contains 79 per cent. lead, 15 antimony, and 8 bismuth. For fine impressions, tin is sometimes substituted for the bismuth. To alloy lead with these metals it is only necessary to melt the lead first, then add the other metals. An alloy of lead and bismuth is much stronger than lead alone, if the proportion of bismuth is not greater than that of the lead. Three parts of lead and two of bismuth has a tensile strength ten times as great as lead, and is an excellent alloy for pipes and wire.

Lead may be softened by melting it in shallow vessels exposed to the air, when the above metals, especially antimony, which are the cause of its hardness, are converted into oxides, and float on the surface of the lead in the form of a slag which may be skimmed off. The process should be continued until the desired degree of purity and softness is attained.

Lead for shot contains from 3 parts for small, to 8 parts for large shot, of arsenic; which not only renders it harder, but has an important influence in determining the spherical form of the shot when it falls through the colander in the melted condition.

The World's Production of Iron.

The aggregate production of iron in the different countries of the world furnishes some figures worthy of note. The British and American yield is known, while Germany produced in 1881, whether inclusive or exclusive of the production of Luxembourg is not stated, about 2,863,400 tons of 2,240 pounds. Luxembourg produced 289,212 tons, and this quantity is given separately in the subjoined statement. France produced 1,866,438 tons; Belgium, 622,288 tons; Russia, 231,341 tons; Austro-Hungary, 448,685 tons (in 1880); and Sweden, 399,628 tons. A few other countries will produce small quantities; thus Italy is said to have produced 76,000 tons in 1877, and Spain, 73,000 tons in 1873; the yield in Turkey is estimated at 40,000 tons, that of Australia and Japan, at

10,000 each; that of Canada, Switzerland, and Mexico, at 7,500 each; that of Norway, at 3,975 tons, and other countries are supposed to have produced in all, about 10,000 tons.

Assuming that the yield in minor countries was the same in 1881 as it was reported to be at the latest dates, the whole yield may be thus stated:

Great Britain,	1881	8,377,364
United States,	1881	4,144,254
Germany,	1881	2,863,400
France,	1881	1,866,438
Belgium.	1881	622,288
Austro-Hungary,	1880	448,685
Sweden,	1880	399,628
Luxembourg,	1881	289,212
Russia,	1881	231,341
Italy,	1876	76,000
Spain,	1873	73,000
Turkey,		40,000
Japan,	1877	10,000
All other countries,		46,000
Total,		19,487,610

In effect, Great Britain produced nearly 43 per cent. of all the iron made in the world; the United States, 21.3 per cent.; Germany, 14.9 per cent.; France, 9.2 per cent.; and all other countries, 11.6 per cent. The four countries which produced 88.4 per cent. of the world's supply of iron are the foremost in power, in wealth, in literature, and in science, and the two English-speaking nations produce nearly two-thirds of the whole. The United States consumed 29 per cent., and Great Britain, 23.4 per cent. of the whole. The total amount consumed by two nations alone thus being 52.4 per cent.—*The Iron Age.*

Duty of the Steam Engine.

"To obtain the possible mechanical duty of the theoretically perfect steam engine, we must know first the absolute heating value of pure coal (carbon). This factor has been carefully calculated by several eminent experimenters, who have determined that if the entire quantity of heat given out in the combustion of one pound of pure carbon could be directly transmitted without loss to water, it would be sufficient to raise the temperature of one pound of water 7,900° of the Centigrade scale. Having this element at hand, it is now easy to calculate the possible duty of the perfect steam motor. We need only determine the mechanical equivalent of the thermal value of a pound of pure coal, to learn the possible duty of the steam engine. This is found by multiplying the thermal equivalent of coal by the figures representing the mechanical equivalent of heat —namely, $7{,}900+1{,}390=10{,}980{,}000$. This result represents foot-pounds. To convert these figures into horse-power, which is a more familiar expression, we divide them by 33,000; and we shall have as a result that one pound of pure coal burned in one minute in the perfect boiler, and utilized without loss in the perfect engine, should yield us in the form of work $\frac{10{,}980{,}000}{33{,}000}=332$ horse-power during one minute; or if burned during one hour, then one-sixtieth of 332, or $5\frac{1}{2}$ horse-power, per hour. This is what the theoretically perfect steam engine should yield. In actual practice the average steam engine (using the term to indicate the entire mechanism) requires from three to four pounds of coal to develop a horse-power; and the best forms of engine, representing the most approved construction, require from two to two and one-half pounds of coal per horse-power, showing that in reality we have as yet only been able to realize about 15 to 20 per cent. of the theoretical value of our fuel. The chief elements of loss are imperfect combustion, imperfect utilization of heated gases, radiation and conduction of heat to surrounding objects, and friction. By the use of steam of much higher pressures than is at present the custom, and by the further development of the use of steam expansively, there is no doubt that our engineers will in time approach much more closely to what theory shows to be possible, than they have thus far succeeded in doing."

The above, which we clip from an exchange, is being quite extensively copied by other papers, some of which ought to know better than to let it pass without criticism. The statement contains serious errors, which are surprising considering the source of the article. At the same time it looks plausible enough to deceive the average reader, who has only a superficial knowledge of the matter.

The very serious error we refer to is the statement that the steam engine theoretically yields $5\frac{1}{2}$ horse-power with one pound of coal per hour. Theoretically it does nothing of the sort. Theoretically the efficiency of the steam engine depends upon the range of temperature through which the steam may be used. We know that the superior limit of this temperature cannot much exceed 500 degrees, or our engine will be ruined. Theoretically we also know that the inferior temperature cannot be less than 212 degrees in a non-condensing engine, nor less than about 100 degrees in a condensing engine. Theoretically we also know that the latent heat of steam, which forms a large percentage of the total heat cannot be utilized by expansion, and must *necessarily* be nearly all wasted. If we make a few simple calculations, we shall find that theoretically if we use steam of 120 pounds per square inch absolute pressure, in a non-condensing engine so perfect that there is no loss by imperfect combustion, imperfect utilization of heated gases, radiation and conduction of heat to surrounding objects, or friction, the utmost power that can be developed by one pound of coal per hour will be $\frac{9}{10}$ horse-power, or 1 horse-power with $1\frac{1}{10}$ pounds of coal; if our pressure is 80 pounds absolute, the utmost would be 1 horse-power with $1\frac{3}{8}$ pounds of coal. With a condensing engine the result would be somewhat better; in the first example 1 horse-power would be developed by $\frac{6}{10}$ of a pound of coal, not less. This is true theory.

In connection with this subject the following from Prof. Cotterill's Treatise on the steam engine may not be out of place: "It appears that, with such temperatures as can be made use of in practice, two-thirds of the whole heat expended is *necessarily* wasted, and thus the low efficiency is in great measure accounted for. The statement is still not unfrequently made that the actual expenditure of heat in steam engines is ten times the theoretical expenditure; but in any legitimate sense of the word 'theoretical', it would be much nearer the truth to say three instead of ten." H. F. S.

AN interesting experiment on the transmission of power by electricity was made at the Munich Electrical Exhibition recently. Two Gramme dynamos were used, one located in Munich and the other at Meisbach, 35 miles distant. They were connected by an ordinary galvanized iron telegraph wire $4\frac{1}{2}$ millimetres or about one-sixth of an inch in diameter, being, in fact, a telegraph line placed at the disposal of the experimenters by the German Telegraph Administration. A second wire was used instead of the earth for the return circuit. The total resistance of the wire was 950 ohms. The resistance of each dynamo was 470 ohms. The total resistance of the working circuit was therefore 1,890 ohms. When the generator at Meisbach was driven 2,200 revolutions per minute, 1,500 revolutions per minute were obtained on the receiving dynamo at Munich. The percentage of power utilized at this distance was therefore $\frac{1500}{2200}$ = over 60 per cent. of that expended, and at the time of the experiment a heavy rain was falling, which must have considerably impaired the insulation of the line.

Weight of Men and Women,

WEIGHED AT THE TENTH CINCINNATI INDUSTRIAL EXPOSITION, OCTOBER, 1882.

It will be remembered that permission was given the Department of Scientific and Educational Appliances to employ a clerk to record the weights of men and women being weighed on scales in the exhibit of the Howe Scale Company. The sheets containing the record have now been added up, and the committee reports as follows:

The object sought was a determination of the average weight of men and women, a fact often required by civil and mechanical engineers. Haswell states that the average weight of 20,000 men and women, weighed at Boston in 1864, was—men, 141½ pounds; women, 124½. We have always thought these weights too low for Western people. The number weighed at the Tenth Cincinnati Industrial Exposition was 22,155,

And the total weight, ...		3,072,306 lbs.
Men weighed	7,467, weight	1,150,108 "
Women weighed	14,688, "	1,922,198 "
Averaged weight of men, ...		154.02 lbs.
" " women.		130.87 "

For men this is 12.52 lbs. higher than the Boston average, and for women 6.37 lbs. higher.

We also determined with reasonable certainty the average weight of people from the country, independently of the general average. This was rendered possible by the excursions that were coming here at various times from this and the adjoining States, parts of which were weighed.

FOR OHIO.

Average weight of 141 men was	157.38 lbs.
" " 179 women was	133.26 "

FOR SOUTHERN INDIANA AND ILLINOIS.

Average weight of 124 men was	158.52 lbs.
" " 193 women was	133.55 "

FOR KENTUCKY.

Average weight of 114 men was	158.43 lbs.
" " 188 women was	133.76 "

The mean of these averages is so much above the general average as to attract attention. For men it is 4.09 pounds higher, and for women 2.65 pounds. The very high and approximate average of these from Southern Indiana and Illinois and from Kentucky, recalls the Kentucky origin of the former.

We are under obligations to the proprietors of the scales for furnishing assistant weighers, thus enabling the work to proceed continuously.

W. A. COLLARD, *Chairman.*

CINCINNATI, Nov. 1, 1882.

—*Cincinnati Artisan.*

A PAPER in the *Revue Scientifique* on the railways of Europe, gives a number of interesting data. In 1840, America had 2,800 miles in working; England, 1,275 miles; France, 310 miles; Germany, 290 miles; Belgium, 200 miles; Austro-Hungary, 89 miles; Russia, 16½ miles; and Holland, 11 miles. In 1860, the United States possessed nearly as many miles of track as the whole of the European system, having 30,460 miles, against a European total of 31,700 miles; England was a long way ahead of Germany in the length of her system, and France was much behind. In 1870, these conditions were altered. During the ten years the European systems had more than doubled their mileage, which then had a total of 64,700 miles, America having at the same time 52,-450. England still retained the lead in Europe, and Germany and France followed her at a considerable distance, Germany being very little in advance of France. In 1878, Germany possessed a much longer system than England, having 19,260 miles against 17,100 in England. On December 31, 1878, Europe had 98,060 miles of track; the United States, 81,650; India, 7,530; Canada, 7,890; and Algeria, 465 miles. The United States had much the greatest mileage in proportion to the population, having 1 mile to every 476 persons; Canada came next with 1 mile to every 606 people. In Europe, Sweden took the lead with 1 mile to every 1,538 inhabitants, while England had but 1 mile to every 1,876 inhabitants, or only about one-fourth as much track per inhabitant as the United States. The number of locomotives running at that time over all the lines referred to was 30,079, representing a power of 10,000,000 horses.

Art Castings in Iron.

A new departure of great interest has recently taken place in iron founding. This is the reproduction of various art works in iron castings. Shields ornamented with repousse work, helmets ornamented in relief, medallions, plaques, and Japanese bronze trays have been used as patterns, and successfully copied.

The work has been done in an iron foundry in Chelsea, Mass. The most delicate patterns have been successfully followed. One large shield represents the siege of Troy, and is a copy of Cellini's shield. The numerous small figures are brought out clearly, and defined with precision. The shield is 22 in. by 28 in., and is colored to represent bronze. This bronzing is produced by copper deposited by electricity. Another shield, heart shaped, and 22 in. by 26 in., depicts the conflicts between Jupiter and the Titans. This has the natural color of the iron. Two circular shields show Bacchus, and accompanied by a leopard. A copy of a bronze plaque with a head of Shakespeare, and a reproduction of some repousse work after Teniers are also to be seen.

A helmet elaborately ornamented with intricate designs has been reproduced from a casting made at the Ilsenburg foundries, in Prussia. Many fine castings have been made there, but there has been no attempt at classical art in the designs employed. Some antique swords with curious hilts accompany the helmet. Even more interesting are the reproductions in iron of two medallions. There are two small panels in iron, which have been "buffed" until they look like steel. One bears an exquisite flower, with its delicate grace preserved in the prosaic medium in which it finds expression. The other bears some leopards taken from antique bronzes.

A Japanese lacquer tray, with fine ornamentation, has also been reproduced in iron only a sixteenth of an inch thick. A medallion, with a head of Apollo in alto relief, is as striking as the foliage and flowers that have been executed in low relief. The bronze castings resemble beaten work in copper.

There are no especial peculiarities about the production of these castings. American iron is used, the moulds are of fine sand, and the best workmen and the greatest care are employed. The "facing" of the moulds is of dust from the beams of the foundry. Impressions are secured in the sand of the shield or panel to be cast, and the mould formed in the usual way. The casts are put under a rag-wheel, with emery to prepare them for plating. The work has been treated in different ways, being polished to show the color of the metal, bronzed, copper-plated, and oxodized, simply that varying effects might be studied. The experiments have proved that remarkable fineness can be obtained successfully in work in iron, and the art castings will now be placed on a commercial basis.—*Van Nostrand's.*

Escape Pipes for Safety-Valves.

To the Editor of The Locomotive:

I wish to call attention through the columns of your paper to the dangerous practice which some men persist in, of piping safety-valves with pipes smaller in diameter than the valve is.

This is not a new subject I am aware, but I think that it is not as well understood by some steam-fitters as it should be.

I knew of a boiler which contained nine hundred feet of heating surface and twenty-five feet of grate surface, with one safety-valve four inches in diameter, which would be large enough, under ordinary circumstances, to relieve the boiler and prevent over-pressure, but it had an escape-pipe attached which was scant three inches in diameter. The casual observer would say that was not much smaller than it should be, but when you consider that a four inch safety-valve has an area of 12.5664 square inches and that a three inch pipe has a sectional area of 7.0686 square inches, the difference is more apparent.

This valve, under these conditions, would not allow the steam to escape as fast as the boiler could generate it, but when the pipe was removed, the difficulty disappeared. In another case, a pipe was used which was about one-third the capacity of the valve. and in another the pipe was but one-quarter the size of the safety-valve, but still it was expected, in each instance, that the valve would discharge the steam as fast as it was necessary. If the law compels the steam-user to apply safety-valves to his boilers which are of ample size, to prevent accidents from over-pressure, and the engineers know them to be in good working order, of what use are they if they have escape-pipes attached which are so much smaller than the valves?

If it is necessary to pipe them at all do not fail to use pipes that are as large as the valve calls for.

W. H. Wakeman, Jr.

Westville, Conn.

Notes and Queries.

W. H. W., Jr., Westville, Conn., inquires:—

First. If an automatic engine can do a certain amount of work with 40 pounds steam pressure, cutting off at one-half stroke, what will be the theoretical economy in using steam at 80 pounds pressure, and cutting off shorter accordingly?

Ans. About 67 per cent., neglecting clearance, and cylinder condensation.

Second. Is there any difference in point of economy whether there are three gauges of water or only one in a steam boiler, provided that one gauge will cover the tube eight inches deep?

Ans. One gauge would have a slight advantage in economy.

Third. Is it possible for a boiler to become so filled with grease from the exhaust steam, and sediment from impure feed water, as to cause it to prime bad enough to blow a cylinder-head off, provided the clearance in cylinder is very small?

Ans. Yes.

According to the *Coal Trade Journal* the largest vein of coal in the world has recently been discovered in what was the Ute Indian reservation in Colorado. It covers 1,600 acres of land; the coal is semi-bituminous, of jet black color, and almost entirely free from sulphur. It will smelt iron without coking, having been used by miners in the neighborhood for dressing their steel tools, and found superior to charcoal for that purpose.

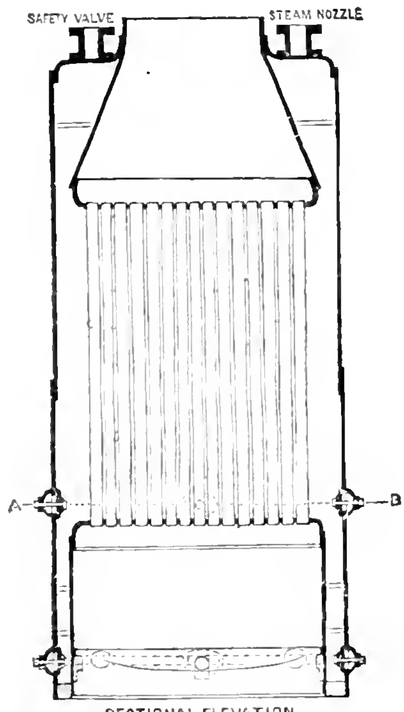
The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

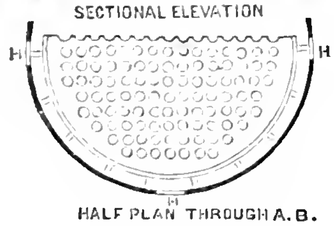
NEW SERIES—VOL. III. HARTFORD, CONN., DECEMBER, 1882. No. 12.

Upright Tubular Boilers.

In the November issue of the LOCOMOTIVE, the ordinary Upright Tubular Boiler was described and illustrated. We called attention to defects in construction, as the boiler is usually made, viz., no provision for removing the sediment which collects in the water-legs, and on the lower tube or crown-sheet, also the neglect of proper staying of the sheets surrounding the furnace. There is another difficulty to which this type of boiler is liable. The upper ends of the tubes being unprotected by water get overheated, and the expansion resulting, together with the contraction from variations in temperature, augmented by cold feed-water (heaters being rarely used with this type of boiler), cause leaks around the tubes in the upper tube-sheet, making it necessary to expand or repair the tubes frequently. To obviate this latter difficulty, the type of boiler illustrated below is recommended.



SECTIONAL ELEVATION



HALF PLAN THROUGH A. B.

It will be seen that the upper tube-sheet is independent from the shell, but connected with a smoke-flue or uptake, which is largely below the upper head, and within the boiler. The water-line in this boiler can be maintained a little above the upper tube-sheet, thus entirely submerging the tubes, and removing the liability to overheating them at this point. By properly proportioning the parts, there will be no lack of steam-room. This boiler has given entire satisfaction where used, is economical for boilers of the upright type, and economical in repairs. We will add that the smoke-flue or uptake should be stayed to the shell of the boiler as shown in the illustration.

Inspectors' Reports.

OCTOBER, 1882.

There were made during the month of October last 2,333 visits of inspection, by which 5,044 boilers were examined. Of this number 1890 were thoroughly inspected, both internally and externally. The number of defects found foots up 3,718, of which 612 were considered dangerous. 453 boilers were tested by hydrostatic pressure, and 36 were condemned as unfit for further service.

The detailed statement of defects is as follows:

Nature of defects.	Whole number.	Dangerous.
Cases of deposit of sediment,	293	30
Cases of incrustation and scale,	469	25
Cases of internal grooving,	24	5
Cases of internal corrosion,	98	17
Cases of external corrosion,	222	41
Broken and loose braces and stays,	37	11
Defective settings,	124	9
Furnaces out of shape,	102	11
Fractured plates,	113	58
Burned plates,	118	35
Blistered plates,	294	32
Cases of defective riveting,	754	39
Defective heads,	37	12
Cases of leakage around tubes,	402	151
Cases of leakage at seams,	278	53
Water gauges defective,	79	15
Blow-outs defective,	32	10
Cases of deficiency of water,	9	3
Safety-valves overloaded,	28	14
Safety-valves defective in construction,	26	10
Pressure gauges defective,	175	30
Boilers without pressure gauges,	4	1
Total,	3,718	612

Leakage at the girth seams, and around the tubes of externally-fired horizontal tubular boilers, is one of the defects most often found, and one which is sure to become very serious in a short time if not attended to, for it induces corrosion in one of its most dangerous forms. There is nowhere to be found a better illustration of the truth of the old saying, "a stitch in time saves nine," than in this matter; and also no better illustration of the economy and value of proper care and management for steam boilers.

Leakage at the seams of boilers may be induced by a variety of causes, of which we need mention here only two,—bad workmanship and bad management.

When the defect is due to bad workmanship, the only help for it is, generally, to dress and recaulk the edges of the plates. Sometimes, though not often, it will be necessary to cut out the old rivets, insert new ones, and then dress and recaulk. This also is generally necessary when a boiler has been overheated, through shortness of water, or otherwise. Sometimes too much lap is given the plate, when it becomes impossible to properly caulk the seams. The writer has in mind now a certain rotary bleacher, whereon the plates lapped *four inches* beyond the rivets. The result may be imagined. Obviously the only remedy in such a case is to reduce the lap.

Leakage is often induced by feeding cold water into a boiler, and delivering it close to the hot plates over the fire. Severe local contraction is thus caused, which no material can resist, and leakage is sure to follow. The solid plates of the shell are very frequently fractured in this manner. Where the use of cold water is unavoidable, the boiler should always be provided with a circulating feed pipe, as a means of economy and safety.

In too many cases, however, the seams are shaken by the habit, which prevails extensively, of pulling the furnace doors wide open, without closing the chimney damper. This is a very common way of checking the generation of steam, when there is a lull in the demand for it from any cause, and cannot be too strongly condemned. The effect of a large body of air some hundreds of degrees colder than the furnace and boiler, rushing along the under side of the shell, is sufficient to loosen the best joint that ever was made, and in many cases it has fractured the shell through the solid plate. The effect of this is even more marked with some types of internally-fired boilers, such as the "drop flue," for instance, than it is with the common return tubular boiler.

Another fruitful source of damage to boilers, and one which has ruined thousands, is the practice of blowing a boiler off and immediately refilling it with cold water, while the brickwork is red hot. Nothing will tear a boiler to pieces quicker than this. Boilers have exploded with disastrous effect from this cause, hours after the fire had been drawn. Probably most persons, not familiar with the matter, would be surprised to know the pertinacity with which cold water will cling to the lowest point of a boiler under these circumstances. Local contraction of such severity is thus induced, that nothing can withstand its effects, and a few repetitions are generally sufficient to ruin any boiler.

Enameling Cast-Iron Water-Pipes.—Two inventors in Bohemia are said to have patented a process for enameling cast-iron water-pipes, which can be applied to other hollow castings that are made with cores. It consists in simply covering the sand core with enamel, and then pouring in the iron as usual. The heat of the melted iron fuses the enamel, which attaches itself firmly to the iron, and detaches itself so completely from the sand that the enamel is said to be all that can be desired for water-pipes and other industrial purposes. In casting sinks, basins, urinals, etc., the enamel can be applied to the sand on that side of the mold which is to form the inside of the basin. The composition of the new enamel is kept a secret, but it is said to differ from the old form in the simplicity of its preparation and the extraordinary cheapness of the materials used. In color this new enamel is gray. It will be useful for gas-pipes and soil-pipes, as well as water-pipes, because it will make the pipes absolutely tight by a glassy lining.—*The Ironmonger.*

A railway carriage painted inside with the Balmain phosphorescent paint is included in one of the trains between London and Rotherhithe, *via* the Thames tunnel. Although only one-half of the available space of the carriage is painted, the phosphorescent light is quite sufficient to enable the passengers to distinguish small objects when passing through the tunnel; and, moreover, the light is powerful enough to enable a person to read the indication of an ordinary watch. It is probable that the railway companies will be enabled to effect a considerable saving in gas and oil by using the phosphorescent paint.—*Boston Advertiser.*

The Locomotive.

HARTFORD, DECEMBER, 1882.

With this issue Vol. III of the New Series of THE LOCOMOTIVE closes. It has been our endeavor to furnish our readers with facts and information that will be valuable not only for present use, but for reference. We have avoided the introduction of fruitless discussions into our columns. Where a great variety of opinions or theories are expressed, the seeker after information which his needs require, is confused and discouraged. One writer of acknowledged reputation says one thing, while another of recognized ability takes him to task, and aims to refute his statements, and recommends something entirely different. Which is right? Are the controversialists practical men? What the manufacturer wants is reliable information; something he can put in practical use in his own mill. Our aim has been to furnish such information to our readers on the subjects treated in our columns. When we know, from repeated trials, that this or that practice gives good results we are ready to recommend and advise their adoption. We would not undervalue the benefits of discussion, for through discussion light is obtained, but discussion without some good practical result is valueless. It may be racy reading, but if nothing is proved it is fruitless.

We do not claim infallibility on the question of boiler construction, setting and management. But we do claim that the care of 17,000 boilers scattered over the country, of almost all known types, under all conditions of use, with all kinds of fuel and qualities of water, gives us opportunities of studying their comparative merits or demerits, economy, efficiency, and adaptability which are afforded to few if any engaged in other occupations. It is our purpose to continue the discussions bearing upon boiler construction, boiler settings, and boiler explosions—the cause and prevention of the latter. The records of inspection will be kept up, and our readers will be furnished with a summary of these reports, with comments thereon, that cannot but be useful to all who have to do with boilers. The question of economy in all manufacturing establishments is becoming such a vital one that great attention is being given to the consumption of fuel. But in the desire to provide an economical boiler do not place too much reliance upon the published reports of comparative tests. It should be understood that such tests are made under the most favorable conditions, such conditions as are rarely if ever found in actual use. These tests may give some indication of comparative efficiency, but should not be accepted as to the efficiency of the boiler in actual use in the mill. Much might be said on this point, but we leave it to some future issue.

THE LOCOMOTIVE has now reached a monthly circulation of over (10,000) ten thousand. It is much sought by engineers and manufacturers, and it will be our aim to make it in the future even more valuable and interesting if possible than in the past.

Knowledge says: Some speculative merchants in Bergen have obtained the right of cutting block ice for export from the enormous glacier Fon or Svartisen (60° 25′ north, 35° 15′ east), on the Senjen Island in Norway, the northernmost of its kind in Europe. The quality of the ice is good. The glacier is about 120 square miles in extent, and the distance from the border of the sea only two miles. A similar attempt to utilize the glacier Folgefonden was made some years ago, but failed, owing to the blocks in their downward course breaking through the wooden conductor in which they were slid down to the sea.

The articles entitled *Unclassified Data*, which are being published in the Locomotive, were handed to us by J. H. Cooper, who is well known to our readers. They are notes jotted down by Mr. Cooper in his researches and readings running over a period of many years, and are convenient for reference when the authorities quoted are not at hand. One noticeable feature is the wide divergence of opinion on some points among men who are eminent in the profession of mechanical engineering. It shows that the requisite data for exact truth has not yet been found, and they probably never will be found until iron or material of known and uniform quality can be produced the world over. We would say further, and not until workmanship is uniformly first-class in every particular. We do not publish these data as our own views, and from many of them we dissent. They are not in accord with the best American practice.

The *Nautical Gazette* (English) says that during the year 1881 the vessels lost at sea averaged about one every twenty-four hours. A large proportion of these losses occurred from carelessness, and mostly from fogs and other darkness. There were 400 ocean-steamer collisions in 1879 and 1880 in the North Atlantic alone. Each of these might have been avoided if the master of one colliding vessel had been informed in proper time of the course pursued by the approaching one. These accidents give an average of over one steamer a day in which human life was sacrificed and valuable property destroyed. The *Gazette* believes that if a system of Fog Signals had been in use, such as the Barker Code, nearly all of these disasters would have been avoided.

A frog was recently found in the middle of a 250-pound cake of ice at New London, Conn. After lying in a pail of water for a few moments, it showed signs of life, and was soon very lively. The ice in which the frog was imprisoned was cut in February, so that he must have been frozen some seven or eight months.

Prof. C. W. C. Fuchs announces that the total number of recorded earthquakes for 1881 is 297; volcanic eruptions, 10, the most important being that of Mauna Loa in Hawaii.

The Transit of Venus.

The following article is from the *Hartford Times* of December 5th, and is so clear an explanation of the Transit of Venus and its importance, that we are pleased to give it to our readers. It was written by Prof. John Brocklesby of Trinity College.

What is meant by the transit of Venus?

When the planet Venus, in her motion around the sun, comes between the earth and the sun, her passage across the face of the sun is called a *transit*.

As Venus shines only by the light which she receives from the sun, the side which she then presents to the earth is in shadow; and during a transit, she appears as a black spot moving across the sun.

Why are observations on the transit of Venus deemed of such importance by astronomers?

Because by means of these observations a certain measurement can be obtained, which enables them to determine the distance of the sun from the earth. This measurement is the angle contained between two imaginary lines, one drawn from the sun to the center of the earth, and another drawn from the same point on the sun to the earth, touching its surface; or what is the same thing, the apparent angular breadth of half the earth's diameter (radius) as seen from the sun.

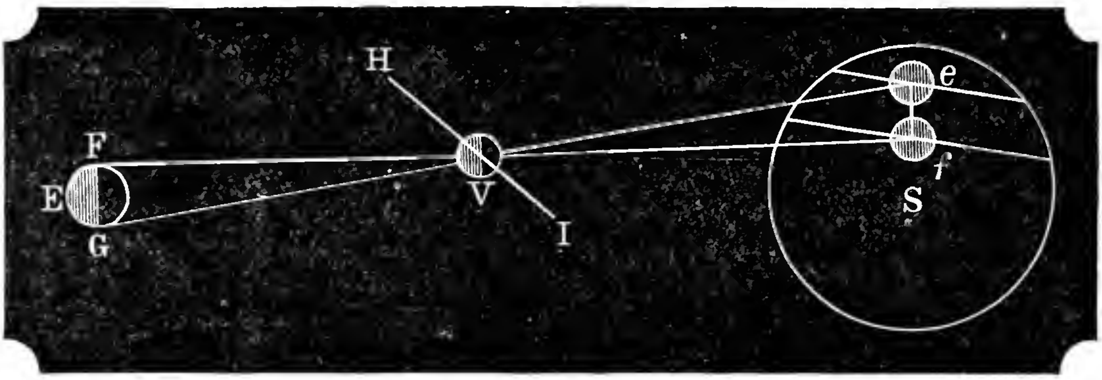
How is this angle found?

Before answering this inquiry it is necessary to form an idea of what an angle is, and how angles are measured. An angle is the opening between two straight lines that meet at the same point; and the following explanation will serve to show how they are measured. If we take the wheel of a bicycle, the opening between any two spokes meeting at the center is *an angle*, and it is measured by the space on the rim between the spokes. If there were 360 spokes, at equal distances apart, the angle between any spoke and the next is called a *degree*.

If this angle is divided into 60 equal parts it is termed a *minute;* and the 60th part of this is a *second*.

If a human hair were placed about fifty feet from a person, two lines drawn from the opposite sides of the hair to the same point in the eye of the observer would make an angle of *one second*—and the breadth of the hair is a measure of the angle, at the distance mentioned.

The angle sought by the astronomers is found in the following way: In the figure here shown let E, V, and S, represent the relative positions of the Earth, Venus, and the Sun, when a transit occurs; H, V, I, a portion of the orbit of Venus; and F G a diameter of the earth, perpendicular to the plane of the earth's orbit.



If at the time of the transit one observer is placed at F, and another at G, the observer at F will see Venus in the direction of F V, appearing as a dark spot on the sun at *f*, and, at the same time, the observer at G will see the planet in the direction of G V on the sun at *e*. If the observers watch the planet during the whole time of the transit, the path of the planet to the observer at F will be the line running through *f*, and to the one at G the parallel line running through *e*.

Now the first thing to be determined from these observations is the relative values of the lines F G and *e f*.

It was discovered by Kepler that there is such a relation between the *distances* of the planets from the sun, and their *times of revolution* about it, that when the latter are known, the relative distances can be computed, and vice versa. The times of revolution have been observed with the greatest exactness—within a fraction of a millionth part of the whole period.

It is ascertained that, when a transit occurs, the distance of Venus from the sun is 2.6 greater than her distance from the earth; that is, the line V *e* is 2.6 greater than V G. And from the geometrical relations of the triangle F V G and *e* V *f*, it follows that the line *e f* is 2.6 greater than F G; and as the number of miles in F G (the earth's diameter) is known, the value of *e f* can be computed, and is found to be about 20,600 miles.

The next step is to find the angular value of the line *e f*, as seen from the earth. The time that Venus occupies in making her circuit about the sun is accurately known, and, in consequence, the time she takes to describe any small angular motion, as a minute or a second, is also known. We have the same knowledge, likewise, in respect to the sun's observed motion.

Having this knowledge, the observer at F, noting very exactly the *time* it takes for Venus to pass across the Sun through the line at *f*, thereby knows the number of angular seconds she has described in that part of her orbit represented by the line through *f*.

The observer at G ascertains in the same way the number of angular seconds on the parallel line that passes through *e*. The angular diameter of the Sun can be measured by instruments, and from these three known quantities, we can, by a simple geometrical calculation, find the number of seconds in the line *e f*.

We have already found the number of miles in the line *e f*, and dividing this number by the number of seconds in *e f*, we find that the linear value of one second at the sun is about 462 miles—that is, if, at the distance of 50 feet from the observer, two lines, which form an angle of one second, are separated only by the breadth of a human hair, if extended to the sun, would be 462 miles apart.

The same would also be true if the observer was on the sun and the lines extended to the earth. An angle therefore of one second at the sun, covers on the earth a space of 462 miles, consequently the radius of the earth (3,963 miles nearly) divided by 462 will give the approximate angle formed by two lines drawn from the same point on the sun to the earth; one touching its surface and the other extending to its center. This angle from the latest computations varies but little from eight seconds and eight-tenths of a second (8.8). It is called the solar parallax.

Now if we suppose a line drawn from the point where the first line touches the earth to its center, a right-angled triangle is formed, and we now know enough of the value of a sufficient number of its parts (viz., angles and sides) to compute the length of the line drawn from the earth's center to the sun—the solar distance. This could not have been computed from the triangle unless the parallax had been first obtained. The distance of the earth from the sun, as at present known, is somewhere between 92,570,000 and 93,000,000.

In this explanation we have supposed for convenience that the observers were stationed at the poles of the earth, a little less than 8,000 miles apart; but those stations are not necessary in order to obtain the angle sought; all that is required is, that the stations should be as far apart as possible, so as to obtain a wide interval between the paths at *e* and *f*.

In the last transit of Venus, in 1874, among other stations, one was in Siberia and another in New Zealand. Among those selected for December 6th of this year, one has been chosen by the Brazilian government at the Straits of Magellan, another at Pernambuco, and a third at Rio Janeiro. England has sent an expedition, among others, to Cape Colony and Bermuda, and in the northern latitudes. Hartford is the station selected by the German government. France also joins in the observations, and our own astronomers have four northern and two southern stations. Washington, D. C., is one of them and Santa Cruz in Patagonia another. May the skies be propitious. J. B.

Unclassified Data.

BY J. H. COOPER.

"By the limit of elasticity is generally meant, as is well-known, the least load by which a permanent alteration of form is effected."—*Styffe*, p. 27, London, 1869.

* * * At higher temperatures, between 212° and 392°, the absolute strength of iron

is considerably greater than at ordinary temperatures, as Fairbairn found in his experiments. See "Useful Information for Engineers, 2d Series, p. 288." No change in tensile strength of wrought iron from zero to 400° Fah.

"Between zero and 550 Fah. the engineer need make no provision for effect of difference of temperature."—*Barr on Steam Boilers*, p. 147.

"As riveted joints destroy the elastic homogeneousness of the boiler, the waves of expansion, contraction, and vibration are arrested there by the greater rigidity of the riveted double-thickness of metal, which tends to localize the fatigue sustained by the iron near these points, and it also appears to increase the susceptibility to corrosive action, since the furrows generally take the line of that fatigue, and are often deeper than the spots on the plates."—*Report of the Board of Trade (English), on Railway Accidents*, 1855, p. 49.

U. S. Government Rules For Steam Pressures upon Boilers. To be applied to boilers made since February 28, 1872:

"Boilers, however, built of steel plates prior to this date, shall be deemed to have a tensile strength of 75,000 lbs. per square inch, whether stamped or not."

"Multiply one-sixth the lowest tensile strength stamped on any plate in the cylindrical shell, by its least thickness in inches, and divide by the radius of the boiler in inches, the result is the allowable pressure per square inch for single riveting, to which add 20 per cent. for double-riveting.

"The hydrostatic test must be one and a half times the working pressure allowed.

Flues of 16 inches diameter must not be less than one quarter inch thick, other flues in proportion, and not less than three inches from the shell.

"A 42 inch boiler, single riveted of one-fourth inch iron, will safely bear a working pressure of 110 pounds to the square inch, and must be tested to a hydrostatic pressure of 165 pounds to the square inch."

The Messrs. Wm. Crump & Sons, Iron Ship Builders and Boiler-makers of this city* use the following proportions for the single-riveted joints of their boiler-plates.

PROPOPORTIONS OF SINGLE-RIVETED JOINTS.

Thickness of Plates.	Diameter of Rivets.	Pitch.	Lap.
$\frac{1}{4}$ inch,	$\frac{1}{2}$ inch,	$1\frac{1}{2}$ inches,	$1\frac{1}{2}$ inches.
$\frac{5}{16}$ "	$\frac{5}{8}$ "	$1\frac{3}{4}$ "	$1\frac{7}{8}$ "
$\frac{3}{8}$ "	$\frac{11}{16}$ "	2 "	$2\frac{1}{8}$ "

D. K. Clark gives the breaking strength of boiler-plates as follows:

QUALITY OF PLATE.	Breaking Strength in Tons.	Breaking Strength in Pounds.
Best Yorkshire, ...	25	56,000 lbs.
" Staffordshire, ...	20	44,800 "
" American, ...	31	69,440 "
Ordinary American, ...	27	60,480 "

* Philadelphia, Pa.

"Prof. Thurston, testing pieces of the wire cable of the Fairmount Suspension Bridge recently taken down at Philadelphia, after being in use about forty years, found the iron to be fully equal in tenacity, elasticity, and ductility to the best wire of the same size found in the market. This fact, and similar results obtained by other experiments in 1878, led him to the important conclusion that iron subjected to the ordinary strains of properly designed bridges, does not deteriorate with age."—*American Machinist, New York, July* 31, 1880.

John Anderson, Woolwich, 1872, p. 249:

"The three kinds of materials for boiler-plates stated in even numbers for tensile strength are thus:

Steel,	90,000 lbs per square inch.
Iron,	50,000 " " " "
Copper,	34,000 " " " "

"The strength of iron in boilers is not much affected by the working temperatures up to considerably over 400°, nor by low temperatures down to the freezing-point. But when the temperature of the plates, through the absence of water or any other cause rises much above 500°, then a change commences. Above 750° the tenacity diminishes very rapidly, and when the plates become red-hot, they have lost fully the half of their usual strength."

D. K. Clarke, Tables and Rules, p. 640, concludes—"The tensile strength of iron plates of good quality is not materially impaired by punching, when done under proper conditions."—p. 633. "Mr. J. Cochran found from experiments no loss by punching."

Wilson, on Steam Boilers, p. 63, says, "Rivet holes may be punched or drilled. Both methods have their partisans—not decided by experiment which is best."

"Steam Boilers." W. H. Shock, Engineer in Chief, U. S. N:

p. 78—"C. H. No. 1 shell iron will bear in the testing machine from 50,000 lbs. to 54,000 lbs. of tensile strain per square inch in the direction of the fibre, and from 34,000 lbs. to 44,000 lbs. across the fibre. . . . It is used especially for the outside shell of boilers."

p. 139—"The tensile stress exerted by the maximum steam-pressure on any part of a boiler should not exceed one-sixth of its ultimate strength. This factor of safety is usually employed for parts of machinery subjected to the alternating stresses acting in opposite directions. The steam pressure in a boiler cannot be considered as a quiescent load, on account of the constantly occurring, and sometimes considerable fluctuations of pressure due to various causes."

p. 140—"It must be remembered that the strength of any structure is to be measured by that of its weakest part, which in the case of boilers is the joint where the sheets are connected."

p. 190—"The experiments made by Fairbairn in 1838, have served, up to the present time, as the basis of calculating the strength of riveted joints. According to these experiments, the strength of a double-riveted joint is 70 per cent. of the strength of the plate; and of a single-riveted joint 56 per cent.—Of these experiments it is necessary to remark:

"1st. That the results are only for the case in which the rivet-holes diminish the section of the plate 30 per cent., while for the most part in practice, and particularly for the single-riveted joint, that loss is very much greater.

"2d. That the experiments were made on plates of only 0.224 inch thickness.

"3d. That the experiments gave 46, and not 56 per cent., for the strength of the single-riveted joint: the co-efficient was arbitrarily increased by Fairbairn to cover certain imperfections in the experiments."

D. K. Clarke, Tables and Rules, pp. 636:

"Experiments on various plate-joints made by W. Bertram, at Woolwich Dockyard, were published and discussed in 1860. The thickness of the plates were $\frac{3}{8}$ inch, $\frac{7}{16}$ inch, and $\frac{1}{2}$ inch, and in the single-riveted joint the net sectional area of the plates in the line of rivets was 62.5 per cent. of the solid plate. The relative strength of the joints of the $\frac{3}{8}$ inch plate is given by him as follows:

Entire Plate, ...	100
Double-riveted Joint, ...	72
Single-riveted Joint, ...	60

p. 203—"The following table of the comparative strength of punched and drilled rivet-work, containing the results of Kirkaldy's experiments, is taken from the "Proceedings of the Mechanical Engineers for 1872," in a paper read by W. R. Browne.

Lap Joint.	Rivet Holes.	Diameter of Rivets to Thickness of Plates.	Lap or Cover to Diameter of Rivets.		Pitch to Diameter of Rivets.	Ratio of Strength of Joints to that of Plates. Per cent.
Single.	Punched.	2	3		3	55
"	Drilled.	2	3		$2\frac{3}{5}$	62
			Chain.	Zigzag.		
Double.	Punched.	2	$5\frac{1}{2}$	6	$4\frac{1}{2}$	69
"	Drilled.	2	5	$5\frac{1}{2}$	4	75

p. 366*—"Boilers have been tested by filling them completely with water and lighting a fire in the furnaces, the pressure being produced by the expansion of the water.

p. 448—"In nearly every case in which severe overheating of portions of the boiler has taken place previous to an explosion, it is reasonable to suppose that the loss of strength in the overheated plates, or their strained condition when suddenly cooled off, would be sufficient to cause rupture even with the ordinary working pressure, and while an increase of pressure produced by the sudden vaporization of a certain quantity of water, and a violent projection of water may have occurred simultaneously, and to a certain degree intensified the disruptive force, it is the weakened condition of the boiler which must be regarded as the primary cause of the explosion."

PHOTOGRAPH OF AN EXPLOSION.—The United States engineers recently photographed the explosion of a wreck, which was blown to pieces by submarine charges of dynamite, to ascertain, among other things, how long the spectacle really lasted. The result was exceedingly interesting. There were six cameras employed, and the instant of the explosion, as also the several instants when the exposures were made by shutter, were electrically timed by a chronograph. A photograph taken one-tenth of a second after the explosion showed the vessel broken and a column of water seventy feet high; a photograph secured 1.5 seconds after the instant of the explosion showed a column of water one hundred and sixty feet high; a third photograph, taken 2.3 seconds after, showed the column at its full height of one hundred and eighty feet, while fragments of wreckage were in the air, but none had fallen to disturb the surface of the water; a fourth picture, taken 3.3 seconds after, showed the column falling and the surface of the water disturbed; while a fifth photograph, secured 4.3 seconds after, showed that all was over.—*Cincinnati Artisan.*

*This experiment to be safe, must be conducted as described, by filling the boiler completely with water. We know of a case in which the boiler was only partially filled, fires were lighted, and a steam pressure generated sufficient to explode the boiler, and kill the unfortunate experimenter.—EDITOR LOCOMOTIVE.

Useful Notes on Specific Heat for Engineers and Firemen.

The specific heat of any substance is the quantity of heat expressed in *thermal units* which must be transferred to a pound of the substance to raise its temperature 1° Fahr.

A thermal unit is the quantity of heat required to raise the temperature of a pound of water from 39.1° to 40.1° Fahr.

The specific heat of different bodies varies greatly; it is therefore necessary to select some convenient substance and make its specific heat a standard by which that of other bodies may be compared. *Water* is the most convenient substance for this purpose, therefore it has been selected for such a standard, and the amount of heat required to raise the temperature of a pound of it 1° Fahr., has been fixed upon as the standard by which all quantities of heat shall be compared.

The reason why the temperature from 39.1° to 40.1° Fahr. is chosen is because 39.1° is the temperature of greatest density of water, and its specific heat, as well as that of all other substances, is different at different temperatures. Thus, it requires about one-twentieth more heat to raise the temperature of a pound of water from 211° to 212° than it does to raise it from 39.1° to 40.1°.

The following simple experiment will better serve to illustrate the nature of specific heat than volumes of explanation:

The apparatus required consists of any vessel in which water may be boiled; a common tea-kettle on a stove answers perfectly; a pound of iron, preferably in sheet form, rolled up into a loose spiral; an ordinary thermometer; and a small tin can—a common quart measure answers every purpose; around this can wrap several folds of either cotton or woolen cloth; tie a piece of twine or thread to your piece of iron, by which it can be readily lowered into and lifted out of the kettle of boiling water; lower the iron into the kettle, and leave it there until the water boils, so it may attain the temperature of the boiling water, 212°; while it is thus being heated, weigh off a pound of water and pour it into your tin can around which you have wound the cloth. This cloth is to prevent a too rapid loss of heat. When the water has begun to boil, note with your thermometer the temperature of the cold water in the tin can; lift the piece of iron out of the boiling water and quickly lower it into the can of cold water; agitate the water briskly a few moments by moving the iron about by means of the thread, until you are sure that the iron has cooled down to the temperature of the water; now note the temperature of the water with your thermometer. We will suppose the original temperature of the pound of water was 70°. If you perform the experiment quickly and dexterously you will find that the hot iron has raised it to about 84°. Let us interpret the result.

A pound of iron, cooling from 212° to 84°, or 128°, has raised the temperature of a pound of water from 70° to 84°, or only 14°. Thus we see that the *capacity for heat* of iron is only about *one-ninth* that of water. After you have performed the experiment several times, until you are perfectly sure of the result, try some other metal, lead or copper for example, and compare the results. You will find that while the capacity of iron is about one-ninth, that of lead is only about one-thirtieth, and that of copper about one-eleventh that of water. These facts are expressed by saying that their specific heats are one-ninth, one-thirtieth, or one-eleventh, that of water being taken as equal to 1.00.

The specific heats of many substances have been determined with great precision for ordinary temperatures by scientific men. An examination of a complete table teaches us many interesting things, among which we may note the following:

The specific heats of metals are low, ranging from one-thirty-third to one-sixth that of water.

Coal averages about one-fourth that of water.
Wood " " one-half " "
Stones " " one-fifth " "
The masonry of steam boiler furnaces is about one-fifth that of water.
Liquids vary from three-tenths to nine-tenths that of water.
Only one substance has a greater capacity for heat than water, viz.: bromine, 1.111.

The specific heat of a gaseous body depends upon whether it is taken with the gas at a constant pressure, or constant volume, being greater in the former case than in the latter. This, perhaps, will bear explanation.

The first law of thermodynamics is as follows: *Heat and mechanical energy are mutually convertible; and heat requires for its production, and produces by its disappearance mechanical energy in the proportion of 774 foot pounds for each unit of heat.* The law has been rigidly demonstrated experimentally.

Now it is a familiar fact that if we take a cylinder fitted with a piston perfectly free to move, introduce a quantity of any gas into it beneath the piston, and apply heat, the gas will expand as its temperature rises, and raise the piston. Now in raising the piston against the pressure of the atmosphere or any other resistance, *work* must be performed, and this work will be measured by the pressure on the piston, multiplied by the distance through which it is moved. Bearing the above facts in mind it will readily be seen that if we allow the gas to expand and raise the piston, as its temperature rises, the quantity of heat required to raise its temperature 1° will be greater than would be required if we fastened the piston down so it could not rise, in which case no work could be done, and that the extra amount required in the first case would be simply that which, converted into mechanical energy in accordance with the first law of thermodynamics, would be sufficient to raise the piston. This has been proved to be true by experiment. The true specific heat of the gas is held to be the amount required to raise the temperature of one pound of it 1° degree when it is *not* allowed to expand.

The difference between the specific heat of air at constant pressure and constant volume was taken advantage of to calculate the mechanical equivalent of heat in the following manner by Mayer, a German physician, forty years ago. Suppose we have a cylinder with a piston just one foot square. For the purpose of simplifying the calculation we will suppose the piston to be without weight, so that the only resistance to its motion is the weight of the atmosphere on top of it. The weight of the atmosphere may be taken at 2,116 pounds per square foot. Let our cylinder be of sufficient height to contain one pound of air at 32° and at the ordinary atmospheric pressure. This will occupy a volume of 12.387 cubic feet; and as our cylinder is just one foot square, our piston will be just 12.387 feet from the bottom of the cylinder. Suppose now we have a second cylinder alongside the first, exactly like it, and filled with exactly the same weight of air at the same temperature. We will secure the piston of this cylinder so it cannot move, leaving the piston in the first one to move freely. Now apply heat to the air in both cylinders until we raise its temperature 1°. The air in both cylinders now has a temperature of 33°. If we compare the amount of heat transmitted to the air in the two cylinders with our thermal unit, we shall find that the air in the first cylinder has absorbed .2377 of a thermal unit, while that in the second cylinder has absorbed only .1688 of the same quantity. What does this difference mean?

It is proved experimentally that air at 32° Fahr., when heated to 33° under constant pressure, expands $\frac{1}{493}$ of its original volume. The air in our first cylinder then has expanded and raised the piston so it now stands $12.387 + \frac{12.386}{493} = 12.412$ feet from the bottom of the cylinder, and in so doing has raised the piston against the atmospheric pressure $12.412 - 12.387 = .025$ feet. It has, therefore, performed work measured by

2,116 pounds raised .025 feet high = 53 foot pounds; which is the mechanical equivalent of the extra heat added to the air in the first cylinder. This extra heat, as we have seen, was .2377 — 1.688 = .0689 of one thermal unit.

Now, if the mechanical equivalent of .0689 of a thermal unit = 53 foot pounds, the mechanical equivalent of our thermal unit is found by the following proportion: .0689 : 53 : : 1 : 768. The exact determination of this quantity by other means gives 774 foot pounds, as before stated.

Another interesting and practically useful application of knowledge of specific heat is seen in the water pyrometer. This consists of apparatus exactly like that described in the first experiment for finding the specific heat of iron; but the conditions of the experiment are reversed. In the application of the pyrometer we have given the specific heat of the water and the iron to find the initial temperature of the iron. By using the metal platinum instead of iron we are enabled to ascertain the temperature of steam-boiler furnaces which cannot be obtained in any other manner.

A table of specific heats is given the LOCOMOTIVE for January, 1881. H. F. S.

How to Select a File.

On purchasing a file bear in mind that there are several qualities—first, second, third, and fourth. The first quality is the best, and represents about seventy-five per cent. of a file manufacturer's product. Firm names are always stamped on files before they are tempered, and if, after they are finished, any of them are found to be poorly cut, or badly tempered, the firm name is ground off and one of several fancy names, coined for all qualities below the first, is stamped on each file belonging to certain quality. Thus, if a file-maker should select the word "Jumbo" for his second quality files, all too poor for the first quality and too good for the third have "Jumbo" stamped on them. First quality files only bear the name of the maker, while fourth quality generally bear no name at all, and are seldom seen.

When you have thought of all these things ask the dealer for a first quality file, bearing the name of well-known file maker. Select the heaviest file in the box (if there is any difference in the weight of them), for a heavy file is generally truer than a light one of nominally the same size, and is better for re-cutting; a re-cut file, by the way, being just as good as a new one. Take the file to the light and hold it in a horizontal position, the point of it toward you. The teeth will now be pointed toward you, enabling you to detect easily any imperfections that a bad file is heir to. If the conformation of the teeth is irregular or uneven, or if the color of the file is not uniform, let it severely alone. A spotted or mottled file denotes unevenness of temper. If, on the other hand, the file presents a clean, white color, it denotes that the temper is even throughout; and if, besides this, it has regular and perfect teeth, and bears the maker's name, you may rest assured that it is an excellent file. The best files are tempered at a low heat. Files of certain sizes and numbers made since the 1st of June are of uniform weight, the file manufacturers of the United States having agreed upon a standard of weights and sizes.—*Age of Steel.*

Progress in Engineering.

Prof. Thurston, of the Stevens' Technical Institute, at Hoboken, N. J., delivered an address at the recent meeting of the Mechanical Engineers, in which he reviewed the state of engineering and its relation to the welfare of the community. He called attention to the importance of more full knowledge of the strength of members of full size in construction. The increasing use of steel permits the building of bridges whose span was not thought of by the last generation.

Modern methods of manufacturing in quantity and then assembling the parts together afterwards has required a corresponding precision in the processes of work, and a demand for standards of gauges and measurement. The talent and expense necessary to produce universal gauges has been furnished under government patronage in other countries, but certain members have engaged in this work at their own risk, and the enterprise of the Pratt & Whitney Company in this respect deserves the highest commendation.

In the matter of machine design the result is not a hap-hazard coincidence, but a matter of the application of engineering principles which attain the fitness of means to ends. The improvements in water-wheels at part gate was referred to as a result of great commercial importance. Milling as a process of attrition between stones has been superseded by rollers which simulate the cracking of the kernel, the same as if reduced with pestle in a mortar. Railway engineering, the applications of electricity, and the need of further improvements in controlling cylinder condensation received appropriate mention.

The address closed with a close treatment of the necessity of the law protecting industrial labor, and providing for its elevation by suitable public education.—*Chicago Journal of Commerce.*

The Coal Industry.

The total product of bituminous coal in the United States for the census year closing June, 1880, amounted to 40,311,450 tons, of 2,000 pounds to the ton, divided among the States as follows: Alabama, 322,934 tons; Arkansas, 14,778; Georgia, 154,684; Illinois, 6,089,614; Indiana, 1,449,496; Iowa, 1,422,333; Kansas, 763,297; Kentucky, 935,857; Maryland, 2,227,844; Michigan, 100,800; Missouri, 543,900; Nebraska, 200; North Carolina, 700; Ohio, 3,922,853; Pennsylvania, 18,004,988; Tennessee, 494,891; Virginia, 40,520; West Virginia, 1,702,570. The number of laborers engaged in mining this vast amount of coal was 96,475, and the wages paid them were $30,707,059. There are only two States that produce anthracite coal, Pennsylvania and Rhode Island. The former produced 28,640,819 tons, and the latter 6,175 tons during the census year. The grand total of coal produced was 71,067,567 tons, and the grand total of hands employed was 170,585. The census bulletin makes comparison with the English production. The population of England is 25,000,000. The production of coal in that country in 1855 was 64,661,401 tons; in 1877, 136,179,968 tons, and in 1880, 146,818,152 tons. The number of collieries in England in 1880 was 3,380, and in the United States, 3,264. The production of coal in England, in an area about the size of Ohio, and with half the population of the United States, is double that of this country. England is supposed to be about up to its maximum, while this country is in the infancy of its coal development. There are hardly figures enough to compute its capacity in this respect, and its production for generations to come will depend upon the demand. American manufacturing industries depend on coal, and in this respect there can be no failure. There are several States in which the deposits have been barely touched that are equal to the whole of England as coal States.—*Chicago Journal of Commerce.*

The *Iron Age* says: The published report of the Master Car Builders' Committee on standard freight and passenger car-trucks is exceedingly interesting, and the diagrams which they give of the car-truck trusses which they have tested are full of instruction to the railway man. A large proportion of those which gave out shows that the upper member of the truss is considerably too weak for the work it has to do, or rather that the lower member can be considerably lightened, while the truck remained of the same capacity. Allen trucks, with the diagonal or arch bar three-fourths inch thick, in the test crippled its upper member, while a similar truss built for the test with this member reduced to one-half inch, but with a seven-eighths inch top piece, showed pretty conclusively that this proportion was about what was needed for the work. The low truck of the Chicago, Burlington & Quincy road seems to have been the best proportioned of the lot, breaking and crippling apparently taking place simultaneously. The standard truck of the New York Central evidently needs only a little modification to make it one of the strongest of any which were tested. The tests are of such a character as will enable car builders to design a truck having about the same weight of metal in the truss, but with an increase in the strength of probably one-half.

Notes and Queries.

F. A. H., referring to our article in the November LOCOMOTIVE upon open heaters, grease in boilers, etc., inquires if the objection obtains where the modern preparations of petroleum are used for cylinder oils? The objection is not as great as when animal oils are used. Still, we find more or less difficulty. The deposit which accumulates is of a tenacious, waxy character, and is more frequently found adhering to the sides of the boiler near the water line and around the upper tubes. We are a little troubled to account for this, but are of the opinion that it is the paraffine in the oil. It should be borne in mind that a large proportion of the oil used in the cylinder is thrown out in the exhaust. We will suppose that one pint of oil is used in a cylinder each day. If the exhaust is returned to the boiler there will have been carried into it in one month not much less than three gallons. If the water is liable to be muddy or carries any considerable quantity of vegetable matter, the oil will combine with it more or less, and certainly give trouble. Therefore, from a wide experience we advise that the exhaust be utilized to heat the feed water, without bringing it in contact with it, which cannot be done unless a pipe or coil heater is used. Crude petroleum is very effective in removing hard scale. But it should be put into the boiler when it is comparatively cool, after blowing down and cleaning out the boiler. The crude petroleum may be put in when the boiler is being filled; it will rise to the surface of the water, and as the water rises in the process of filling, the sides of the boiler will be washed by the rising oil on the surface. We have been able to remove hard scale in this way which could not be removed by any other process. Crude petroleum is volatile, and the amount of residuum which would result from the quantity used in a boiler for such purposes would be so small as to be harmless. We would not, however, advise the indiscriminate use of crude petroleum. If the water carries vegetable matter, or is liable to be muddy, other purgers will be better. But for a hard lime scale we have found crude petroleum very effective. It will be observed that the conditions under which the oil is used in this case are different from those where it is introduced in the exhaust from the engine. In the latter case it is introduced into the water, which is at a high temperature, and may have more or less impurity or scum on the surface; the oil readily combines with this, causing the difficulties mentioned above. While in the former case the oil is introduced cold into cold water, it washes, or "varnishes" the sides of the scale-covered boiler, penetrates it, works its way between the scale and the iron of the boiler, and detaches it. Those who have used petroleum to aid in removing a nut from a rusted bolt will understand its operation. It eats out or dissolves the rust or oxide without injuring the iron. So with hard scale, it works down between the iron and the scale, eats out or lubricates the film of oxide, and detaches it.

FORGOT THE TUNNEL.—M. Aurelien Scholl has an amusing note on what he calls the "forgotten tunnel." The other Sunday, being at Brussels, he was struck by the extreme thinness of the earth covering the Braine le Comte tunnel, and wondered why the common sense of the engineers who made the line did not direct them to continue the cutting, and thus avoid a subterranean passage. The mystery was explained to him by a Mons advocate. When railways were in their veriest infancy the Belgian government sent a party of engineers over to England to acquire experience in the construction of the new iron highways, and on their return they were instructed to lay out the first railway in that enterprising little kingdom. The work was accordingly put in hand, and on its completion one of the engineers exclaimed: "Good heavens, we have forgotten the tunnel!" The consternation was general, especially when it was remembered that there was not a single line in England but could boast of a tunnel. What was to be done? Nothing but to construct the long corridor at Braine le Comte, and when it was finished the earth was put on the top. The tunnel was then, says the witty Aurelien, the glory of the line.—*Cincinnati Artisan.*

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