HARTFORD STEAM BOILER ★ INSPECTION AND INSURANCE CO. ★

HARTFORD, CONN.

The Locomotive.

PUBLISHED BY THE

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

NEW SERIES.

Vol. II.

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1881.

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NEW SERIES — VOL. II. HARTFORD, CONN., JANUARY, 1881. No. 1.

A Midnight Explosion.

The explosion that furnishes the subject of the present sketches was that of a common vertical tubular boiler, used in a light manufacturing establishment in a neighboring city. It was comparatively new, having been used but fifteen months under the charge of licensed engineers, and was tested a few months before by the municipal inspectors at a hydrostatic pressure of 150 lbs., and duly certified as safe at a working pressure of 100 lbs.

Its general description and dimensions were as follows: [This report is made by an

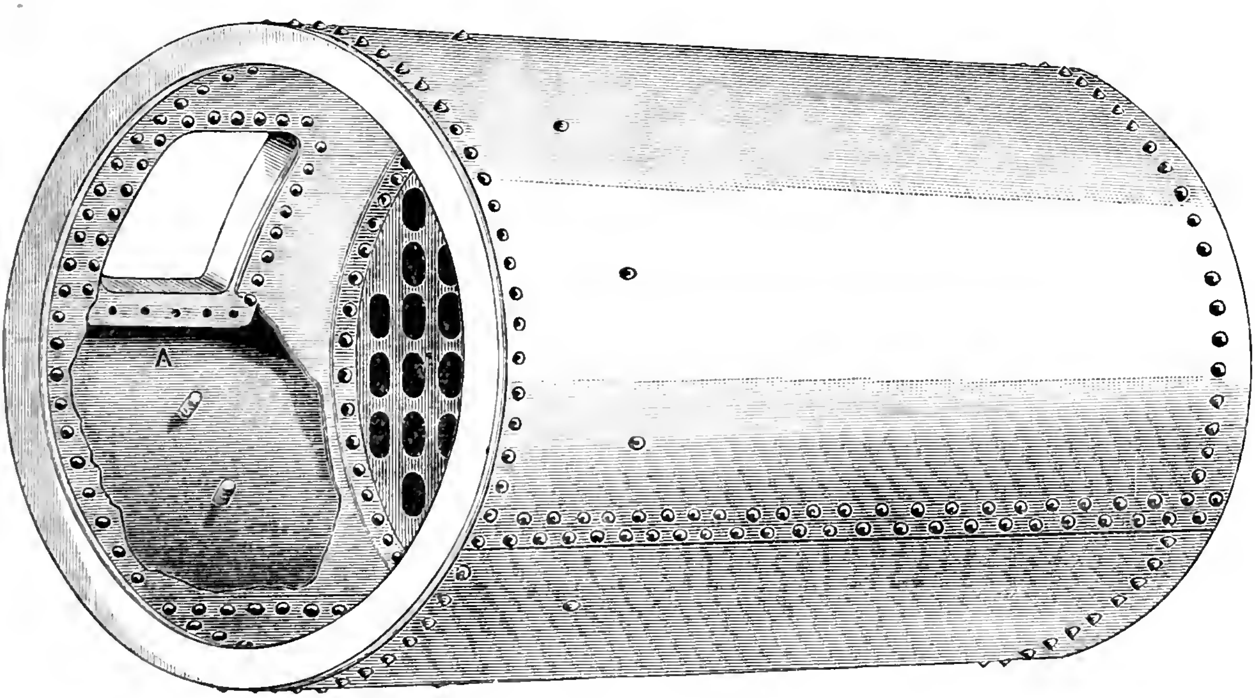

FIG. 1.

engineer of wide experience and who has been long in the employ of this company. — ED.] The shell was formed of one sheet of " C. No. 1 " iron, one-quarter inch thick, double stagger riveted vertically, 32 inches diameter, 64 inches high, and contained 50 two-inch tubes. The shell was extended four inches above the upper head for the purpose of attaching the uptake. The fire-box was 28 × 24 inches, of quarter-inch iron; no brand was found, but apparently it was of no better quality than the shell. It was stayed to the shell by a single row of three-quarter-inch screw stay-bolts extending circumferentially around the fire-box, 11 inches distant between centers.

The location of the boiler was in a one-story brick extension from the main building. The day preceding the explosion the boiler had been used in its ordinary work, and nothing remarkable was noticed in its behavior. The work of the day completed, the engineer left at 6 o'clock, at which time he states there was 40 lbs. steam upon the boiler with a fire on the grate that under ordinary circumstances ought soon to have died out, with the damper closed and fire-door open, as he claims to have left it.

Shortly before midnight the residents in the adjoining houses were alarmed by a loud report, shattering of glass, and hissing of steam. It was soon learned the boiler just described had exploded, leveling the boiler-house, fences, and outbuildings in its path of projection, and had fallen some 200 feet from its starting point. Fortunately no one was injured. Damage to property estimated at $2,000, upon which there was no insurance. There seemed no doubt the explosion had been caused by over-pressure; there were no indications of low water, for the most exposed parts were apparently uninjured. The initial rupture occurred at the fire-door seam of the furnace sheet (A, Fig. 1). At the place of rupture the outer edges of the line of rivet holes, five-eighths inch diameter, were within three-eighths of an inch of the edge of the sheet, the rivets were $2\frac{1}{2}$ inches between centers, and it is possible the ruptured ones, so near the edge of the sheet, might have been checked; the danger of their being so would have been increased with so poor a quality of iron as this is thought to have been, "C. No. 1," for the ruptured edges of all the iron indicated but little fiber.

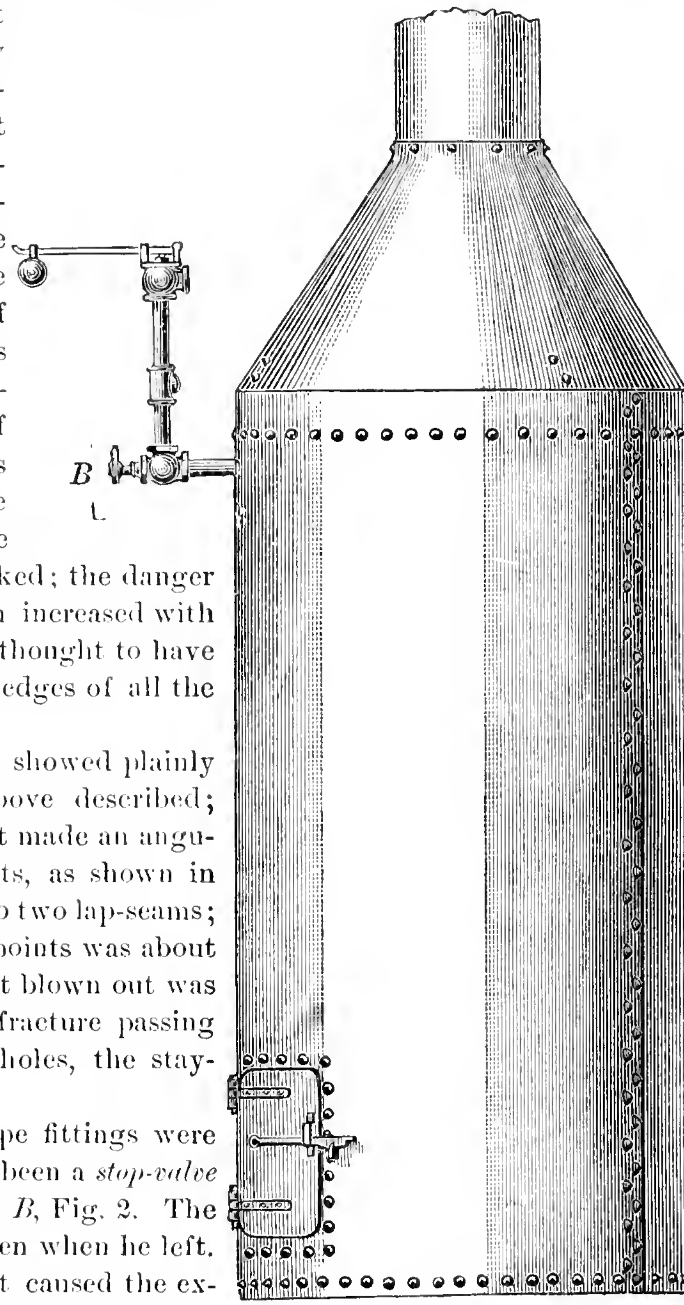

FIG. 2.

The fractured edges of the sheet showed plainly the initial rupture occurred as above described; turning down the lap of the seam it made an angular irregular rip through the sheets, as shown in Fig. 1, part of the distance parallel to two lap-seams; the breach measured at its widest points was about 19×22 inches. The piece of sheet blown out was found in two pieces, the line of fracture passing through one of the two stay-bolt holes, the stay-bolts' heads pulling through.

When the fragments of the pipe fittings were examined it was evident there had been a *stop-valve between the safety-valve and the boiler*, *B*, Fig. 2. The engineer thought this valve was open when he left. Had it been the over-pressure that caused the explosion, it could only be accounted for on the supposition that the safety-valve was set fast in its seat (a not unusual occurrence), or had been tampered with. Immediately after the explosion there were reports in circulation, and there is usually no lack of improbable stories at such times, that some unknown person with malicious intent had burglariously effected an entrance to the premises, hung a weight upon the safety-valve, started a heavy fire in the boiler, and then as mysteriously disappeared. This gave the usual flavor of mystery without which a boiler explosion would be an exceedingly tame affair; yet I must frankly admit this story had as much foundation as that of the average "mysterious explosion."

The safety-valve was of the wing pattern and had abundant clearance in both spindles and guides; its diameter was $1\frac{1}{8}$ inches, much too small. It does not seem possible this valve could have raised at any time during the evening, for the escaping steam would have attracted the attention of some of the occupants of the adjoining houses, or the engineer who lived near by, for this factory was situated in the midst of dwelling-houses. No unusual noise was noticed until the explosion occurred. The foregoing statements, if correct, and they are believed to be so, justify

The Hypothesis

that when the engine was stopped for the day, the stop-valve between the engine and boiler was closed. This, as previously explained, would shut off the safety-valve too (*B*, Fig. 2). More fire and coal was left upon the grate than was intended, or ought to have been; the evening, a clear and frosty one, was calculated to quicken the draft of a fire; the partly burned coal upon the grate become kindled again, steam was generated, and, having no escape, accumulated within the boiler until it reached the limit of its strength at its weakest point, when a rupture occurred at the seam about the fire door; the reaction from the issuing steam and water through the opening just made projected the boiler into the air, it being deviated from a perpendicular to an angular direction by the location of the rupture. The tearing through the sheet may, I think, be explained as due to the leverage obtained from the turning down of the "lap" when it yielded.

The Lesson.

a. The lesson of this explosion is the cupidity, ignorance, and carelessness of steam-fitters that made the connection by which disaster was probable. *b.* The violation of an established principle in boiler engineering, "That the safety-valve shall be attached directly to the boiler without any intervening valves." *c.* The value of a thorough inspection that would have pointed out to the owners of the boiler the great danger to which they were exposed from the stop-valve referred to, that in all probability would have averted the explosion. F. B. A.

Boiler Explosions.

December, 1880.

Paper-Mill (147). — A terrible explosion, which caused damage to the amount of $10,000 or $15,000, occurred December 7th at the paper-mill of Morrison, Bare & Cass, at Roaring Springs, a few miles from Altoona, Pa. One of a group of five boilers, used in cooking wood, burst with terrible force, the boiler tearing out through the roof and rising to a height of 400 feet, lodging on a hill some distance away. A hole was scooped in the ground four feet deep where the boiler struck the earth. David McKee, an employe of the mill, was afterwards found beneath the débris, and some time elapsed before he was reached. His injuries soon proved fatal. Weakness of the boiler was the cause of the accident. It had been tested the day before, and pronounced safe. The proprietors have an insurance of $10,000 (not insured in the Hartford company) with agents in Altoona. This is the third explosion that has damaged these works.

Saw-Mill (148). — A portable saw-mill owned by Marble & Clark, Wendall, Mass., exploded December 8th, killing seven persons and mangling five others. Nearly all the persons were still in bed in a shanty adjoining the mill when the explosion took place.

Boiler-Shop (149).—About three o'clock, December —th, a boiler explosion occurred at the shop of Collins & McKinney, situated near the freight-house, Amsterdam, N. Y. The boiler shot through the roof into the air with terrible force. It described a parabola in the air and fell upon the roof of the shop about thirty feet from its original position. It fell to the ground at the feet of four of the workmen, who narrowly escaped being crushed to pieces. The building was fearfully shattered by the force of the explosion, and looked as if a powder-mill had blown up in that vicinity. Some of the machinery was broken, and a loss of about three hundred dollars caused. George Vedder, the engineer, had one of his legs broken, and was otherwise seriously injured. The boiler was an old one, and not sufficient to do the work required of it. Too heavy a pressure was carried, and, in consequence, it exploded. Messrs. Collins & McKinney were pressed with orders at the time, and could ill afford to endure delay.

FLOURING-MILL (150).— Mr. Lee, the miller at Turney Bros.' flouring-mill near Curlisville, Pa., was killed by an explosion of the boiler December 10th, while trying to get up a good head of steam. The mill is a complete wreck, and will not be rebuilt. The miller's head was severed from his shoulders. The cause of the accident is unknown.

YARN-MILL (151).— The village of Clifton, on the line of the Philadelphia and West Chester railroad, about eight miles north of Philadelphia, has had a sensation caused by an explosion of the boiler, December —th, in the mill occupied by Randolph & Jenks, manufacturers of yarn, etc. The explosion was a terrific one, arousing the entire neighborhood, and the report was heard for miles around. The entire end of the mill where the boiler was located was blown away. As far as information can be obtained it appears that inspectors had been examining the boiler the previous day, and requested that it should not be used again until their inspection was satisfactorily completed. Disregarding these directions the mill was run, resulting as above. Two men, named Frank Lee and Mark Wood, sustained severe injuries, the former not being expected to recover. These men were in the dry-room above the engine. An investigation is in progress.

CAR-WORKS (152).— A boiler in Baker's car-works, at Latrobe, Pa., exploded with terrific force December 13th. Two young men, named William Campbell and John Williams, were badly scalded. They walked to the office of Dr. Anderson, half a mile from the scene of the accident, and had their wounds dressed, and were both dead within half an hour afterward.

SOAP-WORKS (153).—The boiler in Fabel & Sons' soap and candle factory, Louisville, Ky., exploded December 14th, killing Phil Hempel, a carpenter, fatally injuring Conrad Sparkel and Lizzie Ott, and severely injuring Peter Bolenbocke, fireman. The explosion leveled the center of the building, a two-story brick. Insurance (Fire) on stock and building, each of which is nearly destroyed, $40,000; machinery valued at as much more: not insured in this company.

TABLE-FACTORY (154).— A boiler exploded December 15th, in Gottschalk's table-factory, Garretsville, O., immediately killing one man, and injuring another who has since died. The boiler was blown twenty rods, cutting down in its flight trees of considerable size. Loss, $3,000, including damage by ensuing fire; no insurance.

LOCOMOTIVE (155).—Engine No. 252, P. & R. R., attached to a coal train, exploded December 16th, at Belmont, two miles and a half above Palo Alto, Pa., killing Patrick Donahue, the engineer (of twenty years' experience), Thomas Kenvin, the conductor, William Ash and John Maher, brakemen. [A later account mentions this as a mysterious explosion, to be the subject of inquest by the coroner.— ED.]

KINDLING-WOOD FACTORY (156).— A steam boiler in the kindling-wood factory of John Ettle on West Fifty-fifth street, New York, exploded December 17th, caused by a blow from a fragment of a bursted fly-wheel. The boiler immediately exploded, scattering destruction in all directions. Mr. Ettle was terribly scalded by the escaping steam. Several employes had narrow escapes. Another piece of the wheel was whirled through the air, and falling upon the roof of a tenement-house on Tenth avenue, crashed through into the apartment of Mrs. Bloomer.

Chemical Works (157).—The boiler in Willis & Clément's chemical works, West Twenty-sixth street, New York, exploded December 18th, with terrific force, wrecking the rear portion of the factory, and damaging machinery to the extent of $2,000. The roof and walls of the rear extension were wrecked. The boiler itself was carried by the force of the explosion to Sixth avenue, nearly half a block. No one was injured, but several persons had narrow escapes.

Saw-Mill (158).—The boiler of a portable saw-mill exploded December 18th, a few miles below Gallipolis, O., on the West Virginia side, killing an unknown man, and badly injuring another man.

Iron-Works (159).—December 20th, at 9.30 o'clock, one of the battery of three boilers in the Merchant mill, in the Rensselaer iron works at Troy, exploded with a loud report, but did no damage to the mill beyond demolishing the furnace by which the water was heated. At the time it was supposed that no person was injured, but in clearing away the débris the dead body of John McNamara, who was generally known as "John Mack," was found under the ruins. Coroner Green was notified, and, after examining the remains, he expressed the belief that death was instantaneous, and was caused by the mass of brick falling upon the deceased. Mack was sixty years of age. and had been employed at the mill as a water-carrier for over twenty years. It is supposed that the unfortunate man was lighting his pipe at the furnace when the explosion occurred.

School-house (160).—The steam boiler of the North Cleveland public school-building heating apparatus violently burst December 21st, giving the children an extra week's vacation. Nobody hurt.

Tug-boat (161).—The boiler of the tug Martha, lying in Christiana river, Wilmington, Del., exploded December 22d, almost destroying the boat, and instantly killing the engineer.

Paper-Mill (162).—The boiler of Loomis's paper-mill at Piqua, O., exploded December 27th, damaging the building $10,000.

Shoe-Factory (163).—The boiler at E. P. Dodge's shoe-factory, in Prince Place, Newburyport, Mass., exploded December 26th, killing the engineer, James Huntington of Boston, Daniel Bridges, and John R. Bradley. Several other establishments were badly damaged. The boiler was blown 100 yards into Green street, breaking thousands of panes of glass in the vicinity. Several men were slightly injured; the fireman is reported missing. Had the help been at work the loss of life would have been terrible.

Shingle Mill (164).—The boiler in a shingle-mill, at Vestaburg, Mich., exploded December 28th, killing instantly Frank Filkins, engineer, and Frank Ainsley, night watchman, and badly injured George Wilcox, M. Turk, and an unknown man. The mill was shattered to atoms. Frozen pipes were the cause.

Locomotive (165).—An engine on the Chicago & Alton railroad exploded December 30th, going into Joliet, Ill., with a heavy freight train. The engineer and fireman escaped uninjured, but the head brakeman was probably fatally scalded. The explosion was caused by the freezing of water in the pipes between the tank and the engine, allowing the water to get low in the boiler.

Dwelling (166).—The boiler of the range in the house of Mr. Pearson, at Bloomfield, N. J., exploded December 31st with great force, demolishing both boiler and range. Pieces of the broken range struck Mrs. Pearson, who was in the kitchen, severely injuring her about the head and limbs. The explosion broke up a portion of the ceiling, besides smashing the kitchen windows.

DWELLING (167).—An explosion occurred soon after the fire was lighted in the kitchen range of Mr. Paul Dorgeval, No. 282 Ellison street, Paterson, N. J., December 31st. The iron and brick work were scattered about the room, making a complete wreck of the premises, and the house was set on fire. Some gentlemen passing by ran in and put out the flames before they had made much headway. Mrs. Dorgeval had been in the room a minute or two before the explosion occurred. Had she been present at the time, she would probably have been killed, so great was the violence with which the range was blown up. The accident was caused by water freezing in the water back of the range, preventing the free circulation of the liquid, which was soon changed into steam with resistless expanding force.

MACHINE-SHOP (168).—A boiler explosion, December —th, in Andrew R. Moore's machine-shop at Charlotte, Mich., killed the proprietor's 15-year-old son, and a man whose body is not yet identified. The boy's body was blown to atoms. The father was also blown fifty feet, but was not killed. Several other persons were injured.

TELEPHONE OFFICE (169).—The explosion of a small boiler, December —th, under the telephone office at Harvard Square, Brookline, Mass., damaged the electrical apparatus about $500.

FOREIGN STEAMER.—News from Baranquilla, S. A., reports the explosion of one boiler of the steamer Isabella, December —th, killing four persons, and seriously wounding several others, two of whom have since died.

THRESHER (170).—A boiler of a steam-thresher exploded September 27th, on the ranch of H. J. Glenn, near Princeton, Calusa Co., killing a fireman, two Chinamen, and seriously scalding the engineer and six others.

CLASSIFIED LIST OF BOILER EXPLOSIONS FOR THE YEAR 1880.

		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Tot. pr. class.
1	Sawing, Planing, and Wood working mills,	6	6	5	5	3	4	3	..	6	1	2	6	47
2	Railroad Locomotives, and Fire Engines,	4	..	1	..	2	2	1	1	2	1	2	2	18
3	Steamboats, Tug boats, Yachts, Steam barges, Dredges, and Dry Docks,	2	1	1	2	..	1	1	3	2	..	..	2	15
4	Paper, Flouring, Pulp, Grist mills, and Elevators,	1	1	1	..	1	..	2	2	1	2	5	3	19
5	Portables, Hoisters, Threshers, Pile-drivers, and Cotton Gins,	1	..	..	..	1	..	4	2	1	..	3	1	13
6	Iron Works, Rolling mills, Furnaces, Foundries, Machine and Boiler shops,	2	..	1	2	2	..	1	..	1	..	1	3	13
7	Tanneries, Belt and Leather works, Shoe and Hat factories,	..	1	..	..	..	..	..	..	..	..	..	1	2
8	Cotton, Woolen, Knitting, and other textile works,	..	..	1	..	..	..	..	..	..	..	..	1	2
9	Distilleries, Breweries, Malt and Sugar houses, Soap and Chemical works,	2	3	..	..	..	1	..	..	..	2	..	2	10
10	Mines, Oil Refineries, and Oil Wells,	1	1	..	..	1	1	..	2	1	..	1	..	8
11	Bleaching, Digesting, Dyeing, Print works, Slaughtering, etc.,	..	..	..	..	..	..	..	1	..	2	..	..	3
12	Rubber works, and Railroad Stationaries,	..	..	..	..	..	..	..	..	..	..	..	..	..
13	Steam Heating and Drying, Dwellings, Schools, Stores, and Public Bldgs.	..	..	..	..	..	1	..	..	1	..	..	..	2
14	Miscellaneous works, and Mills not designated,	..	1	1	2	2	..	2	..	1	3	2	4	18
	Total per month,	19	14	11	11	12	10	14	11	16	11	16	25	

Summary of Boiler Explosions, and Persons Killed and Injured in 1880.

1880.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Boilers, - - - -	19	14	11	11	12	10	14	11	16	11	16	25	170
No. of persons killed, -	16	22	31	12	30	30	20	9	14	23	18	24	259
No. of persons injured.	44	23	59	46	59	132	41	21	35	28	33	34	555

Close of 1880 Record.

Inspectors' Report.

November, 1880.

The whole number of visits made in the month of November, 1880, was 1,837, and 3,915 boilers were examined. The thorough annual inspections foot up for 30 days, 1,371. The hydrostatic test was applied to 185 boilers, a large percentage of which were new.

The whole number of defects discovered in November was 2,330, of which 635 were dangerous.

They were in detail as follows: Furnace out of shape, 154 — 47 dangerous. Fractured plates, 199 — 115 dangerous. Burned plates, 139 — 27 dangerous. Blistered plates, 408 — 44 dangerous. Cases of sediment and deposit, 374 — 112 dangerous. Incrustation and scale, 359 — 55 dangerous. External corrosion, 156 — 53 dangerous. Internal corrosion, 112 — 68 dangerous. Internal grooving, 43 — 29 dangerous. Water-gauges defective, 79 — 25 dangerous. Blow-outs defective, 24 — 9 dangerous. Safety-valves overloaded, 24 — 11 dangerous. Pressure-gauges defective, 183 — 30 dangerous. Boilers without gauges, 63. Cases of deficiency of water, 6 — 5 dangerous. Defects in bracing and staying, 17 — 4 dangerous. Boilers condemned, 16.

December, 1880.

Whole number of visits, 1,662. Boilers examined, 3,621. Thorough annual inspections, 1,565. Hydrostatic tests, 319. The whole number of defects discovered in 31 days was 1,699, of which 543 were dangerous.

They were as follows: Furnaces out of shape, 90 — 27 dangerous. Fractured plates, 211 — 130 dangerous. Burned plates, 87 — 45 dangerous. Blistered plates, 332 — 50 dangerous. Case of sediment and deposit, 204 — 83 dangerous. Scale and incrustation, 290—64 dangerous. External corrosion, 119—36 dangerous. Internal corrosion, 105—28 dangerous. Internal grooving, 12 — 6 dangerous. Water-gauges defective, 37 — 13 dangerous. Blow-outs defective, 18 — 12 dangerous. Safety-valves overloaded, 21 — 9 dangerous. Pressure-gauges defective, 120 — 25 dangerous. Boilers without gauges, 34 — 1 dangerous. Deficiency of water, 6 — 6 dangerous. Defective bracing and staying, 13 — 8 dangerous. Boilers condemned, 46.

A correspondent of the *Forest and Stream* gives a novel method employed to cleanse a two-inch water pipe which had become choked with mud. A string was tied into a hole punched in the tail of a small eel, which was straightway put into the pipe. An occasional jerk reminded the eel that it was incumbent on him to proceed, which he did, arriving at the lower end of the pipe with a string. A bunch of rags was tied to the string, and thus the pipe was cleansed.

The Locomotive.

HARTFORD, JANUARY, 1881.

WE call attention to the summary of boiler explosions for the year 1880, in another column. We have made an effort to collect each month all the explosions occurring in the country. We may not have succeeded in getting every one, but we feel confident that but few have escaped our notice. The year 1880 was the most disastrous year in this respect that this country has ever known. Just what the cause is we cannot positively say. But from such investigation as we have made we are inclined to the opinion that with the rush of business that began with the beginning of the year many boilers were put into use, which had long been idle, without such an examination as they should have had. With the increasing business new machinery has been added in many instances without proportionately increasing the boiler power. Pressures have been increased, and the tendency has been to give undue attention to the increasing product without due regard to the other end of the mill, viz., the motive power. In our own experience we have seen this. We are often asked for permits to increase pressure beyond that stipulated, the applicants claiming that they could not do their work unless it was allowed. We have found safety-valves on boilers under our care overloaded beyond the limit of safety. This, every person insured should understand, *renders their policy void.* This company will not be responsible for accidents that occur in violation of its rules. Boilers explode, and the facts in the case are not always known. After the damage is done it is next to impossible to ascertain just what did cause it — but we have little doubt that many, and even most cases, are attributed to carelessness of this kind, or some other in management. Another difficulty which should not be overlooked is, with the revival of business came a great demand for new boilers and expensive repairs. Boiler-works all over the land have been overrun with orders, and every purchaser was in haste to have his work done at once. This has laid a great burden upon boiler-makers, and in their haste to fill their orders new and oftentimes unskilled men have been added to their force. May not this have had something to do with the accidents to new boilers? And still again, with the demand for boilers came an unusual demand for boiler-iron and tubes. We have known of cases where boiler-makers were waiting weeks for iron and tubes, hence a burden has been laid upon the iron and tube manufacturers, and in their hurry the same care may not always have been exercised as when the demand was less urgent. We might pursue this subject and speak of the preparation of blooms, etc. But enough has been said to show that manufacturers have all been taxed to their utmost, and it is not too much to suppose that some details have been more or less neglected by all. The record of explosions for the year 1880, as compared with that of 1879, is as follows: Explosions in 1879, 132 — in 1880, 170. Number of persons killed in 1879, 208 — in 1880, 259. Number of persons wounded in 1879, 230 — in 1880, 555,— an increase in explosions of about 30 per cent., and of killed about 25 per cent. This is a record for manufacturers and steam-users to give careful consideration.

Attention is called to the following record of the company's business for the year 1880, a review of which will appear in our February number: Whole number of inspection visits made during the year 1880 was 20,939. Whole number of boilers examined, 45,166. Whole number of complete annual inspections, 16,010. The number of boilers tested by hydrostatic pressure was 3,490. The total number of defects discovered during the year was 21,033, of which 5,444 were dangerous. Boilers condemned, 377.

The Strength of Boiler Flues.

[From "The Engineer."]

Very high pressures are now carried at sea on the outside of tubes of comparatively large size. These tubes are the cylindrical furnaces of marine boilers, and reach in some cases a diameter of 4 feet. It is of the utmost importance that very definite rules should be laid down for the guidance of those who design such furnaces, in order that no mistakes may be made. We say "definite rules," because the whole subject has been fully investigated. There is apparently nothing more to learn about it, and there should, therefore, be no trouble in constructing a simple formula which would enable an engineer to tell, with very little calculation, what is the proper thickness for a furnace tube of any given length and diameter, intended to sustain a stated pressure. Something of the kind will be found in almost all treatises on steam boilers. The practice thirty years ago was to treat the flue as though the pressure were to be exerted inside of it. The pressure was to be found by the well-known rule $p=\frac{2st}{d}$, where s is the strain in pounds per square inch to which the iron is to be subjected, t the thickness of the plate, d the diameter of the boiler, and p the working pressure. Then the proper thickness for flues was half that which would suffice for a shell. This practice is, we are happy to say, no longer followed. It answered fairly well while moderate pressures not exceeding about 46 lbs. on the square inch were used, but it was totally unfit to deal with such pressures as are now carried at sea and on land. Wilson gives the following formula for the strength of flues: $p=\frac{262.4\times t^2}{l\times d}$ where p is the collapsing pressure in pounds per square inch, t the thickness of tube in thirty-seconds of an inch, l the length in feet, and d the diameter in quarter feet; other rules may be found in other treatises. Fairbairn has shown that the strength of a flue to resist collapsing pressure varies directly as the 2.19 power of the thickness, and inversely as the diameter and length. Thus: $P=33.6\times(100t)^{2.19}\div L\times d$, and $p=5.6\times(100t)^{2.19}\div L\times d$. These are very ungainly formulæ, and useless without logarithms. It may not be superfluous to say here, however, for the guidance of those who would like to use Fairbairn's rules as a check on their own practice, that in using the formulæ the thickness of the plate is to be multiplied by 100. The log. of the result is to be found and multiplied by 2.19. This gives a log. the natural number of which is the 2.19 power of $100t$.

It is not to be supposed that the Board of Trade, which is so precise in its instructions and rules for marine engine builders, would allow this subject to pass without consideration. Accordingly the Board has proposed a rule, which runs thus: $p=\frac{60,000t^2}{(l+1)\times d}$. Here 60,000 is a constant for furnace tubes with longitudinal seams, lapped joints, and punched holes single riveted; l is the length of the furnace in feet; d is the diameter in inches; and p the working pressure. To illustrate the application of this rule, let us suppose that a furnace is 40 inches in diameter and 7ft. long, and that the plates are .375 inches thick. Then $\frac{60,000\times .140625}{(7+1)\times 40}=26.3$ lbs. as the working pressure. But the Board of Trade rule is not the only one with which engineers have to deal. "Lloyd's" have a rule also, which is, $p=\frac{89,600\times t^2}{l\times d}$. Applying this rule to the furnace whose dimensions we have just stated we have $\frac{89,600\times .140625}{7\times 40}=45$ lbs. We thus find that one great authority on marine engineering allows nearly twice as great a pressure to be carried as the other. If the Board of Trade be right, then Lloyd's must be wrong, and dangerously wrong. If, on the other hand, Lloyd's is right, then the Board of Trade behaves very vexatiously and insists on a much lower pressure being carried than is necessary. Before any opinion on this point can be properly pronounced it is necessary to call in some other authority. Referring to the tables given in Wilson's treatise on steam boilers, we find that the collapsing pressure of a flue 7ft. long, $\frac{3}{8}$ inch thick, and 40 inches in diameter is nearly 400 lbs. on the square inch. Lloyd's factor of safety is consequently about 9 to 1, while the Board of Trade factor is nearly 15 to 1. If one margin be enough then the other must be too great. In dealing with this part of the question we can only arrive at anything like a satisfactory conclusion by resorting to the result of experiment. Mr. Wilson's figures refers to very perfect tubes such as may or may not be met with in practice. Mr. D. K. Clark has investigated many cases of collapsed tubes, and he has prepared the following formula: $p = t^2 \times \left(\frac{50,000}{d} - 500\right)$. Applying this rule to the case stated, we have 105.4 lbs. as the collapsing pressure. In this case the Board of Trade factor of safety is nearly 4 to 1, and Lloyd's factor is little over 2 to 1. It must be remembered, however, that Mr. Clark's rule applies to flues of considerable length without any strengthening rings; to these he has attached no precise value. But it may be taken for granted that a marine boiler furnace tube, well secured at each end and not more than a few feet long, is very much better able to stand up against a collapsing strain than a tube 25ft. or 30ft. long. We may, we believe, take a mean between Mr. Wilson's figures and Mr. Clark's, and assume that the collapsing pressure of our tube would be about 200 lbs. on the square inch. Under these circumstances Lloyd's formula gives a factor of safety of 4.4 to 1, while the Board of Trade rule gives 7.7.

Now it is evident that the disparity between the rules of the Board of Trade and of Lloyd's ought not to exist. It places engineers and shipowners alike in a very unpleasant position, and will some day cause a great deal of trouble. A case may be cited which recently occurred. Two wing furnaces on board a North-country steamer collapsed with 20 lbs. of steam pressure and plenty of water. The collapsed flues are round topped, with flat stayed sides, and by the Board of Trade rules, the working pressure was 22 lbs. and by Lloyd's 42 lbs. It is probable that when the case comes to be investigated it will be found that the metal was either over-heated by the presence of deposit, or that the flues were worn. Be this as it may, it is not inconceivable that the engineers of the Board of Trade and those of Lloyd's may some day come into collision in a court of law over such questions, and we shall then have anything but an edifying spectacle presented for consideration.

The engineers of a great public department asserting that a boiler is strong enough, while those of the Government assert that it is too weak, will not be a satisfactory display in any sense of the word. The question at issue is one really of very great importance to engineers and shipowners. Is it too much to ask in the interests of common sense that the two bodies should put themselves in communication and agree on so apparently simple a matter as the preparation of a rule for the thickness of furnace tubes?

Editorial Notes.

The above article on the strength of boiler flues should be carefully read by every person who has any ideas or theories as to the strength of boiler-flues. We see here that what is considered perfectly safe by one authority is regarded as dangerous by another, and in the event of accident from collapse of flue these high authorities would be brought face to face, each striving to defend his own theory or practice. It is a lamentable fact that there is such wide difference of opinion on so important a matter. There should be but one rule for the *world* (assuming the material and workmanship to be first-class), and that rule should be based upon the results of careful experiment. But instead we see one class of engineers advocating one rule, and another class advocating a different rule, and so it goes, to the disgrace of the engineering profession. But another matter, that of "INTERNAL PRESSURES," is if possible in a more impenetrable fog than the former. A dozen or more rules are laid down for calculating the safe internal pressure of cylindrical tubular boilers, and from the lowest to the highest there are variations running from ten (10) to ninety (90) per cent., and the latter may be authorized by law while the others are the opinions of engineers, some of which are entitled to great respect because of their careful researches and experiments, but the majority of which are simply satellites, who have opinions founded on some other and wiser man's experiments, which they fail to understand. And of all the "bull-headed" men that one comes in contact with, an *opinionated*, self-constituted "engineer" is the climax. He is always ready to be employed as an "expert," and prepares himself for his case from such authorities as suit the case best. One class of authorities is used to-day and another to-morrow. Each is solemnly sworn to as the best and the only reliable one. Now with such a wide difference of opinion among men who are looked up to as authorities on the *strength of boiler flues*, and on the *safe internal pressure of boilers*, what a fruitful field is furnished for these self-constituted "experts" to operate in, often to the damage of important interests. It is high time that there should be an effort made to reconcile all these differences and have rules that can be adopted by the whole land. As it is now, a manufacturer, acting under a rule which is perhaps approved and adopted by the highest authority in the land, is, in case of accident, accused of wanton disregard of life, criminal carelessness, etc., etc. This is all wrong and should be remedied.

Table XIII—Specific Heat of Solids.

Authority, *Regnault* when not otherwise indicated: P. & D. signify *Petit and Dulong*; P., *Pouillet*; R., *Rankine*.

	Water at 32° F. = 1.000
Bismuth,	.03084
Lead,	.0314
Platinum, sheet,	.03243
" spongy,	.03293
" 32° to 212° F. (P. & D.),	.0335
" 32° to 572° F.,	.0355
" at 572° F. (P.),	.03434
" at 932° F. "	.03518
" at 1292° F. "	.036
" at 2192° F. "	.03818
Gold,	.03244
Mercury, solid,	.0319
" liquid,	.03332
" 59° to 68°,	.029
" 32° to 212° (P. & D.),	.033
" 32° to 572°,	.035
Antimony,	.05077
Tin, English,	.05695
Cadmium,	.05669
Silver,	.05701
" 32° to 572° (P. & D.),	.0611
Brass,	.09391
Cymbal metal,	.086
Copper,	.09515
" 32° to 572° (P. & D.),	.1013
Zinc,	.09555
" 32° to 572° F. (P. & D.),	.1015
Cobalt,	.10696
Nickel,	.10863
Wrought-iron,	.11379
" 32° to 392° F. (P. & D.),	.115
" 32° to 572° F. "	.1218
" 32° to 662° F. "	.1255
Steel, soft,	.1165
" tempered,	.1175
Cast-iron, white,	.12983

	Water at 32° F. = 1.000
Iridium,	.1887
STONES.	
Brick-work and masonry (R.) about,	.20
Marble, gray,	.20989
Chalk, white,	.21485
Quicklime,	.2169
Magnesian limestone, dolomite,	.21743
MINERALS.	
Glass,	.19768
" 32° to 572° F. (P. & D.),	.19
Sulphur,	.20259
" recently cast,	.1844
Chloride of lime,	.16420
" sodium (salt),	.214 to .230
Nitrate of silver,	.14352
Saltpetre,	.23875
Nitrate of soda (soda saltpetre),	.27821
Coal,	.24111
Charcoal,	.2415
Coal and coke, average (R.),	.20
Anthracite, American,	.201
Graphite, natural,	.201
" blast furnace,	.479
Sulphate of lime,	.19659
Magnesia,	.22159
Soda,	.23115
Ice,	.504
WOODS.	
Pitch pine,	.467
Pear tree,	.500
Oak,	.576
Fir,	.650

TABLE XIII is abstracted from an extended one by D. K. Clark (Rules and Tables, Lon. edition, Blackie & Son, 1877), page 359-362. He says (*ibid.*, page 352), "the specific heat of a body signifies its capacity for heat, or the quantity of heat required to raise the temperature of the body one degree Fahrenheit, compared with that required to raise the temperature of a quantity of water of equal weight one degree. The British unit of heat — used wherever the F. thermometer is in use — ED. — is that which is required to raise the temperature of one pound of water one degree, from 32° to 33° F., and the specific heat of any other body is expressed by the quantity of heat, in units, necessary to raise one pound weight of such a body one degree."

A full explanation of the uses that the practical engineer may have for the data which this table contains cannot now be given for want of space. A single example will illustrate an important one. The following is a modification, avoiding as far as possible the use of algebraic expressions, of an example given by Prof. Trowbridge, (Heat and Heat Engines, Wiley, N. Y., edition, 1874, page 198): EXAMPLE — Let it be supposed, for instance, that ten square feet of iron boiler flue, $\frac{1}{4}''$ thick, becomes overheated to 1000° F. (about red-hot, see table Locomotive, Vol. I., N. S., page 165), and water already heated to the boiling point due to a pressure of 50 pounds per gauge (*ibid.*, page 63), or say 300° F., to flow over these plates; the cooling of the 100 pounds of wrought-iron from 1000° to 300° F., will cause a transfer of heat to the water of about 7900 British units, and its temperature will rise about $\frac{1}{9}$ as much per pound as the iron falls. Against wrought-iron in Table XIII. is found the decimal .11379, which means that one pound of iron cooled one degree gives but this fraction (not far from $\frac{1}{9}$) of a unit, one pound of water gives one unit when cooled one degree. Then 100 pounds will yield $100 \times \frac{1}{9}$ or $\frac{100}{9} = 11.3$ nearly. But our iron is supposed to fall 700° — from 1000° to 300° F. — and $700° \times 11.3 = 7910$ units. The authority cited assures us that under the conditions assumed 7900 units received by the water would suffice to evaporate only 7.9 pounds, provided the circulation is such that the heat is equally diffused. The effect, of course, must vary with the quantity of water that receives the heat.

He assures us also that the "transfer of this amount of heat would not elevate the pressure to a dangerous degree," referring no doubt to the ordinary conditions of good boiler practice, where there is considerable water per pound of boiler. The statement about the effect in water evaporated may not apply to some boilers of the so-called sectional type. When space is available for the purpose this subject will be again taken up.

The Weakest Point.

Probably a little thought on this subject will lead to the conclusion that there is a weakest point in every fabric, and it is obvious that the strength of this point is the true measure of the strength of the work to resist a steadily increasing and uniformly distributed force, such as fluid pressure, for example. If it were possible to construct a hollow sphere of absolutely uniform strength throughout, we should have the nearest thing to a boiler that has no weakest point. But such a vessel in this condition would be of no use as a steam-generator, since the emission of the steam after it is generated implies an opening in its wall, which, to be of no detriment to the uniformity of strength, must be exactly compensated for the loss of continuity by strengthening its borders, a problem requiring something more than a theoretical calculation to solve. It is plain that too much strengthening of the opening renders the uncut general area of the vessel the weakest, and the sphere will then break at any or all places, other than at the opening. But, practically, there must be a point in the general surface that has some hidden defect, either of material or workmanship, that will determine the breaking-point, when the structure is uniformly overloaded. Again, the application of heat to this hypothetical boiler must be upon a less area than the whole surface, a portion being the wall of the steam-room, and so much of it would become overheated in that event. This would destroy the uniformity of its strength, if, indeed, it could ever have been made uniformly strong, and when its limit of strength is exceeded it would inevitably break at this, its weakest point.

What is said above about strengthening, applies equally well to the practical steam boiler in its simplest and next strongest form, viz., the plain cylinder with hemispherical ends, although with equal distribution of material it is not uniformly strong in all its parts, neither is any other form that is not exactly spherical.

But suppose it were possible to so distribute the material of a cylindrical boiler that the manhole in the shell should be just equal in strength to the longitudinal seam, and the longitudinal seam exactly equal to the girth-seam, or the head-bracing and tube-ends; still the disturbing effect of the application of heat to a part of the surface would be similar to the effect on the sphere, and, however much we experiment on the cold boiler and reinforce its weak points one after another as they are developed, we have no positive assurance that the tensions are the same when heat is applied. It may be said in argument that since there must be a weakest point it may as well be one point as another, the seam, the head, or the manhole, so long as either is recognized as the weak point, and known to have an ample margin of strength to resist a moderate excess of the working load. But we are never safe without the operative and ample safety-valve. When once this organ, from any cause, ceases to work freely, we are, with an active generator, at once in the presence of imminent danger. The safety-valve should all the time be the weakest point, and always kept at the limit of the working pressure. Much proper discussion has been had on the weakness of necks, manholes, and domes, and the fact implies that there is doubt even in the minds of those who advocate necks of considerable size, and domes as necessary adjuncts of the steam boiler; and the calculations relating to their strength are somewhat complicated, and may be, even with all the refined mathematics that is applicable, at least uncertain, without actual experiments of an expensive if not dangerous character; it is therefore safest to make them, beyond a peradventure, stronger than some other naturally weak point, which is an undoubted necessity in construction of practical forms of generators. Necks and domes may be dispensed with in stationary practice; indeed, the question is an open one whether or not they are not an absolute detriment, aside from their doubtful character as to strength particularly on stationary boilers that are not restricted as to size and weight, by considerations of space and of carrying capacity for dead weight, as is the case with railroad locomotive and marine boilers. In the absence of necks and domes of large size on plain cylinders, the next weaker of the absolutely necessary parts, are the heads, manholes, or the longitudinal seams, but since the first of these may be readily strengthened by proper inside bracing to the shell, or made hemispherical, and the second is only a question of a few pounds of cast-iron properly distributed and attached, we need only consider the last, which in the present state of the art of boiler-making cannot be dispensed with without enhancing the cost to such an extent as to prohibit, practically, the use of welded joints or rolled ingot-rings. But the calculations of the strength of well-made longitudinal seams in a plain cylinder-boiler are comparatively simple, with material of known tensile strength and fairly uniform structure. The conclusion, therefore, is that domes and necks may be omitted, at least, where strength is a matter of primary importance, and that the heads and manhole being beyond doubt, we have a comparatively simple problem when the boiler is new; but it is now acknowleged by all well-informed steam-users that deterioration must be intelligently watched, so as to preserve the preponderance of strength at the points named, while the safety-valve must be constantly watched with scrupulous care, and kept weaker than any other known weakness.

If this conclusion is a proper one, and drawn from sound principles, then a little time may be profitably spent in the study of the weak features of these weaker points, especially such of them as are apparently unavoidable in the construction of the simplest form of steam-generators.

There will hardly be a difference of opinion among intelligent engineers as to

THE WEAKNESS OF THE MANHOLE IN THE CYLINDER,

or as to its necessity somewhere in any boiler of considerable size.

To admit the body of a man of average size, the least admissible dimensions of the clear opening are 11″ × 15″, and the oval form, having less area than any other practicable one that will admit a body of the size mentioned, has properly become by common practice the standard form of the opening in manhole frames.*

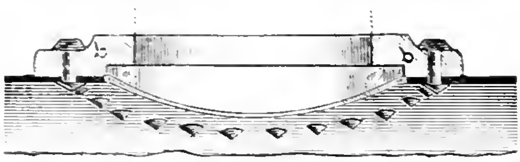

FIG. 1.

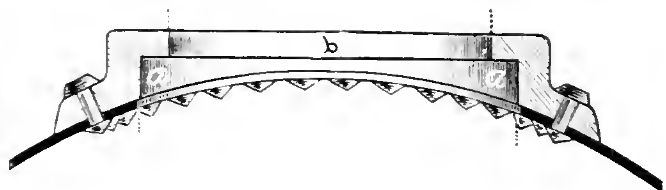

FIG. 3.

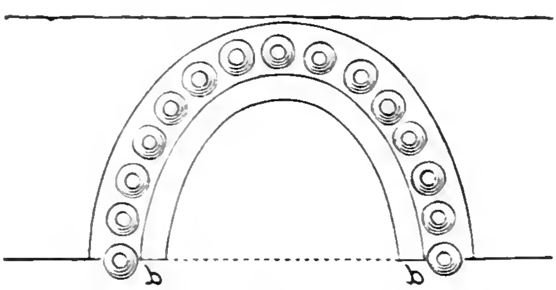

FIG. 2.—HALF TOP PLAN.

When they are placed in the cylindrical part of the boiler it is with the long axis transverse to the axis of the cylinder, because less of the doubly-loaded metal is cut by so doing.

The accompanying cuts, illustrating two distinct plans of oval manhole frames, are here introduced for the purpose of studying their weak features. They may be designated respectively as the outside and the inside frames. Fig. 2 is a half top plan of the common outside frame of cast-iron. Fig. 1 is a longitudinal section, as though cut by a vertical plane through its short axis, parallel to the axis of the cylinder. Fig. 3 is a transverse vertical section through its long axis.

The manhole frame serves the double purpose of a seat for the covering plate, and to compensate for the loss of continuity of material of the cylinder both longitudinally and transversely. The rabbet, *a* (Figs. 1 and 3.) forms the seat for the cover to rest against, the joint being made steam-tight by an annular strip of rubber, called the gasket.

It will be seen, Figs. 1 and 3, that the cover requires a larger opening in the shell than the opening in the frame which it closes. It seems plain, also, that the effect of an overload uniformly pressing outward upon the seat, *a*, when covered by the plate, would be to break this form of frame at its least section, *b*, Figs. 1 and 3, which is not only the weakest on account of its small sectional area, but it is the natural breaking-point of an overloaded bar or girder of equal section throughout. To remedy this defect, increase of strength being considered for the time the primary object to be accomplished, the inside frame shown in cuts 4, 5, and 6 may be substituted in cylinders of such diameter that the inward projections do not so reduce the clear space below them as to interfere with the passage of a man's body for inspection or repairs. This inside plan of frame also recommends itself because less area of shell is cut away, as will seen by comparing the two sets of cuts. Another incidental advantage of the inside frame is the facility with which the cover may be made to fit perfectly by planing both the seat and the cover, thereby avoiding the extraneous tension caused by forcing two uneven surfaces together by means

* Some are found as small as 10x14, but they are not comfortable openings for a good-sized man with a suitable overdress.

of the bolt in making the joint steam-tight. Far less pressure is evidently required to make the joint tight; in fact, the office of the bolt may be considered simply to hold the cover firmly against the seat, the steam pressure against the plate completing the requirements. This latter plan of manhole frame will be adopted for general steam-boiler practice by this company, and it is recommended after practical tests and careful study for all cases where there are no obstacles that prevent its use.

It will be seen that there would be but little advantage in planing the cover alone; in fact, if both surfaces had parallel distortions, planing one of them would increase the inequality, which must then be made good by a thicker and softer, hence a less reliable, gasket; therefore both surfaces should be planed.

The paramount advantage of the inside frame, however, is the one first mentioned,

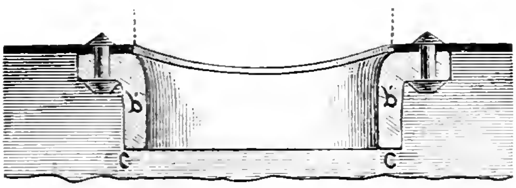

Fig. 4.

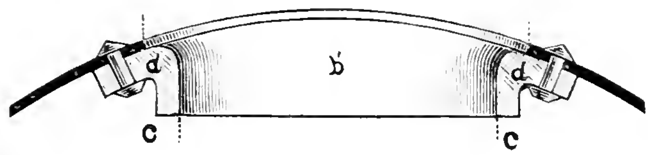

Fig. 5.

that its greatest section is opposed to, and admirably strengthens, the weakest section of the shell. But an important fact must not be lost sight of in this discussion, which is, in brief, no matter how you make the frame, if the curvature of both shell and frame do not coincide with the true curve due to the diameter, and if the riveters are careless, you will know, after all, but little about the strength of your device to resist steam pressure. This last proposition might be illustrated and enlarged on with interest, and perhaps with profit, to some thinking reader who has interests at stake, but space for this, or for the study of other weak points of the cylinder and heads, is not now available.

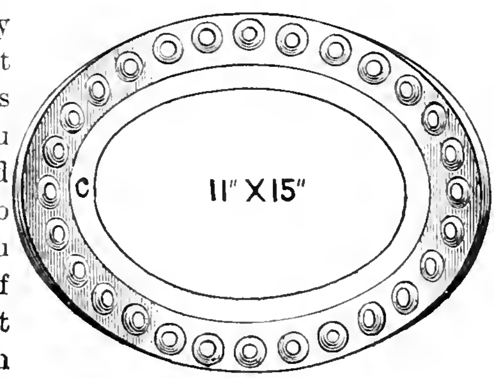

Fig. 6.

How was it done?

The following letter from one of the Hartford company's patrons explains itself; but perhaps a thought that occurs on reading it about the popular literature of boiler explosions may be properly introduced with it.

Of course no regular reader of the Locomotive would be misled by such a paragraph as the clipping, nor yet any thoughtful person who has ever seen steam issue from a tea-kettle nose, but there are thousands upon thousands of people in this enlightened country who take what "*the paper says*" as solemn truth. The pernicious effect of such wretched paragraphing is almost nothing compared with the effect of the promulgation of the specious reasoning of impractical theorists who draw their theories from delicate and astonishing laboratory experiments which heretofore they alone could perform.

The explosion of a boiler of one of the dry-goods palaces of New York city has called out the heavy and pedantic scientist as well as the keen satirist. The one convinces us that the extremely difficult experiment of exploding water inside of a steam-boiler of ordinary construction has been successfully performed, while no doubt the attempt has been made in precisely the same way about a million times in New York last year, and, with perhaps another or two that are not such well defined cases of this experiment, they have utterly failed. The exceptional and successful cases have involved such digressive and trivial conditions as old cracks and jammed safety-valves, which seem to be below the ken of exact science.

Mr. Rushworth, the obscure engineer of Mr. Creery's establishment, is well known to the present writer (proud distinction of writer), and his acquaintance shall not be allowed to die if the writer can help it.

"T" Water tenders his humble congratulations, and begs to remind his quondam shopmate, now the celebrated Mr. Rushworth, of the discussions over Jack's "'oisting hingine," and wood-splitter, and the birth over our dinner-pots in 28th street, or thereabouts, of the little "hupright," grandfather of the New York Safety Power engine, which stood so long, clothed in red, in the show-window of 98 Liberty street. You, my respected friend, have accomplished a feat in practical science that has "stalled" the savants of the Franklin Institute and the French Academy, and perhaps old Ben Franklin himself.

The satirist has given the scientist and all his compeers a piece of his quill, and I hope soon to hear from your humorous correspondent of Cortland who writes this letter. He is hereby invited to open his battery on the other extreme of boiler literature.

"T" WATER.

CORTLAND, N. Y., January 14, 1881.

J. M. Allen, Esq., President, Hartford, Conn.

MY DEAR SIR:—I have been much interested in reading from time to time the reports to your company and the LOCOMOTIVE, and noticing in them the lively interest you take in the advancement of science, I beg to enclose a short newspaper clipping.

THE ALLENTOWN EXPLOSION.

ALLENTOWN, Pa., Jan. 8. At the investigation to-day into the cause of the recent boiler explosion, by which thirteen lives were lost, two boiler-makers testified that the explosion was the result of the accidental introduction of *a current of cold air*, which *forced itself into the boiler* and created a vacuum. One witness swore that he saw the boiler leaking a week ago, and several others testified that they saw the leak just before the explosion.

This has been a *cold* winter, *exceedingly so;* but the *coldest* thing that has come to my notice is this remarkable "current of air" testified to by the Allentown boiler-maker. I suppose the policy I hold in your company is "bomb proof" on such a "cold wave."

Yours truly,

LEWIS S. HAYES.

Action of Gases on Steam Boilers.

A REVIEW CONTINUED FROM PAGE 202, VOL. I, NEW SERIES.

At the risk of repeating what is already well-known to most readers of THE LOCOMOTIVE, a few thoughts and quotations are here introduced on the subject of the deterioration of marine boilers. The history of the subject of corrosion of marine boilers is pretty nearly embraced in the following quotations from Mr. John Bourne's works on the steam-engine. In the London edition, 1858, page 83, he says:

"The corrosion of steam-boilers is one of the most obscure subjects in the whole range of engineering. Marine boilers seldom last more than four or five years, whereas land boilers made of the same quality of iron often last eighteen or twenty years." (The present writer suggests the italics here following.) "*Yet the difference in durability is not the effect of any chemical action upon the iron by the contact of sea-water, for the flues of marine boilers rarely show any deterioration from this cause, and even in worn-out marine boilers the hammer-marks on the flues are as conspicuous as at the time of their formation.* The thin film of scale spread over the internal parts of the boiler would of itself preserve that part from corrosion which is situated below the water-level. But whatever be the cause, *it is a rare thing to find any internal corrosion of a boiler using salt water in those parts of the boiler with which the water comes in contact. The cause, therefore, of the rapid wearing out of marine boilers is not traceable to the chemical action of salt water*, and steamers provided with Hall's condensers, *which supply the boiler with fresh water, have not reaped much benefit in the durability of their boilers.*

"The operation of *steam* in corroding the interior of the boiler is most capricious, the parts which are most rapidly worn away in one boiler being untouched in another, and in some cases one side of the steam-chest (steam chimney is the modern or American name for this part of a marine boiler) will be very much wasted away, while the opposite side remains uninjured. Sometimes the iron exfoliates in the shape of black oxide, which comes away in flakes like the leaves of a book, while in other cases the iron appears as if eaten away by a strong acid which had a solvent action upon it."

The same author repeats, in a later edition by D. Appleton & Co., N. Y., 1866, page 212, as follows:

"The greatest corrosion of a boiler, however, takes place in the inside of the steam-chest (steam-chimney), and the origin of this corrosion is one of the obscurest subjects in the whole range of engineering. *It cannot be the chemical action of salt water* upon the iron, for the flues and other parts of the boiler beneath the water suffer very little from corrosion. Nevertheless, marine boilers seldom last more than five or six years, whereas land boilers, made of the same quality of iron, often last eighteen or twenty years, and it does not appear probable *that land boilers would last a very much shorter time if salt water were used in them.* The thin film of scale spread over the parts of a marine boiler situated beneath the water effectually protects them from corrosion."

A few thoughts on the chemical character of this thin film of scale, which so effectually protects the iron from corrosion, will be proper in this place. If it is composed of the same bodies as the residue obtained from the complete evaporation of a quantity of sea-water, and in the same proportions, then it will be difficult to explain how a compound containing more than three parts in four of common salt can be made to effectually protect iron from corrosion under the circumstances of temperature and moisture which we find beneath the surface of the water in a marine boiler. The practice of "blowing off" from $\frac{1}{4}$ to $\frac{2}{5}$ of the water that is pumped into the boiler would not seem to help the matter, so far as the proportion of salt goes, provided the rejected water contained the same proportion of each of the original solids, although the percentage of residue from the rejected water might be much greater. There would still remain, in the portion left upon the plates as a scale, the same proportion of each of the solids, which would, in the moist, warm state in which it there exists, be a very active corrosive agent. *But such is not the case.* The thin scale is formed from the least soluble solids which the water contains, and which are present in the smallest quantities because they are so sparingly soluble. These are the salts of lime and magnesium, which, it is well known, effectually protect iron when used dissolved in water, or in the form of dry salt sprinkled on, or crystals baked on, such as the thin film or scale is. The practice of immersing brightly-ground tools and ornaments of iron, while dripping with *grindstone water*, in solutions of powders of lime, to preserve them from corrosion till they are ready for a finer polish, is common and effective, and is no doubt a familiar fact to most artisans and engineers. The chemical fact that chloride of sodium (common salt) is readily soluble in water at all temperatures, and that one pound of water, hot or cold, will hold in solution more than $\frac{1}{3}$ of a pound of it, is the important fact in the matter of blowing off. The matter that is blown off is the solution of common salt, and the portion of it that mixes (if any does) with the salts of lime and magnesia to form the scale is so small that the scale is practically a protection to the iron against the corrosive action of the sodium salt that is held in solution in the water surrounding it. Instances are not wanting to show that the celebrated authority is sound even in the supposition "that land boilers would not last a much shorter time if salt water were used in them." Two cases (four boilers in all) are brought to mind of land boilers on the sea-board, using salt-water, that have far outlasted the twenty years.

Preference is always given to fresh and pure water for use in steam-boilers, both at sea and on land, on account of the great loss of heat in blowing out the solids; and much money has been spent in contriving and experimenting with surface condensers that shall bring the steam back into water free from the solid impurities that it contained before vaporization. This has been accomplished (in conjunction with condensing engines), and had been, it seems, before Mr. Bourne wrote on the subject. The economy of surface condensing is unquestionable, so far as expense of fuel goes.—(S. N. H. *in the Locomotive, Vol. X., No. 6, Old Series.)*

It seems that up to the time Mr. Bourne wrote on the subject, steam-boilers had not been benefited by the fresh water which was supplied by surface condensation. On the contrary, there is ample evidence that they suffered more after the introduction of this system than when coated with a thin scale of lime deposited from sea-water, and later on, the perfectly natural expedient of introducing sufficient sea-water to form such a scale on the water-surfaces was adopted in conjunction with the use of surface condensers, and it was successful so far as the coated surfaces were concerned. But there seems to have been still a good degree of corrosion of the *steam-surfaces*, which, after some time spent in chasing the delusive galvanic phantom, were also coated artificially with cement or lime-wash. This method of protecting steam-chimneys of marine boilers is now practiced with variable results; success depending largely on the skill and watchfulness of the engineer.

It is difficult to explain, from the data in possession of the writer, many of the phases of pitting of iron surfaces that enclose hot water or steam, but he has long had a premonition that the causes when found are as simple as many other formerly obscure, but now easily-explained, phenomena in nature. There are some of the same difficulties in the way of a direct investigation of this subject that there are in studying boiler explosions. Among them it is sufficient now to name the grand one, that all the operations of the agents which bring about the results are beyond the reach of the human senses, always within closed opaque vessels, and usually under a pressure and temperature greater than that of the atmosphere, and therefore no actual observations of their action can be made under practical conditions. Frequent inspection of the apparatus will inform us of what progress has been made by an agent that is itself nowhere to be seen—his work is apparent, but his nature and habits must be studied from his tracks.

The following extract from an article in Ure's Dictionary of the Arts, Manufactures, and Mines (Supplement, page 1079, Appleton's edition of 1864), contains some interesting matter relating to the subject of gases in water. It is from the pen of Dr. Normandy, F.C.S., author of a *Handbook of Commercial Chemistry:*

"It is well-known that sea and other natural waters are saturated with air containing a larger proportion of oxygen and of carbonic acid than the air we breathe. In effect, 100 volumes of air held in solution in water contain from 32 to 33 volumes of oxygen, whereas 100 volumes of ordinary atmospheric air contain only 24 volumes of oxygen.

"Again, *ordinary atmospheric air contains only* $\frac{1}{1000}$ *of carbonic acid, whereas the air held in solution in water contains from* 40 *to* 42 *per cent. of carbonic acid.* (Italics by the present writer.) The experiments which I undertook in 1849–50, with a view to determine the amount of these gases present in the water, showed me that this amount varied with the state of purity of the water; that whilst ordinary rain-water contains on an average 15 cubic inches of oxygenated air per gallon, constituted as follows: carbonic acid, 6.26—oxygen, 5.04—nitrogen, 3.70—total, 15 cubic inches,—sea-water, owing to the various substances which it holds in solution, contains on an average 5 cubic inches of gases, *more than half of which is carbonic acid;* or in other words, one gallon of sea-water contains about two-thirds less gases than ordinary rain-water, and one-half less gases than river-water."

Carbonic acid gas in steam boilers may be a still more delusive enemy than galvanic action, but no harm can possibly come from further inquiry as to its nature and sources.

In Watt's Chemical Dictionary we find the following (Vol. I, page 770, under head "CARBON, OXIDES OF—Carbonic Anhydride CO^2, *Anhydrous Carbonic acid, etc.*"): "It is a constant product of the ordinary process of combustion, inasmuch as all substances used for fuel, such as wood, coal, oil, wax, tallow, etc., contain carbon. It is likewise formed by the respiration of animals, in the various processes of fermentation, as in the preparation of wine and beer, and by the decay of animal and vegetable substances. It issues from fissures in the ground in various localities, chiefly in volcanic districts, and is ejected in enormous quantities from the craters of active volcanoes. From all these sources it is continually being poured into the atmosphere, of which it therefore forms a constant constituent; the average amount of it contained in the air of the open country is 4 volumes in 10,000; in the air of crowded towns it is often much greater." On page 438, same volume, it is recorded that "In the air of crowded towns or of closed inhabited spaces (such as dwelling-rooms, etc.), the carbonic acid often rises to ten times the normal quantity, owing to inefficient ventilation. Although the relative amount of 4 volumes of carbonic acid in 10,000 volumes of air appears to be a very small one, yet the absolute quantity of carbon thus contained in the atmosphere is very large, exceeding indeed all that is contained on the earth's surface in the solid form, in the bodies of plants and animals, and that found under the earth's solid crust in coal formations."

Later information on the subject of Carbon Oxides may be found in Watt's Chemical Dictionary, Supplement (*Van Nostrand's*, 1872), pages 401–5.* On page 405 we read: "The dissolution of carbonic anhydride (acid) is greatly accelerated by adding a little common salt to the water, the acceleration being probably due to a reaction between the sodium chloride (salt) and carbonic acid resulting in the formation of acid sodium carbonate, and *hydrochloric* (muriatic) *acid*." This last agent is put in italics to emphasize the fact that it is a perfect solvent for pure iron, that metal dissolving even in dilute muriatic acid quite readily at common temperatures, but more rapidly if heated.

Whatever may be the apparent discrepancies in the statements of the authorities above quoted, as to the average quantity of carbonic acid in the atmosphere, there is no disagreement among them, even if we include many later ones, as to the character of this compound as a corrosive agent when in the presence of moist oxygen.

While there are many other insidious destroyers of the metal of which steam-boilers are made, still most of them are more easily detected and frustrated.

There are acids in great number—not less than 160 are named in the books—some of which are of course very rare, while many common ones are perfectly harmless, not even sour to the taste. These are all neutralized when free, or in a condition to harm the boilers, by the introduction of an appropriate alkaline solution with the feed-water.

Acids are solid, liquid, and gaseous, mineral, animal, and vegetable. They are subdivided and classified according to various characteristics. The most troublesome are compounds of carbon, hydrogen, and oxygen, which are called *fatty acids*. Of this class there are about thirty, generally formed by the decomposition of some kind of grease. Some of them are hard to detect, because after decomposition of the grease one of the resulting compounds is often soluble in water, and the characteristics of the grease disappear.

Galvanic action, spoken of above as a delusive phantom, when it depends on the acidity of the battery, would seem to be summarily disposed of by destroying the acidity with an alkaline solution.

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*This article contains Regnault's Tables of Vapor-Tensions of Carbonic Acid, which is not only interesting, but astonishing to steam engineers who are accustomed to associate the idea of high pressure with high temperature. It seems by the table that the pressure due to a temperature of + 45 C. = 113 F. is equal to about 1,500 pounds to the square inch; thus, mercury column 76314.6 *m m* high ($25\frac{1}{2}$ *m m* = 1″) $\frac{76314.6}{25.5}$ = 2992″ nearly, and $\frac{2992}{2.04}$ = 1466 nearly, pounds per square inch. This by way of digression is offered as an explanation of the fact that Dr. Beins of Gröningen (see *Popular Science Monthly*, Vol. VII, page 123), has labored for many years, in conjunction with his brother, who is director of the Netherlands Soda Manufactory at Amsterdam, to introduce carbonic acid as the successor of steam. The poisonous character of the dilute gas will probably prevent its general introduction—something as the explosive nature of dilute carbon disulphide has worked against that compound as a successor of steam.

The Locomotive.

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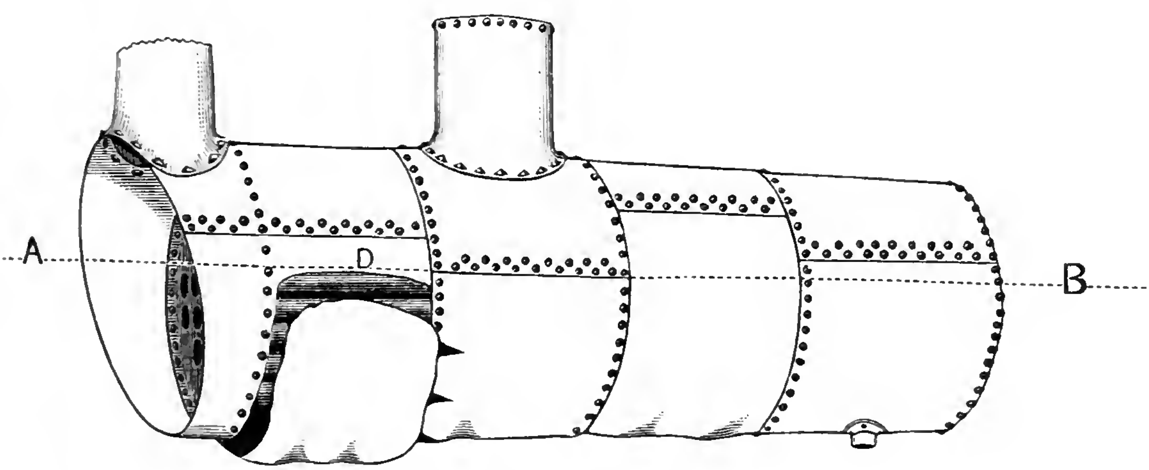
New Series—Vol. II. HARTFORD, CONN., FEBRUARY, 1881. No. 2.

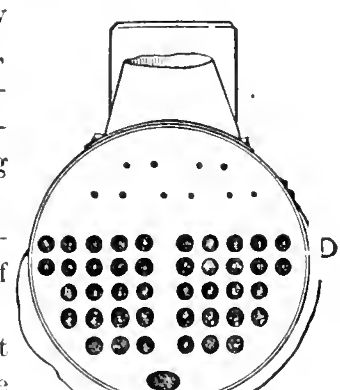
Explosion of an Iron Works Boiler.

J. M. Allen, Esq., *President:*

No. 7 Boiler (Horizontal Tubular 5′ × 15′ at an extensive iron works in this State) exploded Dec. 20th, at about 9.30 A. M. Boiler had on about 60 to 65 lbs. steam. First sheet over fire gave out on side (right) about midway up on side, and started about center of sheet ripping across to girth and head-seams, and thence around those seams, to a corresponding point on opposite side. The torn sheet does not show an opening away



from original position over a few inches, and boilers remained inside the setting on the ground, side walls and front and back plates being thrown over on floor of mill. The cause is very evident. They have at several times had low water in boilers, and have also, contrary to our directions, blown off boilers while brick-work has been hot, thus crystalizing and hardening the iron. At the moment before the accident, they had shut down the engine preparatory to charging the re-heating furnaces.



I send herewith sketch of boiler, as near as possible, showing ruptured sheets, and also serious buckling and sagging of sheets, from the intense over-heating.

If twisted plates are any sign, they must at some time (not many days previous to rupture) have had water all out of the boiler. I send memoranda of inspection on this boiler. Inspector —— made examination, by their request, Nov. 14, 1880, at which time it was ready for internal inspection; and Inspector —— reported everything in good order, except slight bulging on two last courses, not serious.

July 21, 1879. Inspector —— made examination of this boiler, and found it had been over-heated and strained very badly, caused by low water; and also, that the second course of fire-sheet required renewing, which was done, and accepted, as per following inspection, Oct. 11, 1879. Inspector —— says: "Have complied with former report, *i. e.*, putting in new second fire-sheet in second course. They have been in the habit of blowing off boiler, as soon as they hauled the fire; thus leaving boiler, while empty, exposed to intense heat of brick-work." We have repeatedly cautioned them against this and they now see the importance of it.

Very respectfully, R. K. McMURRAY, *Chief Inspector.*

P. S. Verdict exonerated every one except the "water tender." No damage has been done, other than to the boilers, setting, and piping.

An Explosion of a Rolling-Mill Boiler.

Explosions of boilers at rolling-mills and blast furnaces are of frequent occurrence. When we consider their great length, in many cases their defective construction and setting, and the manner in which they are cared for, we confess a feeling of surprise that they do not more frequently explode; run day and night, 144 hours a week, their bottom sheets exposed to an intense heat, with great variation in their work, due to the manipulation of the iron in the furnaces over which they are placed; also from severe strains caused by the sudden slowing and almost stoppage of the rolls at times, by heavy blooms or plates — the engine valves are then wide open, making a sudden draft upon the boilers to keep up the steam supply.

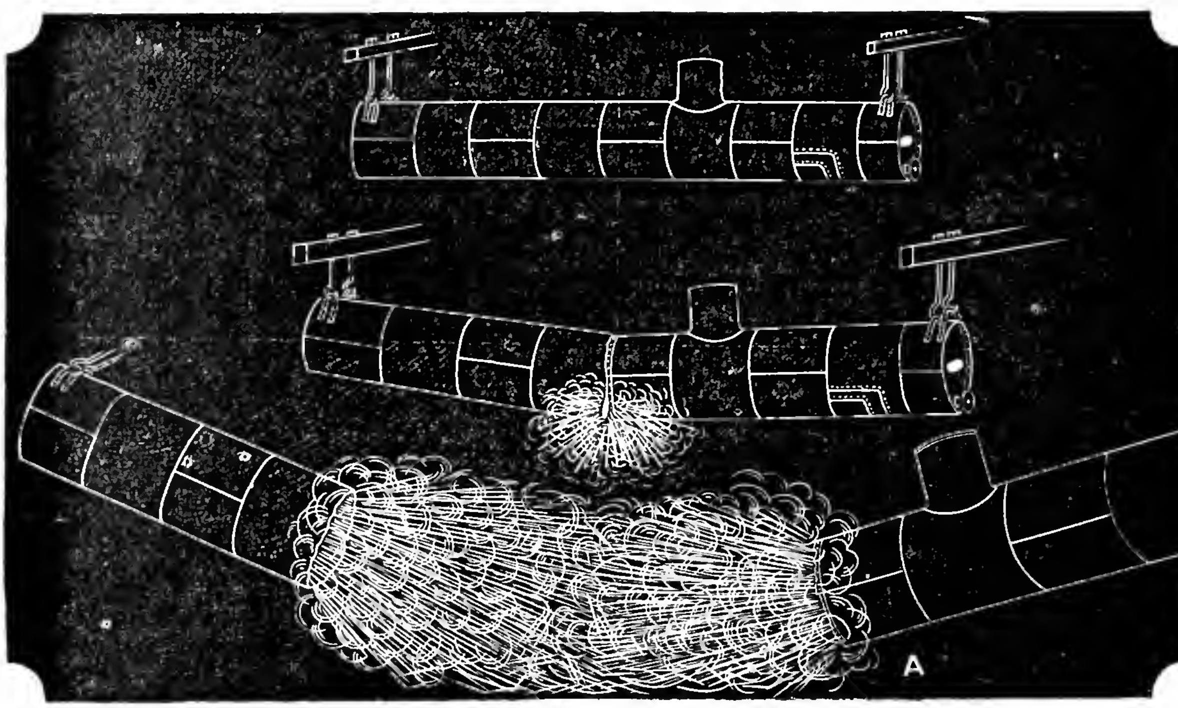


FIG. 1.

The boiler herewith described, known as No. 15 by the mill people, by its explosion caused the death of 13 persons, and the injury of several others, with a loss or damage to property of about $3,000, upon which there was no insurance. It was what is known as a plain cylinder, erected about the year 1871, though it has not been in continuous operation since that time: in dimensions it was 27 feet 5 inches long, 36 inches in diameter; shell $\frac{5}{16}$-inch iron in nine courses, varying a little in thickness as they often do — heads of cast-iron, the feed-water entering through the front head, the blow-off at the back; steam dome 25x32 inches, with a cast-iron head, upon the top of which was mounted a common lever safety-valve of 3 inches diameter, loaded at 65 lbs. pressure; under the valve chamber was a tee (T) connection for the steam-pipe. The arrangement of steam pipes was that generally used in mills of this kind, a main steam-pipe, 8 inches in diameter, leading from the engine through the mill, with 6-inch branches to each boiler. At the places where the branches tapped the main pipe were stop-valves by which its boiler might be shut off the line whenever necessary for examination, cleaning, or repairs. When the explosion occurred, carrying away the connecting branch-pipe, the steam from all the other boilers emptied upon those who were near it; this explains why nearly all the victims of this explosion died from scalds. The setting was built above the furnace in the ordinary way, to utilize its waste heat, which passed upwards through an uptake at one end, turned under the boiler, and thence into the stack,

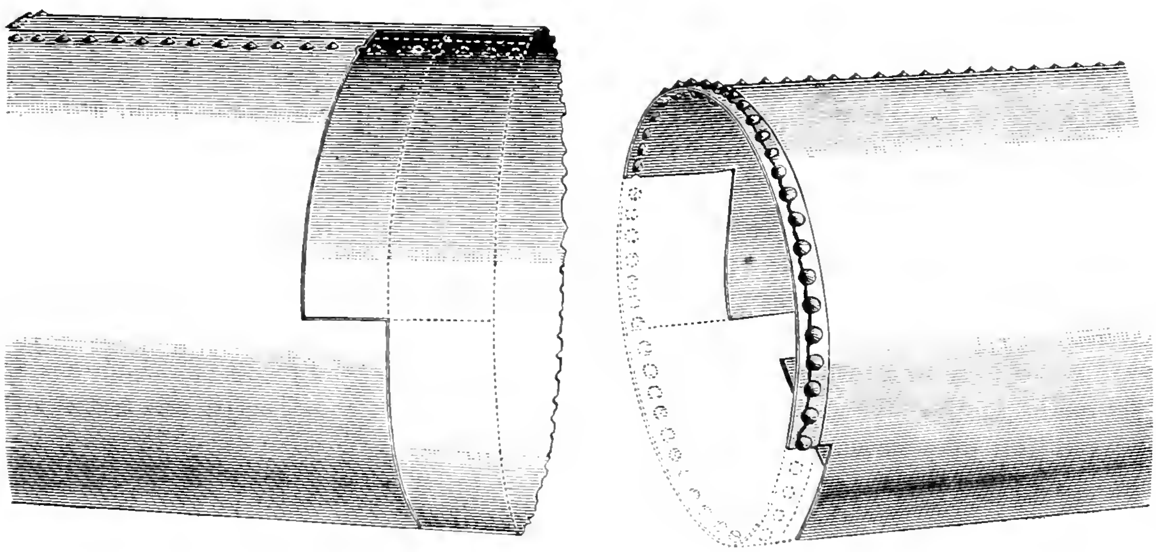


Fig. 2.

the whole resting upon an iron structure about 10 feet above the ground — the weight of the boiler and connections hung upon four brackets (or lugs), one at each side at the extreme ends, making a distance between the supports of 25 feet 3 inches; there were no intermediate bearings or supports. The side walls of the setting closed into the boiler along the middle of its depth about 5 inches below the usual water-line; over the boiler-top was a thin covering of some light material, resting on that a single layer of brick on edge. The foregoing, describing the setting, is based upon an examination of the adjacent boilers, which I was assured were similar in all respects to the one destroyed by explosion.

At the left side of the illustration, Fig. 3, upon the side and bottom of the boiler, it will be noticed there are three patches, patch upon patch, caused by the flame from

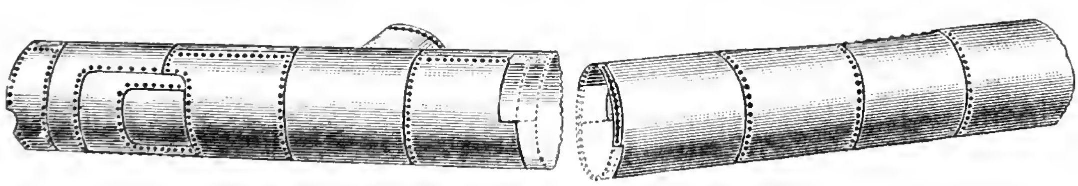


Fig. 3.

the uptake impinging upon the sheet immediately over it, driving off the water, overheating and cracking it. This defect was no doubt greatly aggravated by the feed entering the boiler at that point. It was pumped from an open well at a temperature perhaps of 100°.

The patrons of the Hartford Steam Boiler Inspection and Insurance Company using boilers similarly placed were advised of this danger some years ago. I am speaking more particular of the uptake now, and have generally protected their boilers as advised by its inspectors, by an arch or hood across the uptake, the effect of which is to protect the exposed part as well as curving the flame along the boiler-bottom.

At the coroner's inquest mention was made of the great difficulty and delays occasioned by seam-leaks at back end, and at the uptake end of the boilers. Some of their boilers have, during the last year, been protected by the method just described. No. 15 had been altered in accordance with this plan, at the time a third patch was put on the fire sheet, only five weeks previous.

Some twenty minutes (or more) before the explosion, a leak was reported upon the bottom of the boiler; it seems to have increased for a few minutes after it was thought sufficiently dangerous to have the charge drawn and the fire was dropped. When the explosion occurred, the water tender was at the back watching the leak; he describes it as being in the middle of the boiler, extending about 2 feet around the seam, the point at which separation occurred, see Figs. 1 and 3; the ladder upon which he stood was hurled down and crushed by the fall of the smoke-stack, but he miraculously escaped with some slight bruises and scalds. The rupture, as before stated, occurred at a girth-seam, the line of fracture passing through the rivet-holes, leaving half of the lap held by its rivets in place, as shown by an enlarged view of the ruptured edges in Fig. 2. The parts of the shell missing at the edges were since cut out for the purpose of subjecting the iron to a test to determine its tensile strength, the result of which has not been made public. The material of which this boiler was constructed was apparently charcoal iron of average quality, the workmanship bad, and were its builders known (unfortunately they are not), they richly deserve to be indicted and punished; the superintendent testified their boilers were built for a former management by several different makers, and have since been so changed about they cannot be positively traced, and no one has yet been found who will admit its paternity. An examination of the rivet-holes at the point of rupture proves seven-tenths ($\frac{7}{10}$) were not fair holes, and indicated the drift-pin was used to bring them in position so the rivets could be inserted, thus subjecting the outside lap-seam to a far greater strain in forcing it to its place than it ought ever have been subjected to under steam pressure. There is no good reason for believing that seam was any worse than the others uniting the remaining eight (8) rings of plates; the way the rivet-heads are flattened down and drawn over provokes a strong suspicion that this is the case. If this seam was no weaker than the others, why should rupture occur there? This is answered by many thoughtful men: owing to its great length, and having no intermediate support, the weight of the boiler, connections, and contents, in the aggregate not less than 5½ (?) tons would, by alternate expansion and contraction, bring the greater part of that strain upon its middle seams, analogous to a beam supported at its ends and loaded in the middle; if so, the effect seems evident, it is only a question of the strength of the material composing the lap-seam. It has been determined, by experiment upon single-riveted lap-joints of good material and workmanship, this is from 56 to 60 per cent. of the strength of the plate; but, in the ruptured joint we are writing of, one of these conditions is proven not to exist, viz., good workmanship. Who can tell us the strength of a lap-joint whose rivet-holes have been distended by the drift-pin, as these are believed to have been? Engineers do not agree upon this question of sustaining boilers by center supports, and point to the fact that hundreds of boilers are now running, and have seen some of them twenty or more years suspended as this one was, without giving any trouble, when the material and workmanship were what they should be. A careful inspection should discover evidences of the straining of a girth-seam before rupture occurs. The punching of the rivet-holes is not the only evidence of an utter disregard of all principles of boiler construction by its maker, as is further evidenced by the construction of the steam-dome of 25 inches diameter upon a 36-inch shell with a single-riveted lap, *and the shell cut away the full opening of the dome.*

The effect of the feed-water, which from its source is known to deposit a troublesome lime-scale, has not been discussed, because the scale upon this boiler did not much exceed $\frac{1}{32}$ of an inch in thickness, and did not, in any known way, contribute to the explosion. Nor do I think it necessary, for the same reason, to consider the question of over-pressure (of which there was no evidence). From the preceding statement of what are believed to be facts, I draw the following

CONCLUSIONS.

That this boiler was so faulty in construction as to greatly lessen the margin of safety (strength) which a new boiler should have, that the inherent weakness of its construction was greatly aggravated by the plan of its setting, and, unless sooner discovered and its defects remedied, its explosion was certain, and dependent only upon the strength of its middle lap-seam, and that, in my opinion, had become so weakened by the strain upon it that it ruptured at its ordinary working pressure of about 55 pounds steam, the middle part of the boiler dropping when that occurred; the explosion caused by the issuing steam and water projected its two halves in opposite directions. (See A, Fig. 1.) The fact of so little damage being done to the mill property may, I think, be attributed to the angle at which the parts of the boiler were projected, which probably did not exceed twenty degrees.

This explosion conveys its own lesson, which cannot but encourage those who believe in thorough periodical inspections as a preventive of steam-boiler explosions, and is deserving the thoughtful consideration of others who have not given that attention to the subject its importance demands. The defects pointed out in this boiler as not of uncommon occurrence are, in fact, such as appear in every monthly issue of The Locomotive, under the head of "Inspectors' Reports," but, if they are not discovered and the remedy applied, surely end in disaster. F. B. A.

Boiler Explosions.

Tug-Boat (1).— While the tug-boat General McClellan was towing the oil barge Astral through the draw of the Third street bridge over the Gowanus canal, Brooklyn, N. Y., Jan. 1, 1881, her boiler exploded. A piece of her smokestack struck Benjamin Burt, the captain of the oil barge, injuring his back and breaking his left arm. A flying piece of wood struck Capt. Wilson of the coal barge Mary, inflicting a slight injury. No other persons were injured by the explosion. The tug, which is owned by John McCarthy, her captain, was damaged to the extent of $800.

Paper-Mill (2).— Jan. 1, 1881, a boiler in DuPont & Co's paper-mill, at Louisville, Ky., exploded, scalding two, one fatally. Damages about $1,500.

Rolling-Mill (3).— A boiler in a shop of the Allentown, Pa., rolling-mill exploded Jan. 6, 1881, doing $20,000 worth of damage, killing one man, fatally injuring five men, and badly wounding five others. [Later information is that thirteen persons died.— Ed.]

Smelting Works (4).— Two eight-horse boilers in the vitriol department of Balbach & Sons' smelting works, on the Passaic river, in the southeastern extremity of Newark, N. J., exploded January 7th, from some unknown cause, instantly killing the engineer and three workmen, and seriously injuring two others. Three buildings and about $7,000 worth of machinery were destroyed. One end of the house of E. Balbach, near the works, was wrecked by a fragment of the boiler, and bricks were landed in his room, but he was uninjured. His conservatory and private stable were also destroyed, and two valuable horses killed. E. Babcock, Jr.'s, house, some distance off, was injured by flying bricks, one striking a woman who lodged in the third story. The explosion produced a shock that was felt several miles. Loss, $20,000.

STEAM FLOUR-MILL (5).—Information is received of the blowing up, January 12th, of the Poduc steam flour-mill, situated near Wonewoc, sixteen miles from Reedsburg, Wis. The mill was owned by Jeff. T. Heath. The engineer, George Smith, was killed. Cause, too high pressure of steam; the engineer, being a new one, not understanding the boiler.

THRESHER (6).—The boiler of a threshing engine, near Lucan, Ont., exploded January 12th, killing one man and severely injuring three others.

FLOURING-MILL (7).—The boiler of the Union flouring-mills, Detroit, Mich., exploded January 12th, tearing out the side of the building and completely wrecking the structure. The engineer, a young man named Whittier, the fireman, and oiler were instantly killed and buried under the débris. Three horses were killed. Mr. Sweet, the manager, was just entering the engine-room when the explosion took place, and was blown some distance, but escaped harm.

[Later information is that there was a closed stop-valve between the safety-valve and the boiler.—ED. LOCOMOTIVE.]

SAW-MILL (8).—A terrific boiler explosion occurred in a saw-mill Jan. 13, 1881, at Crossman's Station, Wis., on the Chicago & Northwestern railroad. George Smith, the engineer, was killed, and Wert Benjamin seriously injured.

BLEACHERY (9).—The boiler of John Watson's Passaic bleachery, at Passaic, N. J., exploded January 15th, killing one operative, Owen Gartlin, and seriously scalding another. The boiler was thirty feet long, and the flue which blew out, twenty inches in diameter. No cause whatever can be assigned for the accident, except the temporary absence of the engineer. Coroner Ratan has charge of the case, and will hold an inquest.

DRY GOODS STORE (10).—A singular boiler explosion took place January 16th, in the basement of the large dry goods store of McCreery & Co., Broadway and Eleventh street. Pieces of iron, brick, stone, etc., were hurled in every direction, breaking windows and skylights, but not a person was injured. The damage will fall on the Methodist Book Concern, and is estimated at $10,000.

OIL WELL (11).—A boiler explosion occurred on the Wolf & Nugler lease, near Rixford, Pa., January 16th, seriously, if not fatally, injuring Henry Witherell, who was in charge.

FIRE-BRICK WORKS (12).—The boiler at the Jasper Falls fire-brick works of F. S. Ball, at Elliotville, Ohio, exploded January 17th, utterly demolishing the building, which was 150 feet long by 50 feet wide, and fatally injuring Cooper Stillwell, William Fagan, Frank Stewart, William Dunlavy, and John Layton. Loss on building, engine, boiler, etc., $4,000.

—— MILL (13).—The boiler of Salmon & Moore's mill, Seligman, Mo., exploded January 18th, destroying the mill and throwing the boiler sixty-five yards. William McLaughlin was scalded and terribly mutilated. Three others were more or less injured. Low water in the boiler was the cause.

—— WORKS (14).—Information was received at Steubenville, O., of a boiler explosion near Elliottsville. The accident was occasioned through the negligence of the night watchman, who refused to draw the fires when told there was not sufficient water in the boilers. Shortly after, Engineer Stillwell arrived, and, as he was about to touch the inspirator, the boiler exploded with great force, completely demolishing the building, but not seriously injuring Stillwell. Thomas Fagan was caught under the falling timbers, sustaining serious internal injuries, and having his right leg shattered so that it will have to be amputated at the hip. He cannot live. William Dunlevy had a fearful gash cut above the eyes, and Frank Stewart and John Layton received painful injuries. The damage is $3,500, insured only against fire and lightning; so it will be a total loss. The boiler was an old one, that formerly had been used by the old Buckeye works, and had for several years lain exposed to the weather. The works had only recently commenced operations.

Woolen Mill (Foreign).—A boiler exploded Jan. 19th, in Graham's woolen factory at Dewsbury, England. The building was leveled. Eleven persons were instantly killed and sixteen seriously injured. Several of the injured are not expected to recover.

Thresher (15).—A boiler exploded five miles from Long Prairie, Minn., January 24th, killing Frank Oliver, the engineer, and seriously injuring three others. The men were sawing fence posts, using a threshing-machine engine for power.

Tug-Boat (16).—The towing steamer Minnie, owned by Clark & Co., of Millview, Fla., while on Perdido Bar, exploded her boiler January 24th, killing the captain, the engineer and a fireman. The steamer immediately sank.

Chemical Works (17).—A tubular boiler at the Putnam County Chemical Works, opposite Fort Montgomery, on the Hudson river, N. Y., exploded January 25th, totally demolishing the boiler-house. Four boiler-makers, the only persons in the building at the time, who were making repairs to another boiler, narrowly escaped with their lives. Bartholomew Riley was caught on the head and hand by flying bricks. Francis Kinney was bruised over the eye and on the leg. John Dowling was caught under the falling timbers and had his side bruised. James Finan, who was at work under one of the boilers, remained still and escaped injury. The clothing of each was burned by flying acid.

Plow Works (18).—The boiler of Hall's plow factory at Maysville, Ky., exploded January 27th, instantly killing William Harris, engineer, severely wounding the foreman, and a brother of Harris.

Hoister (19).—By the explosion of the boiler of a stationary engine on Caswell's wharf, Charlestown, Mass., January 28th, four laborers were seriously injured.

Iron Furnace (20).—A terrible boiler explosion occurred January 28th, at No. 11 puddle furnace of the Phœnix Iron Company, Phœnixville, Pa., by which five men were dangerously burned, and several perhaps fatally. The names of the injured are: Michael Hagen, Patrick Hagen, Joseph Crossler, Patrick McCarty, and John Stoneback. It appears that there was a small leak in the boiler, and before it could be fixed the boiler exploded, throwing the iron in every direction. The report of the explosion was heard many miles from the mill.

Steamboat (21).—The steam drum of the steamer Bengal Tiger, which was tied up at the village of California, Ohio, with a tow of coal, was blown out January 28th, and several rooms and the bulkhead were carried away. The crew were nearly all asleep at the time of the accident, and several were injured by the heat and steam. Milton McCabe, the steward, was fatally scalded, and four other persons who were injured were taken to the hospital at Cincinnati. The boat was owned by Joseph Walton & Co., of Pittsburgh.

Picture Frame Factory (22).—The factory of Simmons, Clark & Co., in Clinton street, between Van Buren and Jackson streets, Chicago, was burned January 28th. The fire was caused by a boiler explosion, the engineer, William Platt, being seriously scalded. James Hogan, of the hook and ladder company, received bruises through the falling of the roof. The building, which was owned by the firm, was a plain three-story brick, and the loss on it and the stock is estimated at from $27,000 to $30,000; insured for $18,000.

Dwelling (23).—The explosion of a water back at the residence of William R. Green, at River Point, R. I., January 29th, demolished the range, wrecked the kitchen, and cut and seriously burned two domestics.

Accidents other than Boiler Explosions resulting from the use of Steam.

Cylinder Head Blown Off.—Cylinder head of locomotive on the Delaware, Lackawanna & Western railroad blew off January 18, 1881, disabling the engine.

Vulcanizer Exploded.—Frederick Perry, a lad of fifteen employed in Dr. Tomlinson's dental rooms, 336 Broome street, was left in charge of a machine used in vulcanizing artificial teeth, January 20th. A high degree of heat used in the process was furnished by gas. A gauge attached to the machine indicated the amount of heat to be applied. In some unexplained way the gauge got out of order, and the apparatus exploded with a loud report. The lad, who was near the machine, had one eye put out and his hand terribly burned.

Inspectors' Reports.

1880.

In the absence of returns from some of the large departments for the current month this space, which is usually occupied by the regular monthly reports, is devoted to the consideration of the year's work in detail; the annual summary of visits, inspections, hydrostatic tests, and condemned boilers having already appeared in the editorial columns of the last issue. The whole number of defects, as then stated, was 21,033, of which 5,444 were considered and reported as dangerous. Thus it appears that about one in four of all discovered is the average of dangerous defects for the year. These were of such a character as would not brook neglect, and they were promptly repaired, so that the policy of insurance covering the several boilers in which they were found might continue in force. The mutual advantage to be derived from prompt attention to positively dangerous defects, as well as those of a doubtful and economic nature, has often been discussed in this column, and the readiness with which boiler-owners act upon the company's suggestions and recommendations is a gratifying indication of the growing popularity of this method of securing immunity from boiler mishaps. It is obvious, without argument or illustration, that timely repairs to five and one-half thousand of dangerous conditions has saved many human lives and much valuable property from destruction. Although it is by no means claimed that each dangerous defect would have resulted in destructive explosion within any given period of time, still there is no doubt that a large number of them would have furnished business for professional expert witnesses and coroners if they had been left to themselves or to the management of stupid attendants, who are often hired at a rate of pay that indicates incompetence if nothing more. The advantage that competent professional boiler-inspectors have over even the most competent local engineer in judging of the condition as to safety of any given steam-boiler is something like that of the practicing physicians over the amateur, or even the professional chemist, who does not practice, in judging of the probable termination of a diseased condition of the human body. The inspector, like the doctor of medicine, depends largely upon post-mortem examinations, and their respective abilities may be nearly measured by the interest they take in the study of obscure defects in the defunct subject. The details of the defects for the year 1880 are as follows:

Furnaces defective, 1,105—284 dangerous; fractured plates, 2,075—1,268 dangerous; burned plates, 1,165—369 dangerous; blistered plates, 3,644—421 dangerous; cases of sediment and deposit, 2,759—628 dangerous; incrustation and scale, 3,901—533 dangerous; external corrosion, 1,257—440 dangerous; internal corrosion, 933—300 dangerous; internal grooving, 234 — 109 dangerous; water-gauges defective, 525 — 117 dangerous; blow-outs defective, 218 — 92 dangerous; safety-valves overloaded, 258 — 139 dangerous; pressure gauges defective, 1,685 — 427 dangerous; boilers without gauges, 771 — 21 dangerous; cases of deficiency of water, 119 — 65 dangerous; defective bracing and staying, 403 — 229 dangerous; boilers condemned, 377.

Increase of work in the inspection department in 1880, and the grand total since the organization of the company.

	1879.	1880.	Increase in 1880.	Grand Total.
Visits of inspection, - -	17,179	20,939	3,760	163,697
Number of boilers inspected, -	36,169	45,166	8,997	331,218
Complete annual inspections, -	13,045	16,010	2,965	108,160
Number of hydrostatic tests, -	2,540	3,490	950	24,853
Whole number of defects, -	16,238	21,033	4,795	163,065
Number of dangerous defects, -	3,816	5,444	1,628	36,627
Number of boilers condemned,	246	377	131	1,840

A Good Way to Set Up a Boiler Feeder.

This little item is clipped from a local paper, and printed here as a curiosity of carelessness in the management of steam boilers, as well as a sample of careless paragraphing:

"What might have been a fatal disaster to many was happily averted at the works of ———, in ——— street. A couple of weeks since a man came along, and, after some negotiation, sold the company a patent pump to use with the boiler. The machine was set in operation to fill the boiler, but, after being in operation a short time, it was, by the merest chance, discovered that the pump was forcing water out of the boiler instead of in, and in a few minutes more the boiler must have burst with terrible results. The question now agitating the minds of the proprietors is who the man is that sold the pump. They do not even know his name."

A boiler feed pump — however much it may be patented — that is set with its delivery valve opening toward the water supply, in the absence of the necessary boiler check-valve, or with it reversed, and with the feed stop-valve open, does not require to be set in motion in order to allow the water to flow from the boiler, an excess of pressure on the boiler side of pump being the only condition to be added to the above probably existing ones in this case. Although the item is not accurate in an engineering sense, still it is an interesting commentary on the practice of some steam-users of *playing engineer* themselves, and likewise on that of those who employ men who, notwithstanding their license to act as boiler attendants, know so little about the contingencies of the business as to allow a boiler feeder to be attached so as to feed the tank or the city pipes instead of the boiler. The incident also emphasizes the importance of purchasing boiler-appliances from reliable houses, that employ careful men to attach them *right end foremost*, as well as the advantage to be derived from supplementing all repairs and alterations with competent inspections.

Solar Boilers.

In a note before the Academy of Science, in Paris, Mr. A. Pifre describes a compound reflector having a focal length much less than usual. The zone of maximum heat is nearest to the lower part of the boiler, and the laws of the heating can be easily studied.

The reflector presents a usable surface of about 100 square feet to the sun. The boiler contains 18 cubic feet of water. When the sky is clear the water boils in forty minutes, and the pressure rises one atmosphere every seven or eight minutes. In several experiments every six minutes have been sufficient to raise the pressure one atmosphere. The machine connected with the apparatus has a new construction, and a pump connected with it lifted per minute three and one-half feet of water to a height of ten feet. This labor is ten times as great as that previously obtained at Algiers.—*Scientific American.*

The Locomotive.

HARTFORD, FEBRUARY, 1881.

In another column will be found a report on the explosion of the boiler in the rolling-mill at Allentown, Pa., which has been variously commented on by those who have visited the scene of the accident. The report is made by an engineer of wide experience, who has been long in the employ of this company, and has examined many exploded boilers, and given the cause of such accidents careful study. It will be noticed that the causes assigned are defective workmanship and insufficient support. Of the defective workmanship little comment can be made. Workmanship on boilers is either good or bad. If bad, there is no excuse, and accident may occur at any time. As to the question of the best manner of supporting boilers in iron works placed over furnaces, there is a wide difference of opinion. It is well known that long boilers, particularly of the plain cylinder type, with the heated gases brought in contact with their lower half, are subjected, with reference to their top and bottom, to great differences in expansion, and unless the supports are distributed with some reference to this, there will be more or less trouble and danger of accident. We have conferred with many iron manufacturers, and suggested changes in regard to boilers and their settings or supports, and we are convinced that they may be so set and supported as to be safe. One of the difficulties encountered is this: often the blast is shut off suddenly; the boiler and brick-work are in a highly heated condition; a current of cold air is allowed to pass through the furnace, and, coming in contact with the bottom of the heated boiler, it is suddenly cooled and contracted.

This is liable to fracture the plate at the girth seams in the line of the rivet holes. Now, if the boiler is supported only at the extreme ends, a great strain will be brought to bear at or near the center girth seam, and, as plain cylinder boilers have no tubes and few braces, when this difficulty once begins there is nothing to prevent the boiler from parting, and the two sections flying off in opposite directions. We had a curious experience once, resulting in an accident due to this cause. The blast was shut off when the boiler was under some sixty pounds of steam. A current of cold air was allowed to pass into the furnace. The brick-work being very hot, the steam was kept up nearly to a pressure of sixty pounds for some time. The cold air suddenly cooled the bottom of the hot boiler, fractured it at the central girth seam, and away it went, some half an hour or more after the fires had been shut off. This was looked upon by some as one of the "mysterious agencies" by which boilers explode, but investigation showed that it was the result of causes easily explained. Now the question is, How can these difficulties be easily and inexpensively overcome? We will endeavor in the next issue of the Locomotive to give some suggestions relative to supporting boilers in iron works, with illustrations which we think will be worthy of consideration.

THE INDEX to Volume I. New Series, of THE LOCOMOTIVE, may be had by patrons and friends of this company who have preserved a file for binding, by sending their address, and application for the same, to the president of this company, or the editor, at Hartford, Conn., U. S. A. We would suggest to those who are interested in this paper that they preserve the copies as they are issued, and at the end of the year we will furnish an Index to all who apply for it. It is impossible for us to supply complete sets or bound volumes now.

The Weakest Point.

[Continued from page 15.]

Referring again to the incidental advantage (mentioned on page 14) of inside man-hole frames, it will be seen on examination of the accompanying cuts that the plate or cover, shown in section, elevation, top and bottom plans, in the figures, has a plane surface for its entire top, which may readily be made true and smooth on the planer to fit the planed seat of the frame (shown in dotted lines, Fig. 9), which is the first step in the process of fitting, the bolt-hole having been cored with a square "counter-sink" to receive the head or clinch of the bolt as seen in section Fig. 7, and in plan Fig 8. The object of the square cavity ("counter-sink") is to prevent the rotation of the bolt in the plate when unscrewing the nut, which tendency will be realized if the threaded point above the nut becomes corroded so as to make the nut run tightly. This is frequently the case in an aggravated degree with hand-hole plates in the smoke connections, as every engineer has experienced to his great annoyance. The bolt, therefore, should have no exposed thread outside of the nut on hand-hole bolts. After the plate is planed the holes may be drilled and tapped for the two handles and the four gasket guide-pins, Figs. 7, 8, and 9. The collar of the bolt should be turned on its lower face and threaded for a square nut of good thickness, running freely on the bolt. The bolt-end being of sufficient length below the collar may now be heated, placed screw down in a hole in a heavy iron block, the collar resting on the face of the block, the plate in its place on the bolt, and a good round head formed.

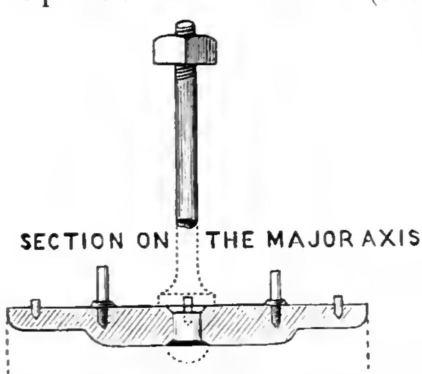


FIG. 7.— Plan for inside man-hole frame.

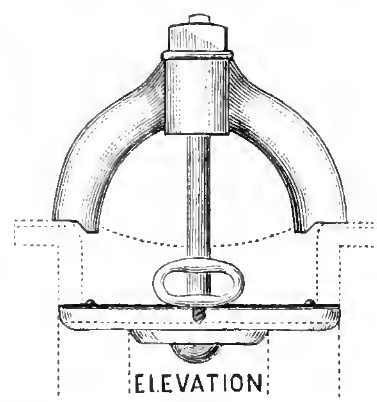
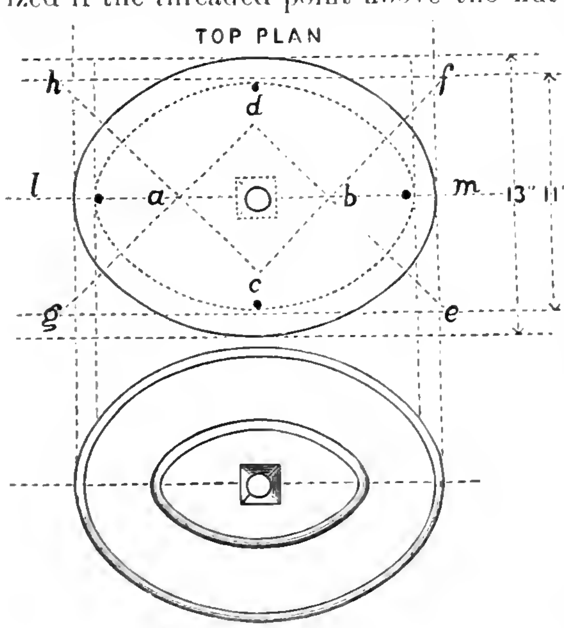
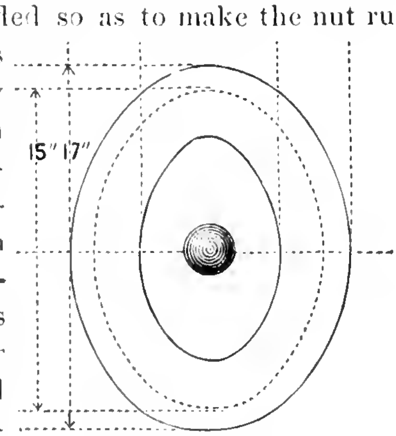


FIG. 9.— Arch and plate for inside man-hole frame.



BOTTOM PLAN

FIG. 8.



BOTTOM PLAN

FIG. 10.

(To be continued.)

Iron vs. Steel for Boiler Plates.

The question of iron *vs.* steel for boiler plates continues to be the subject of an animated discussion in England and on the Continent. Both sides of the controversy are being conducted with considerable skill, and some facts of interest are elicited from various sources. It will be remembered that attention was again directed to the subject by the failure of the steel boilers of the Livadia. After the plates had been passed as excellent in quality by the shipbuilders, by the Russian inspectors, and by the officials of Lloyd's, the finished boilers broke down under a test which was by no means severe. It was naturally concluded that there was something radically wrong. The case does not, however, by any means sufficiently justify a wholesale indiscriminate condemnation of steel as a material for that purpose, nor would it, on the other hand, be wise to pass by such a failure in absolute silence. The present and great prospective value of steel is fully admitted by all who have had occasion to test its merits. We have, however, the testimony of too many intelligent and disinterested constructors as a proof that the new material, "ingot iron" or "mild steel," is subject to sudden and, apparently, unaccountable failures. The interests of producers of steel and of their customers are not well served by any attempt to pass by these failures in silence, and it is certainly a poor argument on the part of the friends of steel to urge that iron is worse. What is wanted is a full and clear statement of facts, so that it may become possible to fix with certainty the dangers to be avoided and settle upon the best treatment to be adopted. Whether and under what circumstances open-hearth, or Bessemer steel, is permissible or preferable is also a matter which will come up for early decision. As yet there is — justly— an inclination to adhere to the milder qualities of metal turned out by the open-hearth process, and, as we have had occasion to state, the result has been very favorable to it in this country. It has been urged that the favor which steel has been gaining in England is due, to a large extent, to the liberality of the rich steel-making firms in the matter of credits and the promptness with which they are willing to replace defective plates by new ones. As a business measure, in introducing an unknown material, such a course is evidently a wise and prudent one, but we doubt whether an attempt to keep occasional failures as quiet as possible, by taking back rejected plates, is still the correct one. Boiler-makers have sufficient confidence in the new material, and consumers will not now be frightened off by a free discussion of the matters relating to its use. Little can be gained, and much lost, by undue reticence, and we hope that in the next few years the questions relating to the treatment of steel boiler-plates will be freely and fully entered into. The failure of the Livadia boilers is a case in point. All that can now be said can only be general in character, until specific and detailed facts are forthcoming to form a sound basis for argument.—*Iron Age.*

The Livadia — the extraordinary steam vessel built for the Czar of Russia — is again brought prominently forward by the failure of her steel boilers under a hydraulic test. *Engineering* has the following concerning the occurrence:

The *Engineer*, of London, states that since the report of the failure of the Livadia's boilers it has received information of other failures which have recently occurred in steel boiler-plates, and that in first-class establishments.

It appears that so far no theory has been advanced to explain the cause. In point of fact, according to the *Engineer*, the matter has been kept quiet, new plates being immediately supplied to replace the defective ones. This is to be regretted, inasmuch as steel being a comparatively new constructive material, the characteristics of which are practically but little known, it would be to the interest of the world at large that the most thorough investigation of every failure should immediately take place, and the results be recorded, to add to our experience on the subject. Steel has come into general use so rapidly of late, and promises so much, that it must be to the advantage of all concerned in its production and use, that all uncertainty as to its capabilities should be cleared away as fast as investigation and experience will accomplish that end. — *The American Engineer.*

The Preservation of Iron from Oxidation.

[From Iron.]

It is now about three years since Professor Barff announced to the world his happy idea of applying in practice the well-known principle of exposing heated iron to the action of superheated steam, whereby it acquires a tenaciously adherent coating of magnetic oxide, which acts as a preservative of the metal against rust. We have now to announce the practical perfecting of another process for producing the same results, which has been developed by Mr. George Bower, of St. Neots, Hunts. This consists in exposing heated iron to the action of air, and also of carbonic acid, whereby it not only acquires an equally sufficient protective coating of the magnetic oxide, but at the same time assumes a delicate French-gray color, which for many purposes obviates the necessity for painting the metal. Before describing this process, it may prove interesting if we briefly glance at the history of its development. And first we may observe that it was only by the merest chance that Mr. Bower did not discover the very process which has added so much to the fame of Professor Barff. It appears that some twelve or fourteen years ago Mr. Bower was making some experiments connected with the decomposition of water, by passing steam through red-hot iron in a retort, when he found that the iron decomposed the water rapidly at first, but that it gradually got less and less active, until it ceased to have any effect whatever. This led him to make an examination of the iron, when he found it coated with a sort of enamel, which suggested the idea of the process being used for that purpose. Upon exposing it to the atmosphere, however, the coating separated from the body of the iron, and Mr. Bower pursued the matter no farther. This separation was due, no doubt, to the iron operated upon being old and rusty. If it had been new the probability is that Mr. Bower and not Professor Barff would have been the first to introduce the coating of iron by magnetic oxide produced by the action of aqueous vapor on red-hot iron.

When Professor Barff's success was published to the world it occurred to Mr. Bower that what the Professor was able to do with water he could do with air, and he began a series of experiments which, by dint of patience and perseverance, and the expenditure of a considerable amount of time and money, ended in complete success. The air process, thus perfected by Mr. Bower, consists in the use of a retort or chamber, heated by the external application of heat. In this chamber the articles to be treated are placed, and when red-hot a few cubic feet of ordinary air are blown into the chamber, and the cover is tightly closed and left for a short time, when it is found that the iron has entered into combination with the oxygen in the air, and a first thin film of magnetic oxide has been formed. By repeating the operation as many times as may be necessary (and this depends on the nature of the articles operated upon) the desired thickness of the coating is produced. The time required for producing the protective coating varies from six to ten hours. Beautiful and simple as this operation is, it was found in practice that it was attended with considerable difficulty, and great wear and tear in heating the chamber, and the articles in it, by the external application of heat. It, however, occurred to Mr. Anthony S. Bower, a son of Mr. Bower, that it would be a great step in advance if the articles could be heated by the combustion of gaseous fuel inside the chamber, and if the coating of magnetic oxide could be produced at the same time. Thereupon commenced another long series of experiments, during which hundreds of tons of castings were treated and broken up as failures, but only to end, as in the purely-air process, in complete success. Having recently been afforded the opportunity of investigating the working of this improved process at Mr. Bower's works, we are able to place all particulars before our readers.

In carrying out the process a set of three small gas furnaces for the production of carbonic oxide are constructed by the side of a chamber sufficiently capacious to contain about a ton of miscellaneous articles, and which, when we were examining the process, consisted of gas brackets and lantern-frames, umbrella stands, pots and pans, and ornamental figures and panels. Under this chamber is a series of pipes for heating the air by the spare heat as it escapes from the furnace to the chimney, prior to its being used for the combustion of the carbonic oxide. This improved process, the joint patent of father and son, consists in alternately oxidizing and deoxidizing the iron. The articles are heated by burning the gaseous fuel inside the closed chamber, and heated air — in excess of the quantity necessary for the perfect combustion of the gas — is made to enter along with the fuel. This air, together with the product of combustion (carbonic-acid gas) produces, next the metal, magnetic oxide, and on the top of it a film of sesquioxide, which is reduced to magnetic oxide by shutting off the air and applying carbonic oxide only, for a short time. But this is not all, for, in addition to the protection from rust, the articles are rendered ornamental in appearance by the delicate French-gray of the outer film of the coating they have received. If, however, the color should not be suitable from an artistic point of view, there is the certainty that, if it be necessary to paint over the coating, it will stand the same as if painted on wood or stone, as no rust can form underneath to throw the paint off, as is the case with paint upon ordinary iron. Another great feature of the process is, that it is an inexpensive one. The apparatus we saw at work at St. Neots is capable of dealing with a ton of iron-work per day, and the wages of one laborer and the cost of five or six cwts. of small coal is all the expense attending the operation.

Where there are foundries connected with blast furnaces, the process may be carried on at very little expense, as pipes, and such-like goods, could be oxidized by the hot-air blast, and, if necessary, be deoxidized by the furnace gas. Indeed, one of the best samples of iron Mr. Bower now has is a bar which was subjected to the action of the hot blast by Messrs. Cochran of Dudley, so long ago as the middle of 1877, and it is perfect as ever, though it has been exposed out of doors ever since that time. In the Birmingham and Wolverhampton districts, there are thousands of tons of small castings produced daily to which the process could be applied. Indeed, the process opens out a new field altogether for the application of iron to the arts, and renders it capable of taking the place of some of the more expensive metals. The oxide thus formed has been tested very thoroughly, and is found to withstand all ordinary atmospheric conditions perfectly. It appears to be thoroughly incorporated with the metal, as, indeed, it must be, for it is the union of the iron with oxygen that forms the coating. A firm of iron founders in Glasgow have successfully put the process to a severe proof both by fire and water, while Mr. F. J. Evans, the late engineer of the Chartered Gas Company, and Mr. Joseph Kincaid, C. E., both approve of the process, after having tested for a lengthened period articles coated by it, and we can testify to its simplicity and the beautiful results obtained by it. We may also add that we have tested articles protected by this process by exposing them to the weather during the whole of last autumn and winter with the most satisfactory results. We certainly congratulate Mr. Bower and his son upon their double success in rendering cast and wrought-iron not only useful but ornamental. — *Van Nostrand.*

Acquiring a Trade.

[An Extract.]

A very general misapprehension seems to exists among mechanics' apprentices as to their duties and the object of their apprenticeship. Nine out of ten consider that the entire object of their novitiate is to acquire a knowledge of the use of the tools of their trade and facility in their handling, and that with this acquirement their trade is learned and their apprenticeship ended. Thus we have so many mechanics who, instead of being masters of their trades, have their trades for their masters. The mechanic who can use his tools only under the direction of a boss or overseer, has not attained to the mastery of his business, and, unless he does, he will be, all his life long, a slave to the contingencies of mechanical demand. It is not to be supposed that every mechanic can be a boss, but it is competent for every mechanic to be qualified by his acquired knowledge for the position, even if he does not possess the necessary natural capabilities to be a leader and director. Not every skillful workman can manage the affairs of a shop or direct a body of men, but he understands, as well as those who can, what is necessary to be done and how it should be done. The market always — with rare exceptions and under peculiar circumstances — is glutted with unskilled labor, but it is seldom, except when business generally is utterly prostrated, that a really skillful workman cannot procure remunerative employment. Such men are always in demand when there is work to be done. An employer prefers an intelligent workman to the most painstaking and faithful laborer who is but an animated machine.

The day's labor should not be regarded by the workman simply as a task, and the hours spent in the shop as so many infractions of his general liberty. If he feels an interest in his work the toil will be a pleasure and the shop be considered a school. This interest can be created and fostered by persistent effort to understand the *why* of a job as well as to know the *how*. All mechanical manipulations are founded on strictly scientific principles, a knowledge of which may be obtained from text-books and manuals, and the possession of which will give an interest to what otherwise would be but a monotonous and wearisome drudgery. This knowledge will incite to improvement, and may lead to invention. A workman who is fertile in expedients, who is ready in emergencies, quick at suggestion, and apt at understanding present requirement, is invaluable in any concern. He cannot long occupy a merely subordinate position and rank among the drudges.

There is scarcely any mechanical business in which a knowledge of drawing and geometry will not be valuable; there are few to which the science of chemistry is not allied; a knowledge of arithmetic and algebra is useful, and natural philosophy, as applied to the science of mechanics, is a great aid to success in mechanical operations. All these may be acquired by the mechanic by his own efforts and the aid of text-books.—*Exchange.*

The Locomotive Engineer.

The London *Telegraph*, in a recent editorial, pays a splendid and deserved tribute to the men who hold the lives of hundreds in their hands — the locomotive engineers. It says: "Most passengers are as ignorant, happily, of the pitfall under their feet as of one of the intricate processes of digestion of the anatomy of the human frame. They take their journeys as they take their food, trusting blindly that somehow or other it will be all right, and that the narrow corners will be shaved, and it seldom occurs to them to express their thankfulness for the manly devotion which contributes to their safety. While faith is the guiding rule of the traveler, duty is the absorbing principle of the railway servant. But does it never occur to the wakeful traveler, as the lamps flash past him, as the train rushes over bridges and through a network of signals, as the tunnel seems a duller roar and the lighted station a suppressed scream, when the pulse of the motion never stops and the impetus at times becomes almost terrible, what a sense of gratitude there ought to be towards those lonely men who, faithful to the end, turn this point and that, shift the lamps, keep watch and ward, and clear the way for the swift express? Those who have trusted themselves to this splendid power are utterly powerless. Their lives are in the hands of the men who drive the train, and of the signal men who watch. Yet there is no sleep in the signal-box or at the tunnel mouth; there is no conversation, no distraction — nothing but a dull monotony of duty. A score of things may have happened; the staff may be short-handed, some one is unexpectedly on the sick-list; some good-natured fellow may have done double duty out of pure comradeship; but this makes no difference in the safety of the line. There need be no cause for fear when such men know their duty and do it."—*Exchange.*

Incorporated 1866.

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The Locomotive.

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Explosion of a Steam Dome.

On the afternoon of Sunday, January 16, 1881, the head of the dome on one of the steam boilers under the sidewalk at No.— West Eleventh street, New York city, blew out with sufficient force to tear up twenty or thirty feet of the heavy flag stones, iron girders, and gratings, composing the sidewalk and rear entrance-steps to the elegant dry-goods establishment of McCreery & Co., corner of Broadway and Eleventh street. The following extract from this company's agent, who saw the wreck soon after the explosion took place, explains itself:

"I send herewith sketch of the steam dome, and such data as I have been able to learn

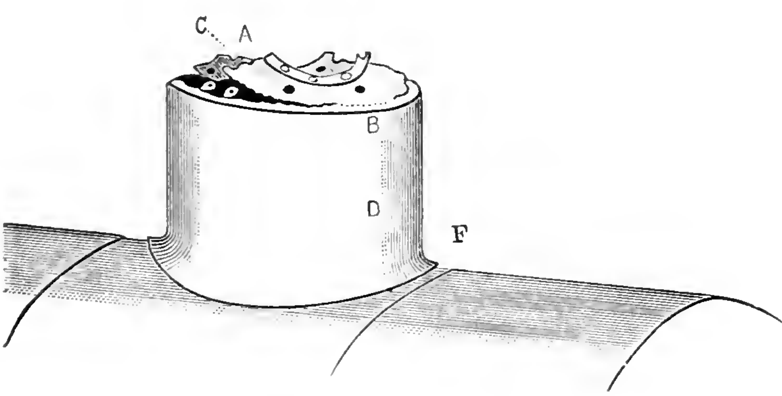


FIG. 1.

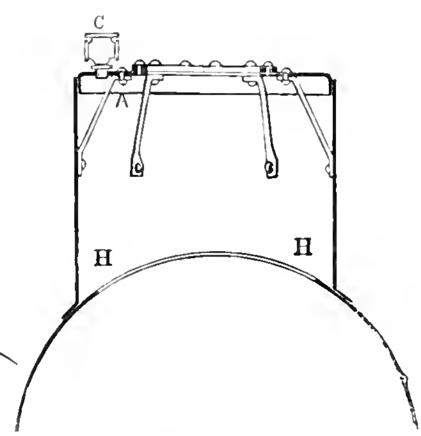


FIG. 2.

concerning the recent explosion at the building owned by the Methodist Book Concern, the boilers being under the control of Messrs. McCreery & Co., who leased a part of the building. The boilers, two in number, are each 54″ diameter by 16 feet long, of the horizontal tubular type, built by the Logan Iron Works about eleven years ago, and

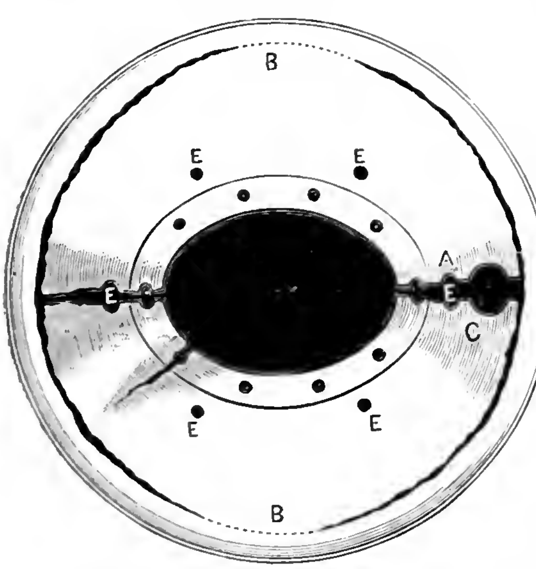


FIG. 3.

they have been in operation since. The working pressure was about 45 lbs. to the square inch, and the work pretty uniform, viz., heating the building. The boilers were situated under the sidewalk in a vault, and it is to this fortunate circumstance that the damage to the property is no greater — $3,000. The engineer and fireman came on Sunday about noon to look after the fires, etc., and they claim to have left everything in good shape, and left soon after, leaving the watchman in charge. During the afternoon the watchman notified the "Burglar Alarm" office that there was an accumulation of gas in the building, and he was going to raise one of the windows. At about 5.30 P. M., there was a violent explosion. It was ascertained that the dome-head of the boilers had been blown off. The dome was 34 inches diameter by 24 inches high. It had a man-hole plate in the head, strengthened by an iron band $2'' \times \frac{1}{2}''$, and there was a two-inch safety-valve on the head (at C), set to blow off at 65 lbs. per square inch. The rupture occurred through the major axis of the man-hole and along the angle of the head flange, leaving the seam intact, the part blown out being thus separated into two pieces, parting through the major axis of the man-hole opening. The shell of the boiler was cut out nearly the full size of the dome (30–34). The braces (6) were of inferior workmanship of $\frac{3}{4}''$ round iron, welded eyes for a single rivet (at each end) and $13\frac{1}{2}''$ long."

The report contains also the opinions of the writer as so the probable conditions that allowed of the over-pressure which undoubtedly existed, and which, as he intimates was probably due to an inoperative safety-valve and an accumulation of steam that could not escape by any of the prescribed openings. It therefore found the weakest point, which under the circumstances was most fortunately located so as to accomplish the least possible destruction.

Every phenomenon connected with the explosion points with unmistakable clearness to a pressure of steam in excess of the strength of this part of the boiler, which the sequel shows *was* the weakest part, when the safety-valve was inoperative. This important organ may have been stuck fast for months, since the hydrostatic test was applied (according to the history of the case) five months before.

EXPLANATION OF THE CUTS.

The figures are each of them correctly proportioned, but not all drawn to the same scale. The same reference letters indicate the same parts or their location in all the figures. The man-hole plate is omitted, to allow of clearness of illustration. It had no important effect on the strength of the head.

Fig. 1 is a perspective view of the dome, showing its position and size relatively to the front end of the boiler, and the probable course of the ruptures from the weakest point A (in all the figures), the brace rivet that first gave way under an overpowering load, the other braces (E E etc. fig. 3) giving way consecutively, breaking the rivet or the brace, or pulling the head or point of the rivet through, the yielding being governed by the character of the new strains that the parts suffered after the breaking of their leaders, B B figs. 1 & 3, the last parts to give way, which were the hinges upon which the halves of the head turned over, striking at D, fig. 1, and falling upon the boiler at F F.

C indicates the location of the safety-valve, which was attached to the head by a $2\frac{1}{2}$-inch short nipple screwed in as shown in fig. 2.

Fig. 2 is a vertical section through the sound head, dome, etc., showing four of the six braces, and the portion of the plate cut away in construction, the section being on the major axis of the manhole, which is also the line of initial rupture. The part of the shell-plate which was removed in construction is indicated by the white portion of the arc H H. This had no weakening effect on the parts that first gave way, but is mentioned in the report above as indicating carelessness in construction. All parts of this dome remained whole except the head and braces.

Fig. 3 is a plan of the ruptured head, drawn $\frac{1}{16}$ of an inch to the inch, or $\frac{3}{4}$ of an inch to the foot. It shows the weakness that existed on the line of rupture. It has been taught by some writers who have illustrated this explosion by drawings that the braces, being the longest of the sides of the triangles, expand more, and finally, by thrusting the middle of the head up, the angle of the flange is so weakened, in time, that the whole gave way simultaneously in the most absurd manner. Now, if the brace was much the hottest of the three sides of the triangle, a slight motion might occur at the angle; then it follows that lengthening and strengthening the braces, as has been done, and as was a proper thing to do to the new dome, would only weaken the structure in case the brace was heated more than the side of the dome. This is the age of discovery— but where is Euclid? As a matter of fact, the angle of the flange along which rupture ran was as sound as flanges in this kind of metal usually are before the braces gave way, according to the judgment of those who have seen hundreds of torn boiler-plates.

THE EXPLANATION OF THE EXPLOSION,

then, is easily made, and may be readily understood by any one having a little practical knowledge of the application of the mechanical powers and the imperfections that creep into all human devices for controlling natural forces. A gradually accumulating pressure being conceded in this case, a single rivet, that at A, for example, which, owing to the "claw-hammer" strain that the loaded brace would communicate to it when its angle yields to the straightening effect of the pressure on the head, would be placed in a state of tension by this leverage, far greater than the calculated strain which is allotted to it as its share in the support of the head. A slight or perhaps a considerable imperfection in this rivet may have existed since it was placed there, even to the extent of being half cracked off under the head. An overpowering load is thrown on its neighbors when it gives way, and then the whole of them go one after another, and the head splits and tears away, turning completely over, and swing out of the terrible current of expanding water that springs with irresistible velocity from every part of the boiler through the opening, carrying everything before it; the fragments of the head hang by the hinges upon which they have turned over till they strike the side of the dome, where the hinge is broken and they both remain on the top of the boiler, where they were found, while the manhole-plate was broken by being thrown violently against the stones of the walk above and projected across the street into a dwelling, narrowly missing some of the occupants as it dashed through the parlor folding-doors.

The explanations that have appeared in one or two local papers, accompanied by incorrect drawings, have tended to convey the idea to the reader that this head was lifted squarely from its place, owing to some fancied defect (not explained) in the angle of the flange through which the secondary rupture passed, or in the braces, which were all so imperfect as to give way simultaneously and let the head go, as a cover might be squarely lifted from a blacking box. This view of the matter leads to the enquiry, "What could have done it? Certainly there is some mystery here." And the mystery is enhanced by the accompanying statement that there was but two or three pounds of steam indicated by the gauge soon after noon, or a few hours before the explosion, and everything in condition to prevent an accumulation of steam, as well as a proper safety-valve to relieve it in case of an accidental error in management. But to readers of this paper no such doctrine will commend itself, unless the statements of thousands of inoperative safety-valves from fifteen or twenty different causes found in the practice of this Company are deemed sensational fiction, or the vilest of trade-tricks to frighten people into having their boilers insured.

Boiler Explosions.

MONTH OF FEBRUARY, 1881.

Plumbing Works (24.) — Mr. Leroy Leavenworth, of the firm of Leavenworth Brothers, Bridgeport, was severely scalded about the face Wednesday night, Feb. —, by the explosion of a boiler that he was using to thaw out frozen water pipes. The apparatus was defective in some respects compared with a finished boiler, and when it exploded threw a cloud of steam around that burned Mr. Leavenworth painfully, and his assistants slightly.

STEAM YACHT (25.)—A few minutes before 12 o'clock, Feb. 2d, the boiler of the pleasure yacht Carrie, of Philadelphia, lying at Chase's wharf, foot of Caroline street, exploded with terrible effect, making a complete wreck of the vessel. Policemen and others hastened to the wharf, which they found covered with débris from the vessel, and the hull sunk alongside the wharf. The large boiler was thrown from its position, and lay against the wall of a warehouse about fifty feet off. All the upper deck and engine-house had been torn off and fragments of wood and other materials on board the boat strewn in every direction. The crew of the yacht consisted of Edward Poplar, aged twenty-two; Harry Poplar, aged nineteen, both sons of the captain; Joseph W. Brown, deck hand; a colored steward named Ellis, and Engineer Young. The crew, with the exception of the engineer, who was not on board, were missed immediately after the explosion. Search was instituted, and the remains of the men found in different parts of the shattered vessel, more or less mutilated.

DWELLING (26.)—The water front of the kitchen range exploded Wednesday morning, February 2d, at the house of Mrs. Mann, in Florence, Mass., smashing the range into pieces and tearing up things generally. Mrs. Mann had fortunately just left the room.

DWELLING (27.)—The range in house of Rev. Andrew McKeown of Charlestown, Mass., exploded soon after a fire had been lighted, owing to the pipes connecting the range with the boiler being frozen. The range was completely demolished and live coals were scattered over the room, damaging wood-work and smashing a window.

FLOURING-MILL (28.)—The boiler in the flouring-mill of Frank Schmidt, at Kimswick, Mo., twenty miles below St. Louis, on the Iron Mountain railroad, exploded about 6 o'clock on the night of February 3d, with terrible force, almost completely demolishing the mill and killing John and Frank Schmidt, sons of the proprietor, and Charles Backler, a boy of fourteen years, and seriously wounding Frank Schmidt, Sr., and the miller, named Taylor. Fragments of the boiler and furnace were hurled in all directions, some of them passing through the brick walls of the National hotel, a hundred yards away, and doing considerable damage to the building. The loss is estimated at from $15,000 to $20,000.

DWELLING (29.)—The water back in the range at the residence of James Guayer, at 302 Garden street, Hoboken, exploded February 4th, just as the family had finished breakfast. The range was totally destroyed, and the walls and windows of the room were torn to pieces. No one was injured.

——WORKS (30.)—While caulking a boiler at Eaton, Madison County, N. Y., February 4th, E. S. Vine was seriously scalded about the face and chest by escaping steam.

—— MILL (31.)—A boiler exploded in Henry Stevens' mill near Fish Lake, Mich., February 7th, fatally scalding William Thompson, the engineer.

HOISTER (32.)—A drill boiler on Bannerman & Co's works, section 33, of the Welland canal, exploded February 4th, instantly killing Herbert Atkinson and seriously injuring six others.

MACHINE SHOP (33.)—The boiler in the Varney Pegging-machine shop at East Brookfield, Mass., owned by Charles Sibley, exploded Sunday, February 13th, but luckily nobody was hurt.

SUGAR-REFINERY (34.)—The man-hole plate in the mud-drum attached to boilers at the Peoria sugar refinery, Chicago, blew out February 14th, with great force, knocking an immense hole in the fire wall and scalding the firemen who were at work. Michael Carney fell down in the steam and water and was almost instantly killed. Others were badly injured.

KNITTING-MILL (35.)—The steam-boiler in the knitting-mill of Lamb & LeRoy, Cohoes, N. Y., exploded February 13th. Several persons were injured, none fatally.

STEAMBOAT (36.)—The Lafourche packet Assumption, discharging at the foot of Conti street, New Orleans, exploded her donkey boiler February 15th, tearing away part of the forward cabin. The damage is estimated at $2,000. One man was killed, and one or two fatally, and eight more or less severely, hurt. The cause of the explosion is not known.

——MILL (37.)—A boiler in Dush's mill, at Dushville, Mich., exploded February 16th, instantly killing Andrew Gearhart, and seriously injuring four or five others.

SOAP-WORKS (38.)—The boiler in the soap factory of F. W. Meyer, Louisville, Ky., exploded February 22d, killing Meyer and injuring his son William. Loss by damage to building $250.

TUG-BOAT (39.)—The tug Minnie Hunt, of Baltimore, while towing a number of barges down the bay, exploded her boiler February 27th, instantly killing Charles Hunt, the engineer, and Joseph Moore, the fireman, both of Baltimore.

——MILL (40.)—The boiler of J. T. Heath's mill, near Wonewac, Wis., exploded a few days ago, killing George Smith, the engineer. The explosion was caused by too high pressure of steam, the engineer being a new one, not understanding the boiler.—*Lumberman, Jan.* 29, 1881.

FOREIGN STEAMBOAT (—.)—The steamer Pitpan, running from Greytown to Lake Nicaragua, burst her boilers on January 2, 1881, while going over the Machuca Rapids in the San Juan river. Among the killed are Dr. Arguello, Mr. Mongalo, a merchant of Greytown, and a native whose name is unknown. General Urtecho, Administrator of the Adnana in Greytown, was severely scalded and otherwise injured. Several others were scalded more or less severely. The accident has caused great distress along the river, and may have a bad effect on shipments from Nicaragua by the river.

Accidents Other than Boiler Explosions.

STOP-VALVE BURSTS.—At the Adams silk and cotton mill in Van Houten street, Paterson, a new 100-horse power boiler has just been put in. On Wednesday night the men finished the connections, and about 2½ o'clock of the morning of January 20, 1881, the wheel of the big globe valve was turned to admit steam from the old to the new boiler to try it. Just then the globe valve burst into a dozen pieces. John Tracy, the boiler tender, was knocked over, but not seriously hurt. Charles Knobler was burned about the hand and arm. Thomas Wheeler was scalded in the face, and will probably lose one of his eyes. Charles Burchell was scalded about the face and neck. None of those injured are likely to die.

PLUG BLOWN OUT.—Louis Dermond, engineer of a portable mill at Aldrich, Minn., recently undertook to stop a leak in the boiler by screwing up a plug, which blew out into his face. Being on his breast under the boiler he was unable to escape, and was so badly scalded that he died on the following day.

Inspectors' Reports.

Below is the one hundred and seventy-second monthly summary of work in this fundamental department of this company's business. It relates to the first month of this year, and, so far as the figures representing the visits and inspections go, it indicates a very encouraging state of the business of guaranteed inspections as practiced by this company.

In the month of January, 1881, there were made 1,701 visits of inspection, and 4,068 examinations were made; of this number 1,250 were thorough annual inspections. The hydraulic test was applied in 264 cases.

The examinations thus made resulted in the discovery of 1,619 defects, of which 484 were considered dangerous. The percentage of dangerous defects is here much higher than the average, being almost exactly 30 percentum of all the defects reported. This feature has rather a serious aspect, and should convey a lesson of warning to both parties to the indemnity contract. It seems to call for greater care on the part of the owner in looking after his boiler-attendant, and more urgent appeals by the company's agents to the assured to heed the directions of the company relating to the preservation of their boilers.

The following figures relate to the nature of the defects discovered in the 31 days of January. Furnaces out of shape, 56—15 dangerous. Fractured plates, 219—115 dangerous. Burned plates, 100—46 dangerous. Blistered plates, 273—49 dangerous. Cases of deposit of sediment, 181—42 dangerous. Incrustation and scale, 291—44 dangerous. External corrosion, 87—44 dangerous. Internal corrosion, 75—18 dangerous. Internal grooving, 17—6 dangerous. Water-gauges defective, 41—12 dangerous. Blow-out apparatus defective, 12—4 dangerous. Safety-valves overloaded, 25—15 dangerous. Pressure-gauges defective, 134—42 dangerous. Boilers without gauges, 60. Cases of deficiency of water, 12—8 dangerous. Broken, loose, and insufficient stays, 36—24 dangerous. Boilers condemned, 32.

Although each item in this report is worthy of and will get attention from prudent boiler-owners who read this paper, still it seems as though special attention ought to be directed to safety-valves, for it is certain that they should receive a greater share of care than is usually bestowed upon them, since so many are found overloaded or inoperative from neglect. A valve that has been adjusted to blow off at a pressure considerably above the working point, and then left to itself, may, and the chances are that it will, become cemented to its seat, for of course it never blows while the usual volume of steam is being drawn from the boiler. When its services are needed in an emergency it cannot respond. And it is actually a *danger-trap* instead of a *safety-valve.*

It is not necessary to warn the observing engineer against an accumulation of pressure from banked fires in his absence, for *he* will be certain that his safety-valve will attend to such a case and give him or others within hearing due notice; neither is it necessary to inform such a man that it is possible for an accumulation of pressure to occur even with closely-banked fires and damper, furnace, and ash-pit doors closed. The draft being strong, the damper leaky or open just a crack (they are never air-tight), air enough will find its way into the ash-pit to keep the bank of coals burning quite enough to keep up a strong heat in the furnace and flues, and under these conditions nearly all the heat will be absorbed by the boiler, and, all steam outlets being closed, the pressure may rise to a dangerous degree much more quickly than when the bank of coals is wasting rapidly under the influence of a large volume of rapidly-moving air which, with damper wide open, passes largely through the uncovered portion of the grates and over instead of through the burning coals, and so dilutes the gases and cools the boiler that steam will fall instead of rise, although the fire is burning much more briskly than when just air enough finds its way through leaky doors to keep up moderate combustion, the heat of which is almost all absorbed by the water, instead of passing off rapidly by the chimney.

Every safety-valve should be heard from once at least in each twenty-four hours that the boiler is at work, or as often as the steam acquires the limit of tension, or else by means of a pulley and cord or chain, arranged as a hand attachment to be used daily when the load on the valve is so much in excess of the working pressure that the valve does not blow automatically.

If these facts were realized, and the suggestions acted on, we should have fewer *midnight and Sunday afternoon explosions* to record and explain the mysteries of.

The Locomotive.

HARTFORD, MARCH, 1881.

Steam Boilers in Iron Works.

In the LOCOMOTIVE for February we had something to say about the insecure manner in which boilers are supported in iron works, and promised some suggestions as to the best methods of accomplishing this end. There are expensive settings which we will not discuss here, our object being to present some plain, practical plans which can be easily and inexpensively carried out by any competent boiler-maker or superintendent of the works.

It is not uncommon to find boilers fifty and sixty feet in length of the plain cylinder type. They are heated by gases taken from the top of the cupola furnace, which enters the boiler under some pressure and "licks" the bottom of the boiler its entire length. These boilers have usually been supported at three points, one at each end and one in the middle, as shown in Fig. 1. This is apparently a proper disposition of the supports,

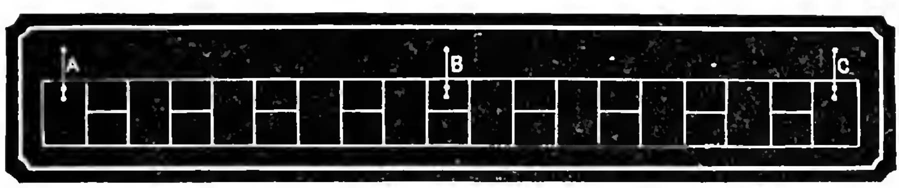


FIG. 1.

but in use it is found to develop some features that are liable to result in accident. When the heated gases are brought in contact with the boiler bottom, this part is raised to a temperature greatly in excess of the top of the boiler, and by greater expansion, corresponding to the excess of temperature, the boiler becomes curved in the direction

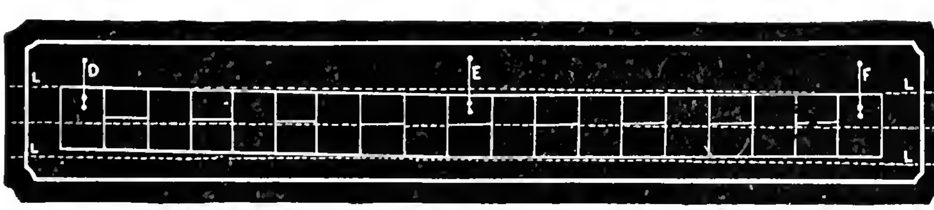


FIG. 2.

of its length, as shown in Fig. 2. By this process, the ends being thrown up, the entire load is thrown upon the center support, and this being unable to carry the heavy burden imposed upon it sometimes breaks away, and the shock — the boiler being under the working pressure of steam — has in a number of instances broken the boiler at the girth-seams, and great destruction followed. As we said in a previous article, when a plain cylinder boiler supported at the ends breaks at a girth-seam, there is nothing to prevent the two portions flying in opposite directions. And with the center support of the above boiler broken, and a fracture at any of the girth-seams, it becomes a very dangerous affair, and unless the fires are stopped at once and the pressure reduced, it is liable to part and fly off. But this defect may not be discovered until too late to prevent disaster. An accident occurred in the Mahoning valley, Ohio, several years ago, which had its origin in the breaking away of the central support of a boiler fifty feet long. This was in a battery of ten boilers, and the breaking or explosion of one broke the steam connections of the others, suddenly releasing the steam, besides knocking them more or less out of place, until nine of the ten boilers left their settings and were scattered in fragments over a wide territory. Great destruction resulted. Freight cars, trestle-work, and bridges were demolished, besides damage to buildings. This accident led to an investigation into the best methods of supporting these long boilers. We consulted with some of the largest iron manufacturers in the country, suggesting such changes and improvements in the methods of supporting boilers as we believed to be safe; and we have known of no disaster to boilers supported in the way described below.

The point to be attained is to so support the boiler that the load will be properly distributed under the changes of form to which the boiler may be liable under heat. If the boiler is rigidly bound to its supports, it will not rest easy. An improvement on the

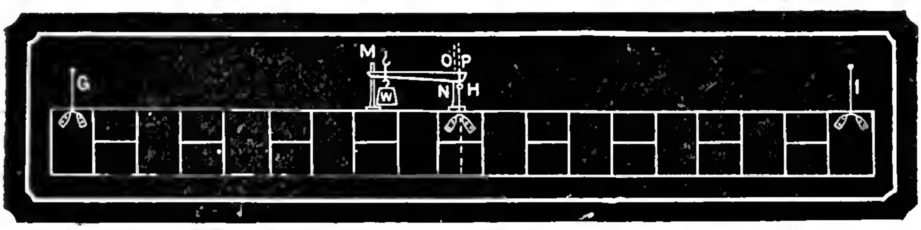


FIG. 3.

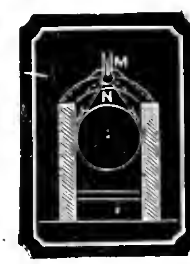


FIG. 4.

old plan is to have two supports at each end, properly distributed with reference to its length. For instance, in a boiler fifty feet long, place one support five feet from the end and the next about five or six feet from the first. This distributes the load among the four supports, and has decided advantage over the three supports. Another plan which has worked well in practice is to have supports at each end and one in the middle, adjusted to a lever and weight arrangement, as shown in Figs. 3 and 4. To properly adjust this apparatus, the weight of the boiler with the contained water must be calculated. We will suppose the boiler to be fifty feet long and four feet in diameter. Allowing for laps, rivets, and cast-iron heads, with the contained water the weight would be approximately 30,000 lbs. The center support would naturally carry half the weight of the boiler, or 15,000 lbs.* We will now suppose the long arm of the lever (measuring from the point at which the weight W is suspended, to fulcrum) to be five feet, and the short arm three inches (as short as possible for easy adjustment of the hanger), and we have 5 feet = 60 inches, divided by 3 = 20, and 15,000 divided by 20 = 750 lbs., the weight (W) required for the proper adjustment approximately. Cast-iron weighs (average) 450 lbs. to the cubic foot, hence the weight (W) would be less than two cubic feet of cast-iron. For easy adjustment the weight (W) might be in several parts, as in the case of ordinary scales. The lever should run in guides outside the weight (W),

* This is assumed on the ground that if the boiler was cut into at center and supported by one hanger, half of the weight of each would be sustained.

as shown in Fig. 3. There should also be a seat for the end of the lever to rest on when the boiler is not under steam.

The cast-iron arched beam for the fulcrum is shown in Fig. 4. The point on the arch on which the lever bears should be narrowed up so as to present as little surface as possible consistent with the required strength. This plan has been used for some years by Fayette Brown, Esq., of Cleveland, Ohio, and he reports it a success. It will be seen by this arrangement that the moment the boiler expands on the bottom and curves as shown in Fig. 2, the load being thrown upon the center support, it easily yields, and the end supports are compelled to do their share of the work.

Another plan which we have often recommended, but which has not been very generally adopted, is shown in Figs. 5 and 6. Little explanation of the figure is necessary, as any one will see the principle at a glance. The location and adjustment of the *beams* so as to properly distribute the load, however, is important. In the illustration the boiler is assumed to be fifty feet long. The first supports from the ends are each five feet distant. The length of beam from outer to inner support is eight feet, making the distance of inner support from end of boiler thirteen feet. This leaves between the

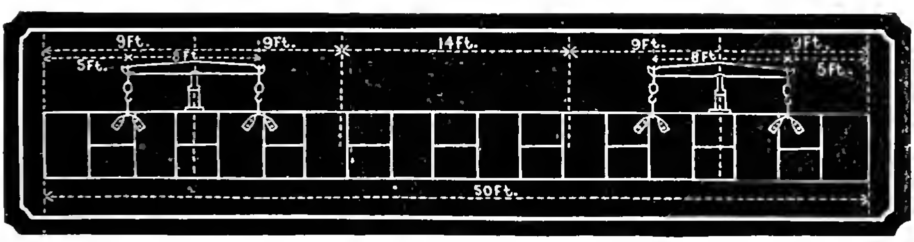


FIG. 5.

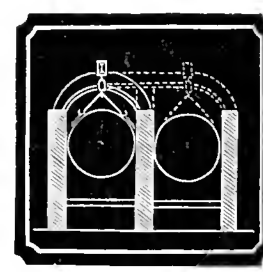


FIG. 6.

inner supports a distance of twenty-four feet. The beam might be made ten feet long, and under some conditions it might be best, leaving but twenty feet between the inner supports. But the ease with which the boiler adjusts itself to the varying conditions of heat and expansion prevents the unnatural strains to which it is liable when supported by rigid hangers. Fig. 6 shows the arched supports for the beams. These arches can be made to extend over two boilers so as to set them in pairs, as shown in the figure. In making the longer span arch, due consideration must be given to the required strength for supporting two boilers instead of one, as well as to extra strength on account of its form. Brick piers might be built up from the boiler walls and a deep iron beam put across for the support, instead of the arch. Whichever plan is adopted, the brickwork and all the work should be thoroughly and well done. We have a feeling that the boilers in many iron works, particularly at furnaces, are not as well cared for as they should be.

They are frequently entirely uncovered, out of doors, subjected to the rains and snows. The attachments become corroded and inoperative, and the wonder is that more do not explode.

We have in this article considered the supporting of long boilers only. But the plans herein described can be adapted to short boilers as well. We believe that long boilers in iron works might be profitably dispensed with and shorter ones substituted. Of this we may have something to say at some future time.

The Weakest Point.

[Continued from page 31.]

Whatever may be said regarding the effect of domes, drums, and the like on the economy of the generation and distribution of steam, the fact remains that many such adjuncts are in use on stationary boilers, where there seems to be less excuse for complications that are not clearly beneficial than there is in locomotive or marine boilers. Notwithstanding the many arguments that are being and have been for years used against their economy, as well as their strength, yet they have many strong advocates, and as it is the business of this company to insure all insurable boilers that are offered, it is proper, and will, no doubt, be beneficial, if both parties to the contract study their weak features in order that a correct estimate may be made of them, and as fair a judgment as may be formed, as to whether they are really weaker than some other unavoidable weaknesses which are inherent in all forms of boilers. The longitudinal seam, for example, may be considered such a weakness, but as stated in a former article the estimation of its strength, when made of fairly uniform material, is a simple problem compared with those to be applied to large openings with everybody's guess-work reinforcements.

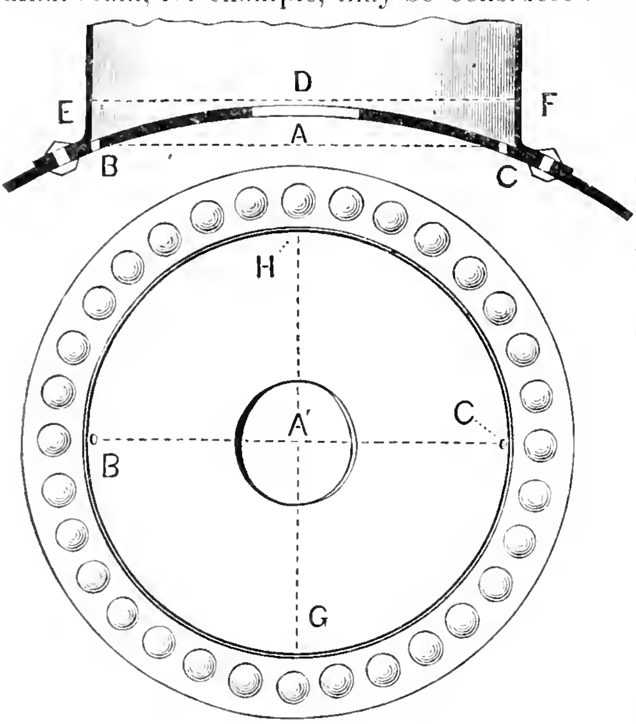


FIG. 1.

The usual method of explaining the parts of steam boilers, as well as other structures, is by plain sectional drawings and elevations, but the section of a steam dome, as usually drawn on a plan, is well calculated to mislead those who are not familiar, in a practical way, with the subject. A good method for such readers is to examine the strength of a common hat brim in reference to its ability to resist a radial outward pressure at the plane where the lowest points of the cylinder join the brim, as at BC, figs. 1 and 2. Pressing outward, with the hands placed at these points just inside the hat, it will be observed that the diameter GH, at a right angle to the line BC, is shortened, and the cylinder (supposing the body of the hat to be a true cylinder) is flattened about as much as the line BC is extended by the pressure inside. It is plain that fixing the points G and H so that they cannot approach each other will resist the extension of the line BC, more especially if the brim or flange is securely riveted all round to a firm object; then it seems that no extension can take place without stretching or splitting both the object at B and C, and the brim at the points EF. In good boiler practice the arc BDC is a plate bent to the true circle due to the radius of the cylinder, and the flange of the dome is accurately formed to the same circle, and they are firmly joined with rivets pitched not more than two inches from center to center, and often by two circular rows. The plate represented in section by the arc BDC has a sufficient hole in the center for the passage of the steam and small drip-holes at the low points B and C for the escape of the water of condensation back into the boiler. Now in this condition the steam pressure will be alike on both the upper and the under side of this plate, and it appears on the drawing to be only a bent stay between the points B and C, and the tendency seems to be very strong when the points B and C, so held, are pressed outward, to depress the summit of the arc to A and reduce it to a straight line. But now keeping in mind the form of the plate, which is that of an arched roof, and examining the plan A, fig. 1, wherein the ridge or summit of the roof corresponds to the line GH, it will appear that in order to depress the arc the line GH must be curved down and extended, stretching or splitting of the material, or drawing the points G and H towards each other. When, therefore, the points B and C are really moved apart the material of both cylinders, the dome and boiler-shell, must stretch or split somewhere. The material of which boilers are made does not admit of very much stretching, but any overpowering load on a dome will usually cause leaks at the low points and give due warning of distress, the significance of which must be estimated by the conditions in each case. This feature of the dome is the most complicated one in its construction; the head or cover may, however, be still weaker if not properly stayed, as was the case in the one illustrated on another page. It is proposed to take this matter into consideration, along with the head-bracing of the main cylinder and that of other flat surfaces.

If, now, the part of the shell that is covered by the dome is all, or nearly all, cut away, as shown in fig. 2, one considerable element of strength is destroyed; then if the

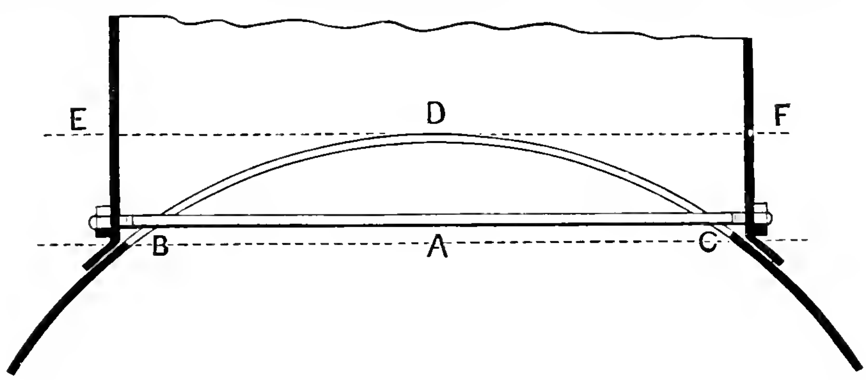


Fig. 2.

dome is of considerable size compared to the main cylinder, say 30″ diameter on a cylinder 48″ diameter, as here drawn, then a stay-bolt should be put across from B to C, fig. 2, which will effectually prevent motion and consequent leakage, as well as greatly strengthen the boiler shell on its weakest line.

It seems to be obvious that wherever it can be done domes covering considerable areas of the shell should be avoided. If, however, the necessity of large storage-room for steam is demonstrated or believed to exist, it may be readily and more safely provided by connecting some desirable form of storage vessel by suitable necks of such construction and size as to leave no room for doubt as to their being stronger than the longitudinal seams of the main cylinder.

The following diagrams, figs. 3 and 4, are introduced for the purpose of comparing their weak features with those of the longitudinal seam in any given boiler sheet upon which it is desirable to attach a drum by means of a neck. Let fig. 3 represent two views of a portion of a 54-inch shell having a 42″ drum attached by means of a neck 12 inches in diameter, as shown. Of course it will appear that the part of the neck which extends below the summit of the cylinder is very trifling, compared with the corresponding part in the large dome, FC, fig. 2, and the brim or flange greatly strengthens the neck and compensates, in great measure, for the weakening of the shell by cutting away the 12-inch disc for the opening. Neglecting this compensation, which, of course, varies with the thickness and consequent rigidity of the flange, let us compare the bare opening, as to strength, by the same rule that some teachers of boiler science use for similar calculations, viz., estimate the whole load on any longitudinal line of a boiler by multiplying the load on a unit of length of the line (say an inch) by the number of inches in the line to be considered. Without affirming or denying the correctness of this method, it may be said that if it is admissible for a whole boiler it ought to apply, in this case, which may be considered (barring the transverse seams which are never considered in calculating the strength of the longitudinal seams) a fourth part of the length, the other three-fourths being uniform with it, the boiler having four necks. It is not uncommon to find boilers of this diameter running at very respectable pressure of steam, with longitudinal seam single-riveted, as shown in fig. 3. And this practice, which is not approved of or recommended by this company, is not only tolerated, but actually defended by the present practice of boiler-makers of long experience and of more than average intelligence and enterprise as business men. The acknowledged weakening effect of the longitudinal lap-joint, E, fig. 3, due to a row of rivet-holes of the ordinary diameter and pitch is from 35 to 45 per centum of the original strength of the plate, leaving from 55 to 65 per centum remaining, and it is easy to compare, by the above rule,

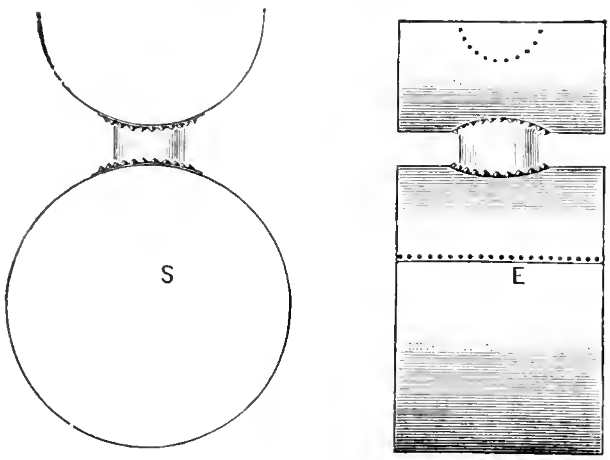


FIG. 3.

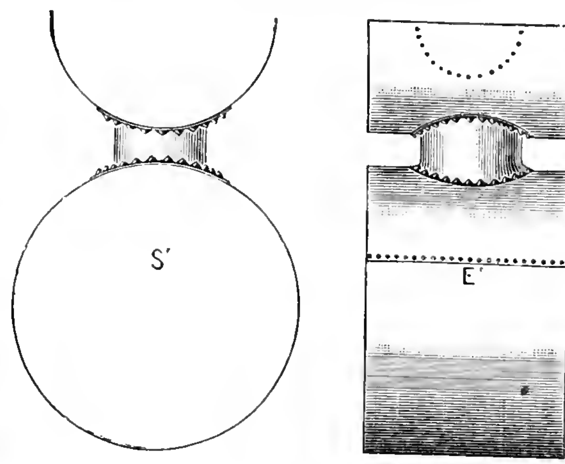


FIG. 4.

the strength of a longitudinal line passing through the uncovered neck-hole, which is its very weakest state, having possibly two rivet-holes in the same line, the main opening being 12″ dia., and the two small ones each $\frac{3}{4}$″, making $13\frac{1}{2}$″, and the whole plate in which they are cut being 48 inches, we have $13\frac{1}{2}$-48ths of the line at the summit of the arc cut away; this is about 28 per centum of weakening, against an average of 40 per centum in the longitudinal seam as above. But when the neck is properly secured to cover the openings the strength is restored to a degree that varies with the correctness of the proportions and the workmanship. This class of work is very apt to be bunglingly performed by the workman by attaching a rigid flange, say of cast-iron, of the wrong curve, or of no particular curve at all, to the cylinder, and so distorting its form, which the internal pressure will restore, or place the parts in a much higher state of tension than what would be due to legitimate strains, which are always the ones contemplated by the rules for estimating them. The neck thus properly proportioned and well made is far stronger than the longitudinal seam. As necks of larger size become necessary, their strength should be increased and the work should be done with greater care, never leaving a doubt about their being much stronger than any seam in the structure.

[To be continued.]

Drums and Domes—What are they for?

[Written for THE LOCOMOTIVE by S. N. HARTWELL.]

It may be profitable to study a few points relating to the necessity of the use of domes and drums and their influence on the economy of steam-making. It is held by some prominent teachers in steam economy that they are not only unnecessary but a positive detriment. If this is true and to be added to the other undoubted objection, which is their weakening effect on the boiler-shell, then they should of course be abandoned. There are two principal reasons why their advocates consider them advantageous. First, increase of steam storage-room, whereby variations of pressure from sudden drafts of a considerable percentage of the volume of steam are reduced. Second, the prevention of priming or lifting of the water which may go over with the steam, the dome or drum effecting a reduction of the velocity of the current within it, and allowing the water to separate and be returned by drip-pipes to the boiler. The steam-chimneys of marine boilers in addition to the above-alleged advantages act as superheaters or re-evaporators of the lifted water, but it is proposed to limit this discussion to stationary boilers.

It will perhaps be conceded by even the most ardent advocate of necks, domes, and drums that an increase in the volume of stored steam in domes, etc., involves an increase of enveloping surfaces, and hence increase of condensation of the stored steam, and that the same volume of steam will suffer less condensation, when stored under like external thermal influences, when all in one body than when divided into a number of small bodies in separate or protuberant vessels, such as drums and domes, partly or wholly out of contact with its source of heat, namely, the water from which it was generated. Mathematical demonstration is not necessary to make it appear that the cooling influence is greater when the entire bounding surfaces consist of more or less exposed iron walls than when a large percentage consists of water-surface from which the steam is constantly arising, for so long as steam does arise from the water no refrigeration can take place at its surface. These facts seem to be too plain to require discussion.

Diagrams intended to show what increase in size of the main cylinder will be necessary to compensate in storage-room for steam, for the omission of the several samples of drums and domes which are chosen for illustration, are in process of preparation and will be introduced in a following number.

[To be continued.]

Benefits of Good Tools.

There is an old saying to the effect that "it takes a good workman to make a good job with poor tools." So it does, and there have been many triumphs, recorded and unrecorded, of brain and skill over seemingly insurmountable obstacles. It is a satisfaction to compass a result with apparently inadequate means, and the mechanic who does it is justly proud of his success. But working with poor tools is never certain to produce good results however great the skill and inventive the brain. Misses are made as well as hits, and even the most self-assured workman feels safer with good and applicable tools. No workman can afford to risk his reputation and success with poor tools; there is so much risk of a failure and such anxiety for the result, that even if success is attained it has been at the expense of time, thought, muscle, and trouble that robs it of half its gratification.

The time has gone by when the workman was expected to "make something out of nothing," when one implement or appliance was made to do duty for another, and "makeshifts," their origination, use, and application to the job in hand were part of the kit of the workman. The constant and growing improvement in tools and labor-saving machinery have not only increased the profits of the manufacturer, but lightened the labors of the workman. The machinist who learned his trade thirty years ago would be ashamed to resort to the wretched substitutes of tools with which he was then compelled to do his work. The carpenter knows the advantages of the mortising machine, the moulding machine, the band saw, and other improvements. The blacksmith sees the advantages of the drop hammer, the shears, the steam hammer, and the portable forge; and even the farmer who keeps up with the times appreciates the mowing machine and the many improved hand tools which facilitate his operations and reduce his labor. There may have been brain-energy and labor wasted in the production of improved tools and appliances; for there are some which have never met the expectations of their contrivers or filled the wants of the users. But, in truth, there has been no portion or department of mechanical endeavor that has accomplished better results or reached higher success. The number of special tools now used is wonderfully great as compared with thirty years ago. There is no manufacture of consequence that has not its special appliances, machinery, and tools, and in tools for general work the improvement has been fully as marked. Even in hand tools the improvement is obvious to the slightest observation. In every department of industry these improvements have made their mark. They save time and labor, and produce more satisfactory results. It is a wise economy to reject imperfect tools, and, as the patent-medicine men advertise, "use the best." Whenever an improved implement is put into the market, one that will do the work better or quicker, it is economy to buy it, even if the old one is intact and serviceable.—*Boston Journal of Commerce.*

Telegraphing Without Wires.

The Washington correspondent of the Hartford *Times* sends the following account of Prof. Loomis's experiments to his paper: In these days of telephonic wonders, nothing, if it is within the range of anything like probability, surprises us. Information has reached here recently that Prof. Loomis, who has been in the mountainous regions of West Virginia for some months, conducting a series of experiments with his proposed aerial telegraphy, has demonstrated finally that telegraphy without wires is practicable. His manner of operating, which has on a previous occasion been described in this correspondence, has been indorsed by many scientists. It consists of running a wire up to a certain altitude, reaching a particular current of electricity, which, according to Prof. Loomis, can be found at various heights. At any distance away, this same current can be reached by a wire, and communication can be had immediately. The apparatus necessary to bring about this wonder is very simple and inexpensive. It has been fully ascertained that telegraphic communication does not take place over or through the wires, but through the ground. This same communication continues when these electric currents applied by nature are used. Prof. Loomis has, as said before, telegraphed to parties eleven miles distant by merely sending up a kite at each end of the distance, a certain height, attached to which, in place of the ordinary string, was the fine copper wire.

When both kites touched the same current, communication was had between them, and messages were sent from one end to the other by means of the ordinary Morse instrument in connection with the instrument invented by Prof. Loomis. This showed that the theory on which he had worked for many years was the correct one, and that by the proper means, such as stationary wire arranged from natural or artificial eminences, could be operated successfully at all times. It is true that aerial telegraphy may not be much of a certainty during violent storms or electric showers, but it will not meet with more obstructions than the ordinary wire telegraphing, which is not at all sure during the periods spoken of. It will be a long time before aerial telegraphing can be carried on between places which are but a short distance apart, if indeed it ever will. In such cases the wires will continue to be used, though for long distances, such as for telegraphing from one side of the ocean to another, the aerial telegraph will take its place entirely. Prof. Loomis has a scheme now on foot for a series of experiments from a point on one of the highest peaks on the Alps, in Switzerland, to a similarly situated place in the Rocky Mountains on this side of the world. If this succeeds, of course his invention will rank in importance with that of the electric telegraph itself, and be even greater than that of the telephone. All of the money necessary to carry on the experiments has already been promised, and it will not be many years, if it turns out to be a success, before ocean cables will be one of the lost arts, which, having played its part, will be laid aside. The cost of aerial telegraphy will not be over one cent where the other is $1,000.—*Iron Age.*

The Poetry of the Locomotive.

A correspondent sends us, *apropos* of our notice of Mr. Reynolds' "Engine-Driving Life," the following lines, forming part of an inscription on a tombstone in Bromsgrove churchyard, to the memory of Thomas Scaife, a driver who was killed by the explosion of his engine:

"My engine now is cold and still,
No water does my boiler fill,
My coke affords its flame no more,
My days of usefulness are o'er.
My wheels deny their noted speed,
No more my guiding hands they need,
My whistle, too, has lost its tone,
Its shrill and thrilling sounds are gone,
My valves are now thrown open wide,
My flanges all refuse to guide.
My clacks, also, though once so strong,
Refuse to aid the busy throng.
No more I feel each urging breath,
My steam is all condensed in death.
Life's railway's o'er, each station's past,
In death I'm stopped, and rest at last."

This inscription is also to be found at Wickham, near Gateshead, where it commemorates a driver who met his death during the execution of his duty. It is stated in both cases that the lines were composed by "an unknown friend." Some very good verses, by the late Professor Rankine, "The Engine-Driver to his Engine," appeared in *Blackwood*, for December, 1862, and were reprinted in the *Builder* of the 27th of that month. They have a stirring refrain of this sort:

"Dash along, crash along,
Sixty miles an hour."

But, after all, perhaps the best thing of the sort was *Punch's* inscription on an old locomotive:

"Collisions sore, long time I bore,
Signals *was* in vain.
Grown old and rusted, my *biler* busted,
And smashed th' excursion train."

—*The Engineer.*

Artesian wells number 1,000 in California. Of these, 300 are in Santa Clara valley, fifty miles from San Francisco. Most of them overflow the surface, and the tubes average seven inches in diameter. The local resources of artesian water are now mapped out. Under the valley runs a broad river, coming from the great lakes of the Sierras, 200 miles off. The pressure from 6,000 feet elevation suffices to throw the water above the surface. The depth of the bore runs from 150 to 250 feet. Outside the boundaries of this subterranean river (several miles wide) no depth of boring has struck artesian water. There is reason to believe that every valley in the state has an underground river leading direct from the same lakes, and lying below the superficial currents that have no direct connection with any elevated reservoirs.

If you want to study the immense variety of the human face in expression, you should bend your gaze upon the mobile countenance of a deaf-and-dumb man when he reaches under the plank walk for a lost nickel, and picks up a raw bumble-bee by the stem.—*Burlington Hawkeye.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES — VOL. II. HARTFORD, CONN., APRIL, 1881. No. 4.

Explosion of two new Horizontal Tubular Boilers.

The accident which is the subject of this report is known as the Newburyport explosion. It occurred in that city (Mass.) on the 27th day of Dec., 1880, and has been freely commented on by a number of New England journals, and fully illustrated in the Boston *Journal of Commerce.* Figs. 3 and 6 are from that enterprising journal, loaned for this report.

The affair has excited much animated discussion, and several theories have been suggested of the probable and possible causes or contributing conditions from which it arose. Some of these theories, especially such as pointed to the influence of the added steam drum, as set forth in the inspector's report below, seemed plausible, while others were merely speculations of amateurs based on insufficient data.

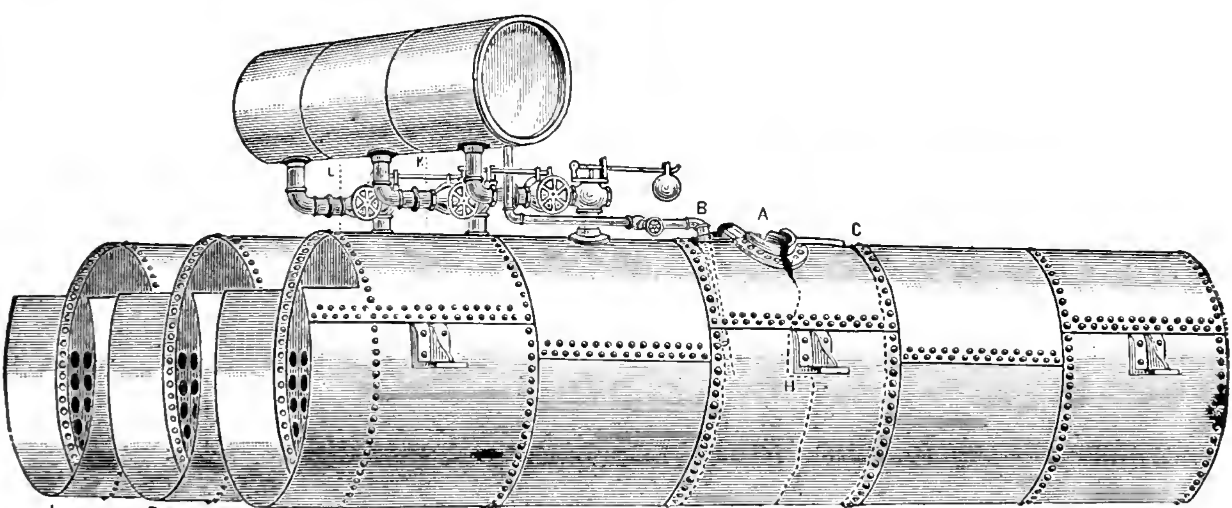


FIG. 1.—Showing relative position of the boilers 2 and 3, the two that exploded breaking first at the manhole of No. 3. BF, AE, and CG, secondary lines of rupture. KL, dotted lines showing location of brick piers built for the support of the steam drum, upon the mid-walls of the setting.

Later information received through the regular channels of this company embraces a statement of all the facts that now appear to be entitled to a place in the foundation of the conclusion embodied in this report. The following extracts from two reports of Inspector Fairbairn's contain the gist of the matter. The cuts, except Fig. 1, are carefully drawn copies of photographs that accompanied the report. Fig. 1 is intended to represent the proportions, relative position, and some of the main attachments of the battery of boilers, two of which, No. 2 and 3, were employed to supply steam to the engine, and No. 1 for warming the buildings. No. 1, the heating boiler, was shut off by a stop-valve (*not* between the boiler and safety-valve) in the steam connection to the drum, and run at a lower pressure, delivering steam through a nozzle located elsewhere on the shell (not shown in the cut nor mentioned in the report). Near the close of the noon hour on the day above mentioned, but before many of the workmen had returned from dinner, No. 3 boiler exploded, and in opening struck No. 2, its nearest neighbor, which also broke in pieces and they flew away almost simultaneously.

The following is from the inspectors' report dated December 29, 1880: "They were 17 feet long, 54 inches diameter, with shells $\frac{5}{16}''$ C No. 1 iron, stamped 45,000 lbs., with marks Paxton Rolling Mill, Harrisburg, Pa., and on other sheets Pottstown, Pa. The heads were made from flange iron $\frac{7}{16}''$ thick, with 50 tubes $3\frac{1}{2}''$ by 16 ft. long. All longitudinal seams double riveted. The boilers were well stayed, and considered safe at the required working pressure, with the proper appliances. They were set up at the factory in Newburyport, and inspected on the 13th day of October, 1880, for the purpose of insuring. Their setting and appliances were found in excellent condition and under careful management." The only defects found at this inspection were some slight leaks at a few of the tubes, and at the laps, which were to be repaired at once, and the repairs were made and the boilers insured October 20, 1880. Up to the 24th of December matters remained the same. On that day they (the proprietors) commenced to make alteration by connecting to the safety-valve nozzle a steam drum.

The drum, which was not there when the boilers were accepted for insurance, is shown, with attachments in perspective, Fig. 1.

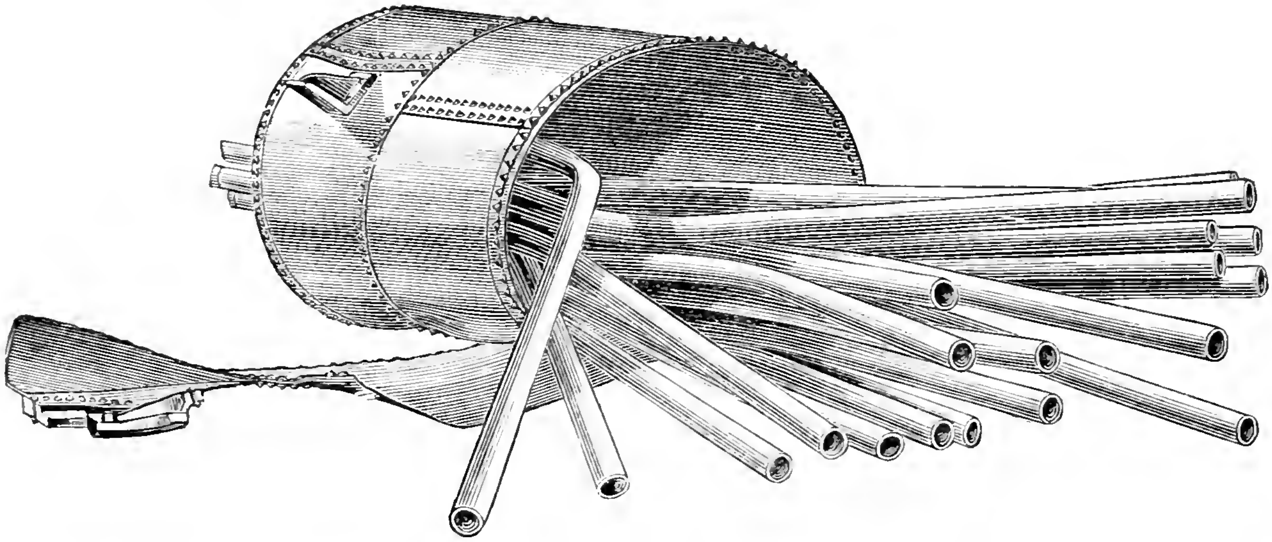


FIG. 2.—Part of No. 3 boiler, thrown 400 feet from the boiler-house.

"Alterations were completed on Monday morning, and the boilers fired up and worked until the explosion took place."

Referring to 1880 calendar it will be seen that the 27th day of December fell on Monday; the boilers therefore exploded within six or seven hours after alterations were completed and (comparing dates) *within the third month of their working age.*

In a later report dated Feb. 15, 1881, the inspector says, "The iron in their composition was of good quality, the workmanship was also good. Fragments show no signs of heating from lack of water. Between the 24th and 27th of December alterations were made in the way of connecting the steam drum to the safety-valve nozzle (as already described). In so doing the man-hole plates were taken out; when the work was completed the plates were returned to their places. It is reported that one of the workmen assisting in making the repairs said, in speaking of the replacing of the man-hole plates, "the ordinary wrench was found too short to bring the plate to its place, so we took a piece of pipe $3\frac{1}{2}$ or 4 feet long and put over the end of the wrench," thus increasing the leverage, which, with the united efforts of two men, might become a dangerous and destructive agent, fracturing the man-hole frame. Without deciding as to whether this was or was not the cause of the disaster, it is proper to warn people who use boilers against such practices. If the man-hole plate does not fit tightly, it is conclusive evidence that there is a defect in it, or in the frame, or that some foreign substance has found its way between the two; under these conditions, or if the castings were warped it will be seen that such a pressure as might be applied by the contrivance described above would produce fracture and locate a weakness that would ultimately result in disaster. The arrangement of the drum is a matter that has caused considerable comment. It was attached to pipes some four or five feet long, extending out from the safety-valve nozzle. The drum was supported by piers built up from the walls of the setting. It will be seen by this arrangement that if the piers were too high or too low, a strain would be brought to bear on the walls of the safety-valve chambers that would prevent the easy working of the valves. If this were the case the steam might arise during the noon hour to a dangerous point. We have rarely seen the steam drums of boilers connected in this manner. In one instance where such was the case, the parties in charge informed us that when the boiler was heated up and in use, the drum was lifted off from the piers, and it became necessary to wedge it up. With a drum weighing two or three tons — more or less — a heavy strain would be brought to bear upon the safety-valve nozzle under such circumstances. That the safety-valves were found after the explosion in good working order, is no argument against the

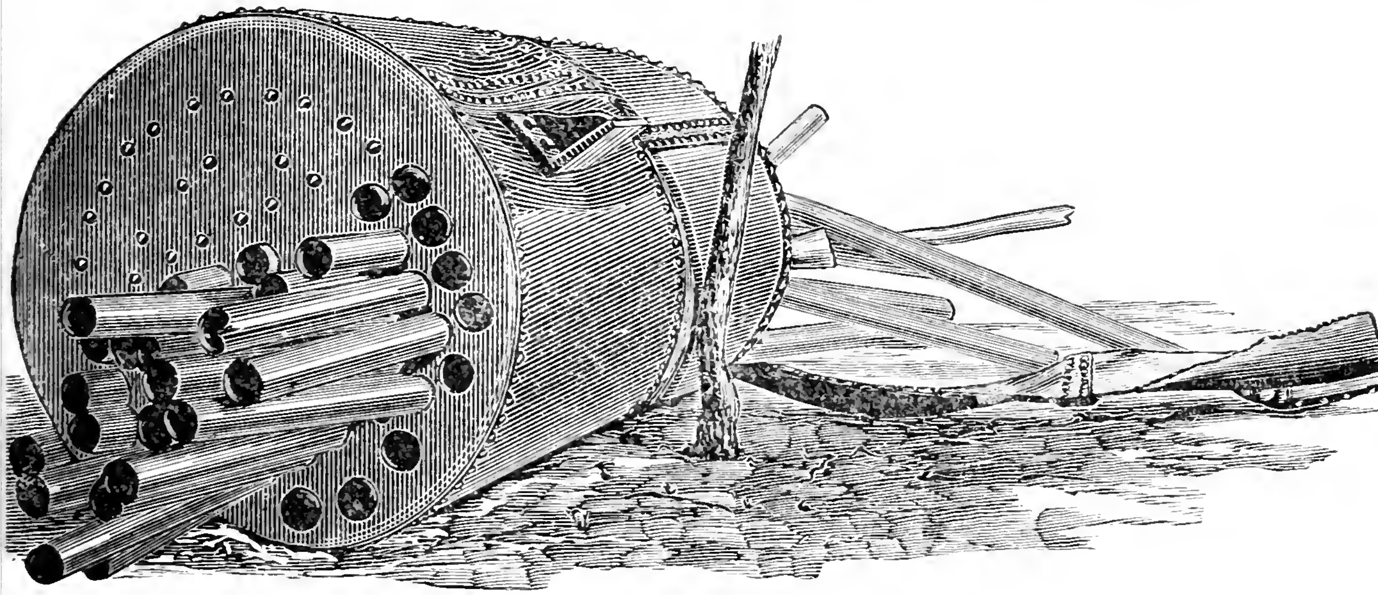


Fig. 3.—Rear view of the part of No. 3 boiler which is shown in Fig. 2.

above theory, for they were then under entirely different conditions — the strains were removed and their condition was normal, unless broken and damaged by the explosion, which seems not to have been the case. While we do not favor this plan of setting up drums, we cannot say that it was the cause of the accident, but that some condition of things, brought about by the changes in the boilers, was the cause of the accident is probably true, though it may be impossible to say just what it was. In this connection we will say that we always advise a safety-valve nozzle entirely independent of other steam connections (but our advice is not always followed). It costs but little to put on an extra nozzle, but when done the safety-valve is free and independent of any other complications. It will be seen on examining fig. 1, that there was a drip pipe attached to the bottom of the drum which extended back near to the man-hole of No. 3 boiler, where it entered the boiler through a $1\frac{1}{2}''$ hole tapped through at the summit of the cylinder between the man-hole and the next forward girth-seam. B, fig. 1. Being thus on the weakest line of the shell it is presumed that the initial rupture passed through this hole, as shown at B, in fig. 6.

The parts of No. 3 boiler are shown in figs. 2, 3, 4, 5, and 6, figs. 2 and 3 being different views of the same piece, viz., the rear head, the tubes, and two courses of plates, and fig. 4 is the front end, showing the head from which the tubes are drawn, likewise two courses of plates, on the second of which is seen the flange of the main

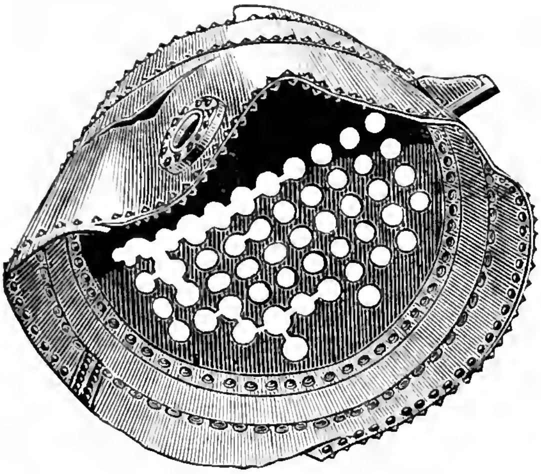


FIG. 4.—Front end of No. 3 boiler.

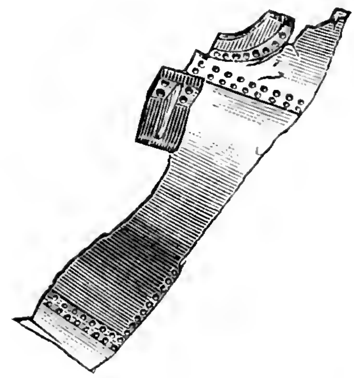


FIG. 5—Part of middle course of boiler No. 3.

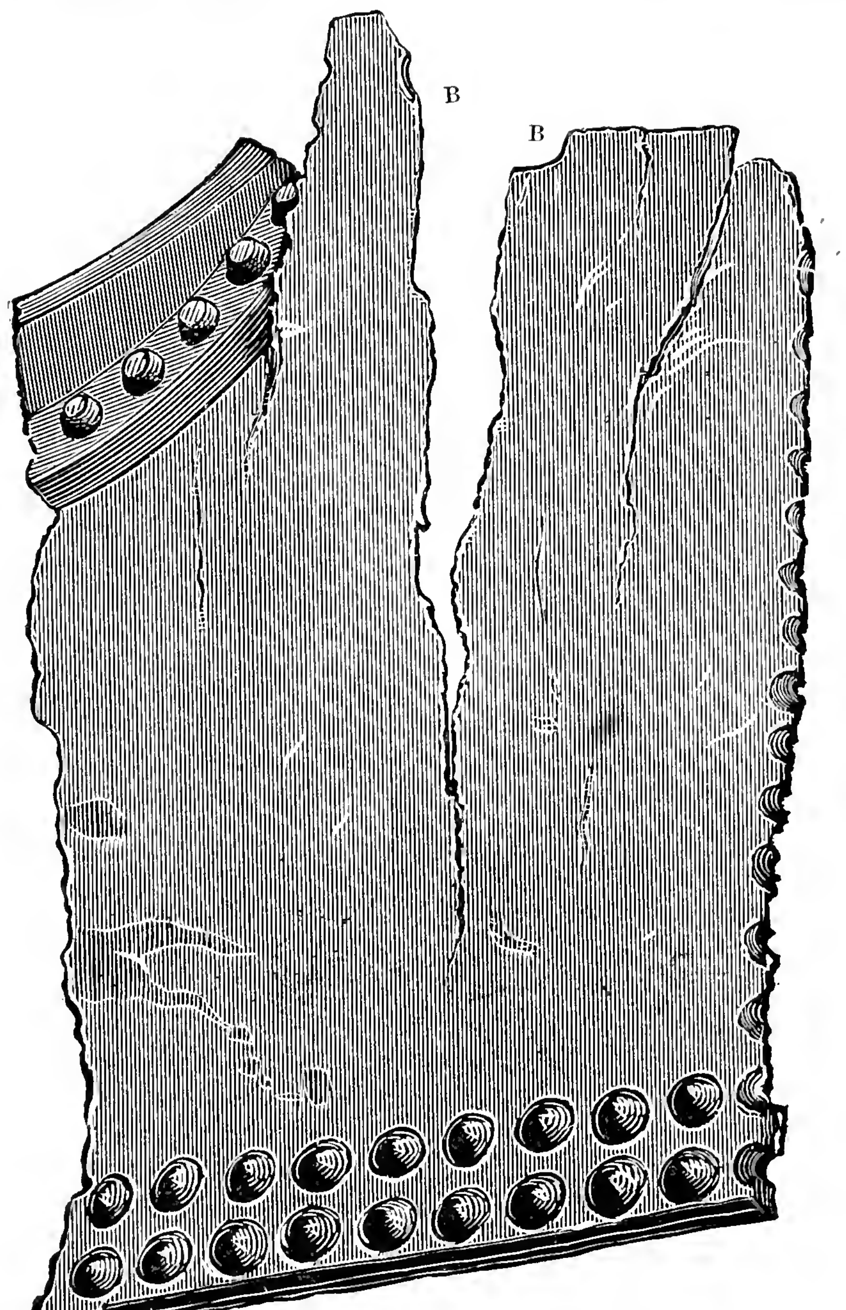


FIG. 6.—Part of the middle course of plates, boiler No. 3, showing broken manhole frame which struck and fractured boiler No. 2, splitting itself. Also showing at B B parts of the tapped hole through which the dregs pipe entered the boiler, as shown at B, Fig. 1.

steam connection, while figs. 5 and 6 show a portion of the middle course of plates which carried the man-hole frame and the drip pipe; this course, other parts of which are not drawn, completes the 5th course of No. 3 boiler which it is thought first exploded. The lines of secondary rupture are shown by the dotted lines BF *en* AE, and CG, fig. 1. Figures 7 and 8 are parts of No. 2 boiler which seems to have broken on transverse lines from a blow struck by the spreading middle course of plates of No. 3, which must have been of such a character and direction as to have instantly caused an extensive transverse fracture, for it has in this direction double the strength per unit of measurement that longitudinal lines have, besides the support afforded by the tubes

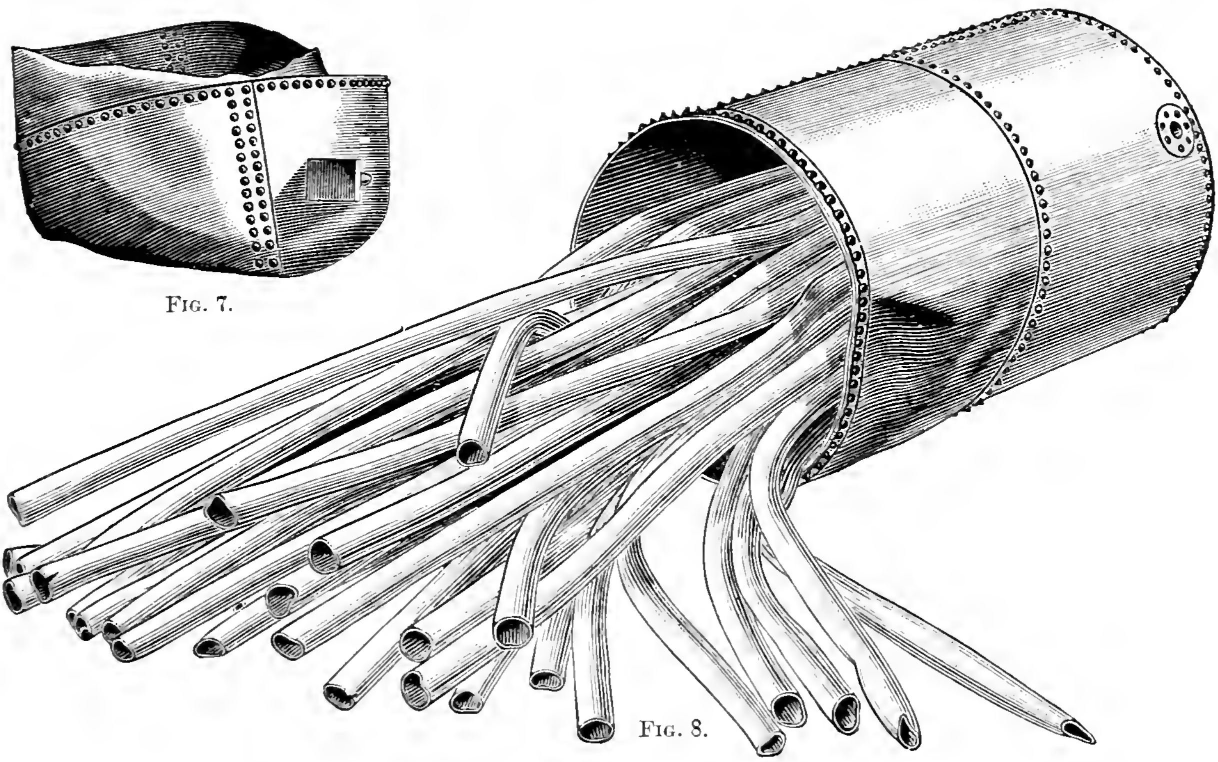


Fig. 7.

Fig. 8.

Figs. 7 and 8 are parts of boiler No. 2.

extending from head to head. Fig. 7 is most likely the middle course of No. 2 boiler that received the blow from the middle course of No. 3, armed with the broken man-hole castings.

It has been stated that these boilers were inspected and insured by the Hartford Steam Boiler Inspection and Insurance Company shortly after they were built. Such was the case, and at the time they were regarded as safe for the work required of them. The addition of the drum was made without the company's knowledge, and the boilers were put to work at once without the "improvements" having been examined by the company's inspector. They exploded a few hours afterwards, and until then the Insuring Company was not aware that any changes had been made. What defects in workmanship or material would have been discovered by an inspector we can not say. But that important changes were made without our knowledge is true. The character of the risk was changed. We can only give opinions as to the real cause of the disaster, but that there was carelessness somewhere is very evident.

Boiler Explosions.

Saw Mill (41).—At 9 o'clock this morning, February 28, a terrific boiler explosion occurred in the extensive lumber mill of C. E. Hayden & Co., of Texarkana, Ark., demolishing the mill buildings and slightly injuring three persons. No cause is assigned, the engineer claiming to have had plenty of water in the boiler at the time.

SAW MILL (42).—A special to the *Inter Ocean* from New Castle, Ind., says: The boiler of Charles Horrence's saw mill, located at Melville, exploded this afternoon, March 3, killing instantly L. N. Martz, and injuring several others.

LUMBER MILL (43).—A boiler in Closson & Gilbert's mill near Manton, Mich., exploded March 3, badly scalding Benjamin F. Ranney, the fireman.

AXE-HANDLE FACTORY (44).—By a recent boiler explosion in James Woolworth's axe-handle factory at Bowling Green, Ky., J. C. Kinzer was instantly killed and several others wounded.—*Lumberman, March* 12.

SAW MILL (45).—The boiler in the saw-mill of Boyle, White & Co., in Obion county, Tenn., near the Memphis and Paducah and Northern Railroad, exploded March 9, and besides wrecking badly the mill killed an off-bearer named Joe Keith, and broke a leg of Jack Wease, the engineer. Several other employees were wounded slightly about their faces and heads. The mill had been stopped for repairs, and had just started up when the explosion occurred.

SAW MILL (46).—On the 9th of March a terrible boiler explosion occurred at the saw-mill of Allen & Williams, at Africa, Texas, on the H. & W. T. narrow gauge road. The cause of the explosion is not known, but the result was fearful. Scarcely a remnant of the mill is left to mark the spot. The report states that one man was killed, one mortally injured, six others seriously wounded, and but one man escaped from the mill uninjured.

BOILER TEST (47).—A large boiler in the Phœnix Boiler Works, at Buffalo, N. Y., owned by Donaldson & Patterson, exploded March 12, instantly killing six men and wounding seven others, one of the proprietors, Mr. Patterson, being among the killed. An old boiler belonging to the tug-boat Mary E. Pierce, which had been in use eighteen years, was being tested, when without any apparent cause it burst, literally leveling the works, which were 100 feet long, 80 feet high, and 40 feet wide. Mr. Patterson was, with a large mass of the boiler, hurled across the street and through a solid board fence, leveling a portion to the ground. His body was terribly mutilated, portions of his entrails and limbs hanging to the wrecked fence and his leg being found fifty yards away from the building. The bodies of the killed were scattered in all directions. The force of the explosion was so great that the windows of a building nearly half a mile distant were blown out, while many people in houses in the immediate vicinity were thrown to the ground. Tables were overturned, windows demolished, and the adjoining buildings shaken to their foundations. A large piece of the boiler was blown hundreds of feet in the air and went crashing through the roof of the Wells elevator, nearly 500 feet away, and the dome of the boiler was thrown over 100 feet in the air and landed fully half a mile distant. Six men were killed and seven wounded. The loss will probably reach $15,000.

March 13.—Carl Otto Voltz and George Ballue, wounded at Friday's boiler explosion, died to-day. Total deaths, eight.

SAW MILL (48).—A terrible boiler explosion, resulting in the killing of three men and the serious wounding of five others, occurred about six o'clock in the evening of March 18, at Tyler & Harrod's circular saw mill on Long's Branch, near the mouth of the Elkhorn, twelve miles below Frankfort, Ky. It seems that the engine and boiler used in running the mill were portable, and were formerly attached to a thresher, and were only placed in the mill a short time since, after having stood a thorough test. It required almost every pound of steam that the engine would carry to run the mill, and it is supposed that an excess of steam caused the explosion. All of the employees—nine in number—were in the mill at the time of the accident, and only one escaped unhurt. John Harrod was blown forty feet in the air, and was killed instantly. His brother, Lawrence Harrod, one of the proprietors of the mill, was so badly wounded that he died an hour afterward, and Frank Graham died three hours later. The wounded were William Arnold, jaw-bone broken; James Reading, scalded; William Whalen, scalded; Louis Harrod, scalded. Hugh Tyler, the other proprietor, was slightly wounded. The only person who escaped uninjured was William Skeggs. The engine and boiler were blown to atoms, and considerable other damage was done to the mill.

Tow-Boat (49).—The tow-boat John Means, of the St. Louis and New Orleans Transportation Company, *en route* to St. Louis, exploded her boiler March 17 at six o'clock, P. M., just about Osceola, Ark., and sunk out of sight almost immediately. She carried a crew of twenty-six men, four of whom—John Zeals, pilot; a deck hand named Morris, and two firemen, Germans, are missing, supposed to be drowned. Charles Purcell, pilot on watch at the time of the accident, was blown into the river and had a leg broken; Tom Cannon, a deck hand, had his skull fractured; William R. Wooldridge, second cook, was scalded on the neck and legs. Captain McClellan was slightly bruised on the head. Later investigations of the disaster only show the gross neglect of the engineer of the fated steamer. Her boilers were in a leaky condition ever since passing Vicksburg. Some repairs were made last Wednesday but the boilers still leaked. Her tow was very heavy, and at times it was almost impossible for her to stem the current. Morris Fitzgerald is the name of the deck-hand missing. It is impossible to obtain the names of the two firemen. The last seen of John Zeals, the pilot, he was standing just over the boilers when they exploded.

—— Mill (50).—A Middlefield, O., dispatch states that the boiler in the steam mill in the eastern part of that town exploded on the morning of March 21, instantly killing Joseph Hamilton, Seldon Sprague, and John Patchin. The cause of the explosion is unknown. The mill was owned by White & Russell.

Heating Boiler (51).—A three-story brick building, 100 feet square, on Water street, owned by the Rochester Hydraulic Company, and occupied for manufacturing purposes, fell in ruins this morning, March 21, the cause being the explosion of a steam boiler used for heating the building. Joseph Schell, aged 20, was killed instantly on the sidewalk by the falling wall. Four or five other men were injured, none of the latter fatally. The losses to property were as follows: Rochester Hydraulic Company, owner of the building, $20,000; Frank Schweikert, billiard manufacturer, second floor, $5,000; Burt & Brace, chair manufacturers, third floor, $2,000; Henry Wilson & Co., millers, first floor, $1,000; Hatch Flexible Shoe Company, second floor of adjoining building, $300. The boiler which exploded was purchased new from a Syracuse firm ten years ago. It was a tubular boiler of 25-horse power. It was overhauled, repaired, and pronounced safe, two years ago, by Peter Kelly, of Rochester. Its capacity was 110 pounds of steam, but it had only 15 pounds when it exploded, as near as can be ascertained. After careful investigation, the cause of the explosion is believed to be that William Richner the engineer, blew off the water to clean out the boiler flues, Saturday night, and turned on cold water some minutes after it was thoroughly heated this morning.

March 28.—The coroner's jury in the case of Joe Schell, killed by explosion of the boiler in the Hydraulic Company's building, find the company criminally negligent in employing an incompetent man to run a defective boiler, and should be held answerable.

Saw Mill (52.)—The boiler in the saw and planing-mill of C. T. Haydon & Co., of Texarkana, Texas, exploded a few days ago, almost demolishing the building, and blowing five men a distance of fifty feet, but strangely, they escaped with a few scratches. —*Lumberman*, *March* 26, 1881.

——Mill (53).—The boiler in the mill of Davis & Bro., of Forestville, Ill., exploded March 22, killing Peter Moore, the engineer, and seriously injuring a mill hand named

Robert Field. It is claimed that the engineer at the time was in a state of intoxication.

Gas Works (54).—The boiler at the Rockland, Me., gas works exploded March 25, completely wrecking the building, and injuring John Hartnet, a boy, probably fatally, and a man named Cronan severely. The boiler was carried through the roof and landed eighty feet away. The city will be without gas till the works, principally owned in Boston, are repaired.

Rock Drill (55).—Thomas J. Gerrity, a contractor, began yesterday to grade East Seventy-first street, New York city, between Avenue A and the river. An old horizontal boiler, which had not been in use for some time, was placed in position in the street to supply motive power to steam drills. James Sheridan, whose license is recorded at police headquarters, was the engineer. At 7 o'clock, when the gauge indicated a pressure of 60 pounds, Sheridan called William McGowan, aged 14, of No. 502 East Seventy-first street, and told him to mind the boiler until he returned from his breakfast. The boy was instructed not to meddle with the boiler or to allow any one else to do so. It is not known if McGowan obeyed these instructions, but twenty minutes after Sheridan left, the fire sheet of the boiler burst, fragments of iron flew in many directions, and the boiler itself was thrown to a height of twenty feet and a distance of fifty feet. The boy McGowan was seriously if not fatally injured by portions of the wreck and steam. He was taken to the Presbyterian Hospital. Sheridan, when he returned from breakfast, was arrested by Officer Ward, of the Twenty-eighth Precinct.

Iron Rolling-Mill (56)—The man-hole plate of a boiler over a puddling furnace in Brown, Bonnell & Co's rolling mill at Youngstown, O., blew out March 28. The escaping steam and flying debris wounded twelve men, three seriously, two of whom have since died.

Inspectors' Reports.

The evidence of neglect in the care of boilers is forced upon our minds, as the reports of our numerous inspectors are spread out before us each month. If every steam user could see and understand the meaning of these reports as we do, we believe there would be fewer dangerous defects found, and less frequent accidents to steam boilers. During the month of February, 1881, the number of visits of inspection made was 1,687, by which 3,623 boilers were examined; 1,025 of these boilers were examined internally and externally. What is known as an "entire" inspection was made. The balance were external examinations, and were mostly made when the boilers were under steam. In 301 cases the hydrostatic test was applied. These were new boilers, or in localities where municipal laws enforced its use. The number of defects in all discovered were 1,412, of which 400 were regarded as dangerous. These defects may be classified as follows: Furnaces out of shape, 57—13 dangerous; fractures, 143—99 dangerous; burned plates, 91—36 dangerous; blistered plates, 327—37 dangerous; deposit of sediment, 142—29 dangerous; incrustation and scale, 210—30 dangerous; external corrosion, 85—25 dangerous; internal corrosion, 49—17 dangerous; internal grooving, 7—5 dangerous; water-gauges defective, 12—7 dangerous; blow-out defective, 9—4 dangerous; safety-valves overloaded, 33—13 dangerous; pressure gauges defective, 103—25 dangerous; boilers without gauges, 45; cases of deficiency of water, 4—4 dangerous; braces and stays broken, 64—56 dangerous; boilers condemned, 31. The above record may appear to some as partaking somewhat of the sensational, but it is simply a record of facts.

How many of these defects would have led to disaster, if left to run without attention, we cannot say, but we believe the number of boiler explosions would have been very materially increased. Steam gauges were found with variations from 20 to 30. Among the boilers condemned were two new ones. The workmanship was so poor that we would not even encourage their use. Engineers are often very careless in allowing boilers to go uncleaned and unrepaired, when the latter is needed. They take the chances of running up to the next Sunday or holiday, and then expect to make repairs; but that day never comes to some, and the risk is too great for any man to assume.

The Locomotive.

HARTFORD, APRIL, 1881.

In the early history of the Horizontal Tubular Boiler, it was regarded necessary to crowd as many tubes as possible into the lower half, especial care being taken to put them in after the plan known as "staggered," because more tubes could be inserted, and all the room economically (?) occupied. Little regard was paid to the spaces between the tubes and shell, or to the distance of the tubes from each other. The question of the circulation seems to have been little thought of, and almost no regard was paid to facilities for inspecting and cleaning. The tubes used were usually 2″ and 2½″ in diameter. They were packed so closely together that after a year or two the spaces became filled with deposits of lime and mud, and their efficiency was greatly impaired. In time, 3″ tubes were introduced, but the manner of setting them was not changed. When *The Hartford Steam Boiler Inspection and Insurance Company* first began business this was the condition of things mainly, and we at once set ourselves at work to influence if possible, a change in this practice. Our aim was to have the tubes not less than 3″ in diameter, and to have them arranged in vertical and horizontal rows, and not in any case nearer than 3″ to the shell of the boiler. This, of course, reduced the number of tubes, and consequently the calculated heating surface of the boiler, and was bitterly opposed by many boiler-makers. The rapid increase in manufacturing and consequent increase in the use of steam demanded important changes in the methods of constructing boilers, but the old prejudices lingered, and gave way only under severe pressure. A manufacturer wanted a new boiler of a certain horse-power. He would apply to two or more boiler-makers for estimates of cost. They would make up their specifications accompanied with the estimated cost. On examination it would be found that their specifications agreed only in length and diameter. One would be crowded with tubes, while the other would have them well arranged and judiciously distributed. The former would claim greater efficiency because his boiler had more tubes, and consequently more heating surface, while the latter would contend that his boiler was superior because it provided for free circulation of the water. There was great difference of opinion among boiler-makers on this point, and there seemed to be no well established authority on the subject. Again and again were we applied to as umpire in such cases, and without reference to workmanship, which would be equally good in both cases, we believed, we invariably advised the tubes to be set in vertical and horizontal rows, well distributed, and in no case nearer than 3″ to the shell. At the bottom we advised at least a distance of 6″ in the smaller boilers, and 8″ in the larger ones, for abundant room to adjust the hand-holes — one in each end of the boiler, — and to give a larger body of water over the fire, which is the hottest part. This was a great improvement on the old practice and came to be very generally adopted, and is largely the practice to-day, particularly in the East.

But experience raised the question some time ago as to whether this plan could not be improved upon? Were the tubes equally efficacious? It was found that the levity of the heated gases naturally carried them to the upper rows of tubes and the lower ones consequently did comparatively little work. The question then arose how many tubes can be removed and the maximum efficiency of the boiler maintained? Another question was, as to whether the size of the tubes should not be increased. We have experimented more or less in this field, and to say the least favor a reasonable departure in this direction. We have furnished many specifications for boilers constructed on this plan, and they have given good results. Boiler makers in many parts of the country are constructing boilers on this plan.

Over the center of the bottom there should be a distance of 18″ from tubes to shell. This gives space for a good solid body of water over the fire, besides allowing room for a man-hole in the front head underneath the tubes. The latter arrangement greatly facilitates the work of inspection. The entire bottom of the boiler can be inspected internally and externally, and sediment can be easily removed. The experiments bearing on these points will be reverted to at some future time. Also the questions of the sizes of tubes, as well as some remarks on boiler construction and setting.

Early Steam Engineering.

R. K. McMurray, Chief Inspector of our New York Department, has placed in our hands a book of reports of the Secretary of the Treasury of the United States, "in relation to steam engines, &c.," Dec. 13, 1838—25th Congress, 3d session. In it we find that "the whole number of steam engines of every kind in the United States, reckoning one to each boat, is ascertained and estimated to be 3,010. Of this number about 800 are supposed to be employed in steamboats, 350 are employed in locomotives on railroads, and the residue, 1,860, are used in manufactories of various kinds."

ACCIDENTS.

The number of accidents occasioning loss of life or much injury to property, which have occurred in the use of steam engines of every kind in the United States, is computed to have been about 260. Such accidents, by explosions and other disasters to steamboats, appear to have constituted a great portion of the whole, and are supposed to have equaled 230. The first of these in boats is believed to have occurred in the Washington, on the Ohio river, in 1816. In a classified summary of these accidents, we find that 1,676 persons were killed, and 443 wounded. The accidents to locomotives and stationary engines and boilers up to this date were 28, by which 37 were killed and 98 wounded. It is interesting to note that of these 28 accidents, 24 were railroad locomotives and 4 stationary engines, the locomotives taking the lead in regard to accidents as they do now.

Among the boats sailing from New York is mentioned the Augusta, 218 tons, C. Vanderbilt, captain; also the Lexington, 488 tons, J. J. Vanderbilt, captain. The latter ran between New York and Stonington, and was burned on the Sound January 15, 1839. Many passengers were lost. The Charter Oak ran from New York to Hartford, M. Sanford, captain. She was rated at 439 tons. The other Hartford boats were the Bunker Hill, 356 tons, and the Cleopatra, 402 tons. The DeWitt Clinton, Erie, Albany, Robert L. Stevens, Henry Eckford, and others ran to Albany.

The United States steam frigate Fulton's engines are described as having 50-inch cylinders, 9 feet stroke, 250 horse power each, 900 tons. Charles W. Skinner, Esq., captain; Charles H. Haswell, engineer.

In Massachusetts there were 12 steamboats, 37 locomotives, and 165 stationary engines, in Connecticut 19 steamboats, 6 locomotives, and 47 stationary engines. New York had 140 steamboats, 28 locomotives, and 87 stationary engines. Pennsylvania, 134 steamboats, 96 locomotives, and 383 stationary engines. Virginia, at this time, claimed 16 steamboats, 34 locomotives, 124 stationary engines. Louisiana had 30 steamboats, 10 locomotives, and 274 stationary engines.

These are interesting facts, and when we compare them with the steamboats, locomotives, and stationary engines of to-day, it gives us some faint impression of the unparalleled growth and development of the resources of our country. It is a good thing to compare notes of the past and present occasionally, that we may know how fast we do move.

India-Rubber Gathering on the Amazon.

Narrow paths lead from the hut of the India rubber gatherer through the thick underbrush to the solitary trunks of the India rubber trees; and as soon as the dry season allows, the woodman goes into the seringle with a hatchet in order to cut small holes in the bark, or rather in the wood of the caoutchouc tree, from which a milky-white sap begins to flow through an earthenware spout fastened to the wound. Below is a piece of bamboo, which is cut into the shape of a bucket. In this way he goes from tree to tree until, upon his return, in order to carry the material more conveniently, he begins to empty the bamboo buckets into a large calabash. The contents of this are poured into one of those great turtle shells which, on the Amazon, are used for every kind of purpose. He at once sets to work on the smoking process, since, if left to stand long, the gummy particles separate and the quality of the India rubber is hurt. This consists in subjecting the sap, when spread out thin, to smoke from nuts of the Urucury or Uaussa palm, which, strange to say, is the only thing that will turn it solid at once. An earthenware "bowl without bottom," whose neck has been drawn together like that of a bottle, forms a kind of chimney when placed over a heap of dry red-hot nuts, so that the white smoke escapes from the top in thick clouds. The workman pours a small quantity of the white, rich, milk-like liquid over a kind of light wooden shovel, which he turns with quickness, in order to separate the sap as much as possible. Then he passes it quickly through the dense smoke above the little chimney, turns it about several times, and at once perceives the milk take on a grayish-yellow color and turn solid. In this way he lays on skin after skin until the India rubber on each side is about an inch thick, when he considers the *plancha* done. It is then cut upon one side, peeled off the shovel and hung up to dry, since much water has got between the layers, which should dry out if possible. The color of the *plancha*, which is at first a bright silver gray, becomes more and more yellow, and at last turns into the brown of rubber as it is known in commerce. A good workman can finish in this way five or six pounds an hour. The thicker, the more even and the freer from bubbles the whole mass is, the better is its quality and the higher its price.—*Iron Age.*

Immunity of Brewers from Steam Boiler Explosions.—Any one acquainted with the routine of work in a brewery and knowing how severely brewers' steam boilers are tried, would wonder that their explosion was not more frequent. We are safe in saying that nearly every one of the 3,000 breweries in the United States has a steam boiler. This boiler is used not only to drive one or more steam engines and several steam pumps, but it also has, in the majority of breweries, to heat the mashing water, heat the mash and boil the beer, and to do these many things the steam pressure existing in the boiler varies greatly every hour. The reason why so little trouble is heard with regard to brewers' boilers is not only that they generally buy a good boiler to commence with, but that a majority of them hold policies in the Hartford Steam Boiler Insurance and Inspection Co. of Hartford, Conn., whose practical inspectors not only see that the boiler is kept in a perfectly safe condition, under ordinary treatment, but advise as to the best methods of handling the boiler, mode of repairing or reconstructing it, etc. This is a great anxiety off the mind of a man not accustomed to the running or ownership of steam boilers, and saves him in pocket besides far more than the cost of insurance.—*The Brewers' Gazette, February,* 1881.

A four-masted schooner, built by George W. Adams, of Buffalo, for the shipping of grain on the Lakes, is 234 feet long, 40′ 3″ beam, 20′ hold, draft loaded 15′ 3″. She will carry 126,000 bushels of oats and 87,000 bushels of corn, and is probably the largest schooner afloat.

Old Bridges in China.—The most remarkable evidence of the mechanical skill and science of the Chinese at an early period, is to be found in their suspension bridges, the invention of which is assigned to the Ham dynasty. According to the concurrent testimony of all their historical and geographical writers, Sangleang, the commander of the army under Kaou-tsoo, the first of the Hams, undertook and completed the formation of roads through the mountainous province of the Shensa to the west of the capital. Hitherto, its lofty hills and deep valleys had rendered communication difficult and circuitous. With a body of one hundred thousand laborers he cut passages over the mountains, throwing the removed soil into the valleys, and where this was not sufficient to raise the road to the required height, he constructed bridges, which rested on pillars or abutments. In another place he conceived and accomplished the daring project of suspending a bridge from one mountain to another over a deep chasm. The bridges, which are called by the Chinese writers, very appropriately, flying bridges, and are represented to be numerous at the present day, are sometimes so high they cannot be traversed without alarm. One still exists in Shensa, stretching 400 feet from mountain to mountain over a chasm of over 500 feet. Most of these flying bridges are so wide that four horsemen can ride on them abreast, and balustrades are placed on each side to protect travelers. It is by no means improbable (as Mr. Pautheier suggested) that as the missionaries to China made known the fact over a century and a half ago that the Chinese had suspension bridges, and that many of them were made of iron, the hint may have been taken from thence for similar construction by European engineers.—*Iron Age.*

New Castle, Ind., March 23.—John Detweiler, aged 34, was smothered in a boiler at Red Jacket Furnace to-day. He was attempting to clean the boiler. Charles Coon, who went to rescue Detweiler, was also overcome by the gases and died. Two other men, in attempting to save these two, narrowly escaped a similar fate.

We suggest that when "Steam Notes" copies bodily from The Locomotive it give due credit.

An ordinary man in a state of repose makes about sixteen respirations per minute, each of 40 cubic inches, according to Menzies. Admitting, therefore, that air should not be respired a second time, we have $16 \times 40 \times 60 \div 1{,}728 = 22$ cubic feet of air thus vitiated per hour.—*Box.*

Mr. J. H. Cooper is preparing a series of articles on the Elasticity, Rupture, and Driving power of Belts. These articles are prepared for the Boston Journal of Commerce, and those interested in the subject should secure them.

In the manufacture of charcoal-iron it is estimated that the average consumption of coal to the ton of iron is not less than 130 bushels. Reckoning 50 cords of wood to the acre, and 40 bushels of coal to the cord, gives for the coal product of one acre, 2,000 bushels. A modern furnace, making 10,000 tons of iron a year, would clear annually about 600 acres of land. It is believed that very little of the iron marked C. or C.H. ever saw a pound of wood charcoal.

The Corrosion of Iron and Steel.

An interesting paper on the comparative endurance of iron and mild steel, when exposed to corrosive influences, was read before the British Institution of Civil Engineers recently by Mr. D. Phillips, who was a member of the committee appointed by the Admiralty in June, 1874, to inquire into the causes of corrosion in boilers, and since the dissolution of the committee he had made further experiments with the same object in view. The results were given of numerous tests, the surfaces of the specimens in nearly all cases being bright. Illustrations were shown of gutta percha and plaster of Paris impressions taken from many of the specimens. Tubes of different brands of iron and steel were subjected to various tests in a special apparatus at Sheerness Dockyard. Some of the tubes were welded, others were cold-drawn. With one exception they were all specially prepared. Each tube had an exposed surface of 9.58 square feet. The iron tubes lost 45.4 per cent. less in weight than the steel. Small disks of iron or steel were also tested in another set of tubes in the same apparatus. The percentage in favor of the irons was 56.7. Pieces of iron and steel of different brands were suspended for 12 months in two marine boilers, one vessel having a jet condenser, and the other a surface condenser, and also in a feed-water heater supplied with fresh water. The percentages in favor of the irons were 32.7, 27.5, and 11.8 respectively. Plates of Bolton steel and Lowmoor iron, 10 inches by 8 inches, were likewise placed in the boilers of the two vessels mentioned. Half of the number were withdrawn after 13 months, and gave a percentage in favor of the irons of 32.7, corrosion in the steels, in the form of pitting, being most marked. Of the remaining 8 plates, four remained in the boilers 21 months and four 22 months, the result being 28.6 per cent. in favor of the irons. Plates of the same two metals, 15 inches by 8 inches, were suspended for 13 months in the feed-water heater. The percentage in favor of the irons was 10.9. The corrosion in the steels was only slightly more marked and irregular than in the irons. Plates of Lowmoor iron and Landore steel, suspended in pairs in vessels under slightly different conditions, gave a percentage of 4.8 in favor of the irons.

Reference was next made to a series of experiments with iron and steel plates (Crucible, Bessemer, and Siemens steel, and Staffordshire and Yorkshire irons) suspended in the boilers of ocean and coast-going steam vessels belonging to the various ship-owners. The exposed surface of each plate was 37.89 square inches. Taking the results from 56 sets, the percentage in favor of the two irons over the Bessemer and Siemens steels was 21.3. The different results obtained from some of the sets are carefully summarized in the paper. These results clearly proved the error of the conclusions arrived at by many experienced persons previous to the appointment of the boiler committee.

Experiments made by the author with plates similar to those last mentioned, placed in sea-water, in rain-water, exposed to the weather only, and exposed to the weather and dipped in sea or rain-water daily, gave a result of 64.8 per cent. in favor of the irons, omitting the hard steel. The corrosion was strikingly local and severe in the set placed in rain-water. Wetting the metals daily, especially with sea-water, and exposing them to the weather, caused very severe corrosion. The results of these experiments incontestably proved that, under almost all circumstances, iron, and especially the harder sorts, was far superior to steel in the resistance it offered to corrosion. Such theories as that corrosion was caused by galvanic action between metals and their oxides, or between different brands of iron or steel, or between iron and steel, were, in Mr. Phillips' opinion, practically unworthy of consideration. He then proceeded to say the steel had probably received more than its fair share of praise as regarded homogeneity and uniformity of temper. Although iron was inferior to steel as regarded cinders, laminations, etc., yet mild steel was not without original defects, as was shown by several of the gutta-percha impressions. Moreover, some of the tubes and disks before mentioned presented, after testing, a damaskeen appearance, similar to gun barrels. Surprising differences of temper were exhibited in the cold-bending of the metals tested in the tube apparatus, not only between the various brands, but also between the tubes of each brand. The difference between the behavior of the tempered and the annealed steel specimens under the cold-bending test was also most marked.

It would seem that in the purifying of metals in order to render them more ductile, elements such as carbon, phosphorus, etc., were eliminated, which, no doubt, rendered the metals more liable to corrosion. In the metals tested in sea-going boilers, the ordinary BB Staffordshire iron proved 9.6 per cent. better than the best Yorkshire as regarded loss of weight, and the hard steel 20.9 per cent. better than the two mild steels. In the tube experiments the ordinary iron tubes proved 122.2 per cent. better than those specially prepared. Again, the tubes called improved metal were 31.1 per cent. better than the tubes called improved homogeneous metal, by far the most ductile and expensive of the two. It appeared from recent analyses that the percentage of phosphorus ranged from 0.20 to 0.21 in the crude irons, and 0.7 to 0.14 in the better sorts, and from 0.016 to 0.04 in the milder steels. The amount of carbon in iron ranged from 0.0545 to 0.074 per cent., while in mild steel it varied from 0.131 to 0.273 per cent. From 0.0649 to 0.1080 per cent. of manganese was found in iron, and from 0.238 to 0.3317 per cent. in steel. These results confirmed the author's conclusions that the commoner irons, containing the most phosphorus, resisted corrosion better than the superior sorts, and the harder steels containing the most carbon better than the softer and finer sorts.

In conclusion, the author remarked that much yet remained to be done to produce a metal at once strong and ductile, but at the same time better able than mild steel to withstand corrosion. On the other hand, the treatment of marine boilers might be so modified, especially with the aid of zinc properly applied, as to enable the purer metals to be used in their construction.—*Iron Age.*

What is Coal?

[From Galloway's Treatise on Fuel.]

"The owners of an estate at Torbanehill, in the county of Linlithgow, had granted a lease of the whole coal, ironstone, limestone, and fire-clay contained within it, except copper and any other minerals whatsoever than those above specified; and it should be remarked that the true coal measures of geologists were proved to exist under the same estate. In the course of working the lessees extracted a combustible mineral of great value as a source of coal-gas, and realized a large profit by the sale of it as gas coal. The lessors, thereupon, denied that the mineral in question was coal, and disputed the right of the lessees to work it. At the trial there was a great array of scientific men on each side, including chemists, botanists, geologists, and microscopists; and of practical gas engineers, coal-viewers and others, there were not a few. On the one side it was claimed that the mineral was *coal*, and the other it was a *bituminous* schist. The evidence, as might be supposed, was most conflicting. The judge, accordingly, ignored the scientific evidence altogether, and summed up as follows:—'The question for you (the jury) to consider is not one of motives, but what is this mineral? Was it coal in the language of those persons who deal and treat with that matter and in the ordinary language of Scotland? *because to find a scientific definition of coal after what has been brought to light within the last five days is out of the question.* But was it coal in the common use of that word, as it must be understood to be used in language that does not profess to be the purest science, but in the ordinary acceptation of business transactions reduced to writing? Was it coal in that sense? That is the question for you to solve, for you to determine.' The jury found that it was coal. Subsequently to this trial the mineral was pronounced *not to be coal* by the authorities of Prussia, who accordingly directed it not to be entered by the custom-house officers as coal."—*Percy.*

Japanese Leather Paper.

Among the numerous forms in which Japanese art has been so popularly represented in this country of late years, there are few proving so practically useful as the subject of this notice. Introduced at a time when startling innovations were being made in matters of taste, it readily lent itself to the efforts of designers who were gifted with fresh and original ideas. With no associations wedding it to any particular style, and with a character which neither asserts nor obtrudes itself, it harmonizes with almost every style of decoration. The paper is rich and generous in color and charming in design. Some have wonderful bits of detail, amidst a mass of suggested form and foliage; others show more than a suspicion of European influence. One of the latest now before us has all the familiar features of the best old Spanish leather, but accentuated in a manner both novel and characteristic. But whether drawn from their own resources, or elaborated on accepted forms, they are peculiarly adapted for the purposes for which we recommend them, viz., interior decoration, such as dados, entrance-halls, staircases, etc. But from their variety, both in design and color, they can also be used with fine effect wherever decoration is introduced. Apart from its value as a decorative agent, Japanese leather paper possesses in a large degree the desirable quality of durability, and in this respect thoroughly deserves its name, being practically indestructible when once fixed on a wall. The origin of this interesting material in its present form may be regarded as a legitimate outcome of one of our International Exhibitions. Before 1872, specimens of the material were only to be found in the hands of dealers or collectors. But in 1872 two or three pieces of the then-orthodox size, that is, 18 inches by 12 inches, in no way striking in pattern, were exhibited in a case at South Kensington, where they were regarded only as an object of curiosity. Mr. Robert Christie, recognizing its value as a material for the purposes for which it is now so largely used, and having at that time business connections with Japan, at once endeavored to find out the makers there, with the view of getting it produced in a form more useful for European requirements. His efforts were so far successful that he was enabled to exhibit several rolls of different patterns, measuring three feet wide by 36 feet long, at the Exhibition in 1874, and for which he obtained a medal. Since then Mr. Christie has been in constant correspondence with the makers in Japan, and having had practically the monopoly of its manufacture up to the present time, has used his influence in impressing on them the desirability of adhering as near as possible to their own old colors and designs. Although the manufacture of this material has been largely developed, its reproduction has in no manner deteriorated, unlike other native productions both of India and Japan, where trade competition and indiscriminate orders have had such a baneful influence on their art work; the only deviation from this rule being as regards size, in order to do away with the patchy and unsatisfactory appearance which was found to be unavoidable where the original small pieces were used, particularly in cases where the pattern ought to but did not intersect. We are glad to hear from Mr. Christie that its sale at the present time is largely increased both in this country and America, and is now regarded by an intelligent class of decorators as one of the most promising staples of trade with Japan.

Circulation of Air in the St. Gothard Tunnel.—M. Stapf has been giving careful attention to the variations in the air currents between the two openings at Goschenen and Airolo. He finds two principal causes to be operative in these changes: First, the southern opening is 30 meters (32.809 yards) higher than the northern, which represents a pressure equivalent to that of a column of air 36 meters (39.371 yards) high at the subterranean temperature; second, the difference of barometric pressures upon the two declivities of the mountain. If the external temperature was always lower than the internal, if the barometric temperature was the same at each side, and if there were no modifications of velocity due to the heating and expansion of the air or to the friction against the walls, the draft would always be southward. Meteorological observations are regularly taken, both at Airolo and Göschenen, to determine the elements which are required in order to know, monthly or annually, the number of days for which a given direction of current or an absolute calm may be expected in the interior of the tunnel.

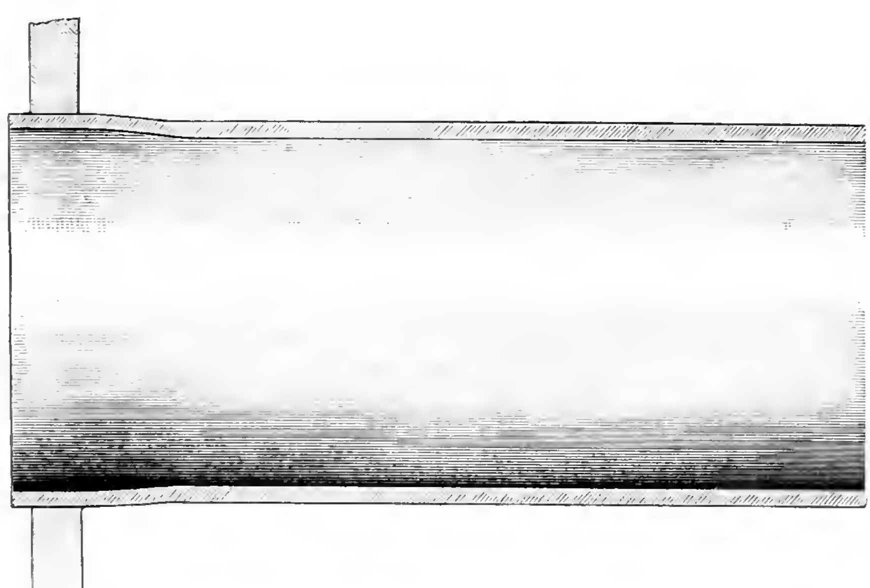
The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES — VOL. II. HARTFORD, CONN., MAY, 1881. No. 5.

Holding Power of Tubes in Steam Boilers.

In the valuable work on *Steam Boilers, Their Construction and Management*, by William H. Shock, Chief of the Bureau of Steam Engineering, U. S. Navy, is a long and interesting chapter on the holding power of steam-boiler tubes. Numerous experiments are described with tubes set in different ways, with illustrations that are valuable to study. It is not our purpose to enter into a full discussion of this subject, but simply to give the results of some experiments that have been made in our own work, and which may be of service to boiler-makers. Considerable discussion has arisen to the effectiveness of the Dudgeon tube-expander. It has been claimed that by simply rolling in the tubes with this apparatus little holding power was secured. This apparatus has become so generally used by boiler makers that it seemed important that some experiments should be made to ascertain just what the holding power of a tube would be, rolled in by this apparatus. Accordingly, we arranged with H. B. Beach & Son, boiler-makers in this city, to prepare for us three (3) specimens composed of tubes three inches external diameter, rolled into $\frac{3}{8}$-inch plate in the ordinary way without any expanding other than that produced by the apparatus. The following figure shows the tube as it appeared in section, one-half the original size.



It should be stated that $\frac{3}{8}$-inch plate is thinner than is usually used for heads of boilers of ordinary dimensions. The thicker head or tube-sheet would give more frictional surface, and consequently more holding power. These specimens were handed to Mr. Charles B. Richards, Consulting engineer* at Colt's Armory, in this city, with the request that he subject them to the required test.

* Mr. Richards has since removed to Philadelphia, and is now Superintendent of the Southwark Iron Works.

The following is Mr. Richard's Report:

Report. by The Colt's Patent Fire Arms Manufacturing Company, of tests of the holding strength of three boiler-tubes expanded into iron plates. The samples were received October 4th from Mr. J. M. Allen, and were tested for him.

The external diameter of the tubes was 3 inches, and the thickness 0.109 of an inch. One end of the tube was fastened in an iron plate 6 inches square, being simply expanded into the plate without the projecting part being flared or beaded. It was therefore held in the plate by friction only. The tube end, where it passed through the plate, was increased in diameter by 0.1 of an inch by the expanding process.

The thickness of the plate into which the tube was expanded was $\frac{3}{8}$ of an inch in sample No. 1,075, and $\frac{15}{32}$ of an inch in samples Nos. 1,076 and 1,077.

The test was made by observing the stress necessary to draw the tubes out of the plates, except with No. 1,077, where the tube was drawn only partly out.

The greatest observed stress sustained without the tube yielding in the plate was,

For specimen 1,075, 6,000 lbs.
" " 1,076, 4,500 lbs.
" " 1,077, 7,000 lbs.

The observed stress which occasioned yielding was,

For 1,075, 6,500 lbs.
" 1,076, 5,000 lbs.
" 1,077, 7,500 lbs.

The force was applied parallel to the axis of the tube, and the plate surfaces were held in planes at a right angle to the axis.

C. B. RICHARDS, *Engineer*.

OFFICE OF THE COLT'S PATENT FIRE ARMS MFG. CO.,
HARTFORD, Oct. 7, 1880.

From the foregoing it will be seen that the observed stress which occasioned yielding was 6,500, 5,000, and 7,500 lbs. To ascertain what the holding power of the tubes in an ordinary tubular boiler 48 in. in diameter would be, we have to multiply the holding power of one tube by the number of tubes.

The following figure represents the tube-head of a 48-inch boiler.

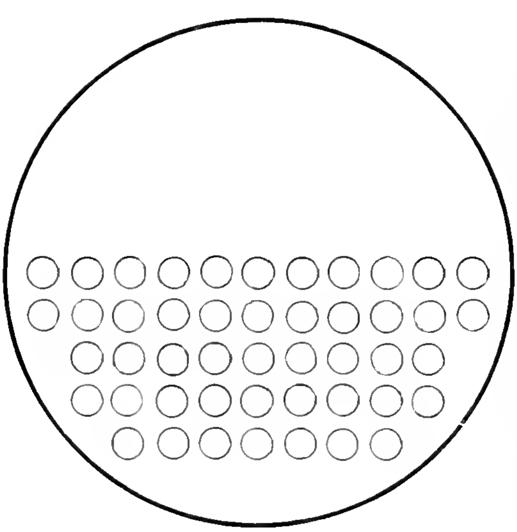


FIG. 2.

We will assume the lowest result of the experiments, viz., 5,000 lbs., as the holding power of one tube (the average in a boiler would probably be higher). In the above tube-head there are 47 tubes, and $47 \times 5{,}000 = 235{,}000$ lbs., the holding power of all the tubes. It will be seen that these tubes are in the lower half of the boiler. The upper half is supposed to be thoroughly braced and stayed by stay-rods running back on to the body-sheets of the boiler. Consequently the tubes furnish the support for the lower half of the tube-head. (We are not now taking into account the support derived from the joining of the flange of the head to the body of the boiler.) To ascertain the actual resistance of internal steam-pressure to be overcome and provided for, we first ascertain the area of the head in inches, and multiply it by the internal pressure per square inch. The area in square inches of a tube-head 48 inches in diameter is 1,809.6 square inches. But we have already stated that the upper half is supported by braces and stays running back on to the body-sheets of the boiler; therefore only half the head is dependent upon the tubes for support, $1{,}809.6 \div 2 = 904.8$ square inches. Again we find that the lower half of the head is largely taken up by the tubes, consequently the area upon which the internal pressure can act must be further reduced by the area of the tubes. The area of a 3-inch tube is 7.069 square inches, which, multiplied by 47= 332.243 square inches, 904.8—332.243=572.557 square inches, the area of lower half of head upon which the internal pressure would act. We will assume the internal pressure to be 80 lbs. to the square inch, then 572.557×80=45,804.56 lbs., to sustain which we have the holding power of the tubes, 235,000 lbs., or more than five (5) times the internal pressure on the lower half of the tube-head. This, it must be remembered, does not take into account the fact that the tube-head is firmly secured to the body-sheets of the boiler by its flange besides. This result would seem to indicate that the Dudgeon tube-expander is a perfectly safe machine to use for this purpose. It should be borne in mind, however, that to be safe and effective it must be in judicious hands. We have seen tubes only half rolled in, and their holding power would probably fall far below the lowest result of the above experiment; and again we have seen cases where the rolling has been carried to excess. The tube-sheet was cracked from one tube-hole to its neighbor. Hence it will be seen that, like all other parts of the boiler, the work should be done by judicious and skilled workmen. We have other experiments on tubes which will be explained and considered in our next issue.

Boiler Explosions.

MONTH OF APRIL, 1881.

Saw-Mill (57).—The boiler in Aldrich & Willet's mill, near Pentwater, Mich., exploded March 21st. Fragments were thrown about fifty feet.

Saw-Mill (58).—A boiler in Long & Co's mill at Beaumont, Texas, exploded March 29th, doing damage to the amount of $500.

Locomotive (59).—Locomotive No. 148, attached to the Clearfield passenger train, exploded at Tyrone, Pa., on the morning of April 1st, shattering everything in the vicinity of the new depot. The Ward House and Ray's tannery were badly damaged, and windows were broken for two squares distant. Mr. Williams of Orbisana had an ear cut off, and was otherwise badly hurt; Henry Haupt, telegraph operator, had both legs badly bruised; Mr. Test of Phillipsburg was badly cut about the face, and Michael Bowlinger of Tyrone had his face badly cut. A great many others received less serious injuries. The engineer of the engine escaped unharmed.

Saw-Mill (60).—By a boiler explosion in a saw-mill at Berkley, on April 2d, Andrew Brown (white), Thomas Creek, Moses Conway, and Luke Whitehurest (colored) were scalded to death. Robert James and Robert Brown (colored) will die. Lee Mingo, Lorenzo Backus, and Edward Morton (colored) were badly scalded.

Locomotive (61).—At one o'clock, on the 13th of April, a small engine, used in hauling mine cars at Nanticoke, Pa., exploded just as it was emerging from the tunnel. The engineer and fireman were blown about thirty feet and picked up unconscious. They revived in a short time, and were found not to be seriously injured. The engine had just come from the shops after being repaired.

Schindery (62.)—A terrible explosion occurred at Mr. Havealer's schindery, April 13th. He secured the carcasses from the stock yards, and on the first floor of his schindery is a vat used for boiling purposes. The vat is heated by steam, which runs from the boilers in pipes. Yesterday the pressure of steam became heavier than the boiler could stand, and it exploded with terrific force. The explosion was so great that the first floor and roof were carried away, and the whole building was gutted and completely wrecked. Those employed at work on the second floor, named Richards and Westerman, were injured, the first named so badly that it is hardly possible he can recover. Richards is badly cut about the body and head, having been struck by pieces of iron. Westerman was slightly injured, having made a miraculous escape. He was standing over the spot where the vat was located. Loss $3,000.

STEAM FORGE (63).— On the morning of April 14th, the night watchman at the Baugh Steam Forge Works turned the blast on the furnace used for heating iron which is shaped into car couplings. Connected with the furnace was a boiler which furnished the steam to operate the machinery. About six o'clock there was an explosion, and the boiler was hurled up through the roof of the forge building, and taking an eastward course, passed through between the spars of the barge Iron Cliff, now building at the Springwells dry dock, and dropping in the yard, bounded over near the engine house. Those who saw the boiler in its flight say it looked like a huge rocket with a streaming tail of steam. The bricks in the furnace were scattered in the building and through windows. The explosion is attributed to some defect in the furnace. Nobody was hurt, as there were no workmen about the place when the explosion occurred.

PILE DRIVER (64).—The boiler of a pile-driver at Fort Atkinson, Wis., exploded April 21st, killing a valuable horse and destroying a quantity of lumber belonging to A. D. Wilcox & Co.

ACCIDENTS OTHER THAN BOILER EXPLOSIONS.

The cylinder head of a large engine in the National Rubber Works at Bristol, R. I., blew out April 15th. Half of the works must be idle for two or three weeks in consequence of the accident.

At the Reliance Lumber Co's mill, Beaumont, Texas, a few days ago, a piston-rod became uncoupled, and the head of the cylinder was torn out.

Inspector's Reports.

Below will be found the one hundred and seventy-fourth monthly summary of the Company's work in this most important department. The whole number of visits of inspection made in March, 1881, was 1,851; the number of boilers examined was 3,976, an increase of 353 over the preceding month. Of this number 1,234 were examined throughout, both internally and externally. The whole number of defects found was 1,432, of which 423 were considered dangerous. The detailed statement is as follows: Furnaces out of shape, 83—14 dangerous; fractures, 167—86 dangerous; burned plates, 73—34 dangerous; blistered plates, 206—36 dangerous; cases of deposit of sediment, 206—46 dangerous; cases of incrustation and scale, 249—41 dangerous; cases of external corrosion, 95—39 dangerous; internal corrosion, 58—16 dangerous; internal grooving, 16—7 dangerous; water-gauges defective, 33—12 dangerous; blow-out defective, 18—8 dangerous; safety-valves overloaded, 18—8 dangerous; pressure gauges, 154—47 *dangerous*; boilers without gauges, 25; cases of deficiency of water, 4; broken braces and stays, 27—21 dangerous; boilers condemned, 23.

We would call special attention to the item relating to defective pressure gauges, as its importance can hardly be over-estimated. The records of the inspectors show a variation of from 50 *pounds* per square inch *below*, to 50 pounds *above*, the correct pressure when tested by the company's standard gauges. For instance, if a gauge is 50 pounds slow—*i.e.*, shows that amount *less* than the actual pressure, and indicates 80 pounds—the actual boiler-pressure will be 130 pounds. Using a boiler at such pressure, which may have been designed for not over 60 or 80 pounds per square inch, is likely to result very disastrously, sooner or later. This disarrangement of pressure-gauges is a very common defect, and one which is decidedly dangerous in the extreme heavy variations. Steam gauges are so much relied upon that they should be frequently tested and compared with a standard gauge.

AN EXPLOSION AT A PEANUT STAND.—An old woman whose face is familiar to persons crossing the Jersey City ferry replenished the fire in the little furnace of the machine attached to her stand, opposite Taylor's Hotel, yesterday afternoon, and put a fresh supply of peanuts in the revolving cylinder, in which they underwent the process of roasting. Seven small boys stood near and marveled at the mighty power of steam (for the machine boasted a boiler), which not only roasted the nut in its shell, but drew lively music from a little whistle that formed the ornamental portion of the apparatus. But the whistle blew a warning note, the steam rushed out with unwonted rapidity, and the old woman, foreseeing danger, was preparing to empty the cylinder, when an explosion startled the street. The seven boys were blown wailing away, and the old woman was thrown upon her back and almost buried beneath several quarts of half-roasted peanuts.

The boiler had burst, but so far as could be learned the old woman was not hurt. Nor were the peanuts seriously injured, for the boys who gathered them up by handfuls, agreed that they rather preferred them in a half-cooked condition.

THE American Society of Mechanical Engineers met in Hartford on the 4th inst. There was a large and enthusiastic meeting. Prof. R. H. Thurston presided. Many interesting papers were read and the reunion was one of unusual interest. There were many men of note present, those whose names we often see connected with great engineering works. To see them together was a sight well worth a long journey. We have no space to comment upon the papers read. Reports of these will be found in the technical journals.

THE *Zeitschrift des Verbandes der Dampfkessel-Ueberwachungs-Verein*, published in in Magdeburg, reproduces the article on man-hole plates and frames which we published in the January LOCOMOTIVE. They also copy statistics of boiler explosions in the United States, and illustrate an exploded upright steam vessel of peculiar construction. The fracture evidently began at a weak man-hole frame. The paper has many interesting items and profitable suggestions in it.

MILLS' Directory of Boiler Owners and Steam Users for New York and New Jersey is just out. It is the third of the series of similar directories being prepared, and is a useful hand-book for manufacturers and dealers in boilers and boiler appliances. It can be had by sending to the J. N. Mills Publishing Company, 165 Broadway, New York.

THE Boston *Journal of Commerce* has appeared in a new dress and enlarged form since our last issue, and in appearance and matter is a most attractive sheet. It has grown to become one of the most influential manufacturing and commercial papers in the country. We congratulate its editor and managers on their well-earned success.

The Locomotive.

HARTFORD, MAY, 1881.

Steel and Iron Plates for Boilers.

In the April issue of this paper was an article on "The Corrosion of Iron and Steel," from a paper read by Mr. D. Phillips before the British Institution of Civil Engineers. We had no space to comment upon the article at the time, but there was so much of interest in it that we feel moved to call attention to some of the results of the experiments mentioned therein. It was found that iron tubes, under experiment or test with the surroundings such as to induce corrosion, lost by weight during the test, 45.4 per cent. less than steel, and iron disks under similar circumstances lost 56.7 per cent. less than steel. Various other tests were made with different kinds of iron and steel, but in all cases the results were in favor of the iron. The use of steel for boilers has not been of sufficient length of time to decide fully in regard to its excellences as compared with iron. Its homogeneity, freedom from lamination and consequent non-liability to blister, has been looked upon as a most desirable quality, and, other things being equal, would make it preferable to iron for boiler construction. Our own experience with this material for boiler construction has been favorable. It is true that in some instances, and with certain brands, there has been trouble. A piece lies upon our desk at this writing which was the result of a fracture from punching rivet-holes. The piece which was ruined by this fracture was one upon which expensive flange-work had been done, and the whole consequently became worthless. This experience is not only provoking, but very expensive to boiler-makers. There are brands of steel which, so far as we know, give very little trouble, and again some which work exceedingly well at times are quite refractory at other times. This would seem to be the result of a want of due care in the manufacture. We have little confidence in a quality of steel for boilers, the tensile strength of which is much in excess of 65,000 lbs. per sq. inch of section, especially if it is to be used over or near the fire. The percentage of contraction of area at fracture under test should never be less than 40%, and even 50% would be better. And yet we know that the softer and purer metal is most liable to corrosion. It would seem therefore that in the purifying of metals in order to render them more ductile, elements such as carbon, phosphorus, etc., were eliminated, which, no doubt, rendered the metals more liable to corrosion. Here then we are between two fires. If the metal is hard, and resists corrosion, it has too little ductility. If soft and ductile, it is liable to corrode. We do not feel that this condition of things should preclude the use of steel for boilers. We regard the corrosion, if the facts are in accordance with Mr. Phillips' report, as the greatest obstacle. For steel can be made of good quality and ductile, and an honest manufacturer will do his best to produce a first-rate quality. The corrosive evil, if noticed, must be overcome by the use of such anti-corrosive in the water as will neutralize it, and render it harmless. In our own experience with thousands of stationary boilers we have not thus far found that steel was any more liable to the corrosive action of impure waters than iron. Our opinion in regard to this matter is not founded upon experiments with prepared specimens and corrosive substances, but upon what we have seen with boilers in actual use. As was stated in the beginning of this article, steel has not been used long enough in boilers to give the proper data for making up an intelligent and final opinion on the subject.

Much has been said about the behavior of the steel in the boilers of the "Livadia." In the *London Engineering* of April 15th, is an interesting article on this subject by B. W. Parker, Chief Engineer Surveyor of Lloyd's Register.

Mr. Parker found that punching holes in the plate made them extremely brittle. In experiments upon plates where the holes had been punched and afterwards reamed, he found good results, also on specimens which were annealed after punching. The results were thus. The reamed specimens broke at a stress of 27.6 tons, with an elongation in 8 inches of 7.5 per cent. The annealed specimen stood 26.6 tons, and stretched 6 per cent. in the same length, and the plain punched specimen broke short off with no extension under a strain of 18.4 tons per square inch. This would seem to indicate that steel plates should be annealed after punching. We are, notwithstanding this report, of the opinion that there must have been some error in the manipulation of the metal, for we have seen steel plates that worked perfectly satisfactory, and hundreds of boilers under our care to-day made from steel plates are doing good service, with no indication of fracture or unusual deterioration. If there is a degree of uncertainty as to the reliability of steel plates for boilers, boiler-users and boiler-makers will return to the better qualities of iron. It is a question that interests every manufacturer of steel in the country, and no effort to ascertain the true cause of such behavior, or accidents as are herein referred to, should be spared. It is proper to say here, that some of the difficulties referred to above are no doubt due in some measure to the "rush" with which everything is being done. Due care under these circumstances may not have been given to the product of steel works, and in the great demand for boilers, it is not improbable that there has been over-heating, and too much working in flanging.

Domes and Drums — What are they for?

WRITTEN FOR THE LOCOMOTIVE BY S. N. HARTWELL.

(Continued from page 49.)

The proposition that steam stored in one mass or body, in contact with the water from which it rises, suffers less condensation than it does when stored partly in a vessel adjoining the boiler, was suggested in the last number of this paper, and it was thought to be so plain a fact as to be almost an axiom, it being understood that both are in like conditions of temperature, and that the temperature of the surrounding bodies is something lower than that of the steam. It may be true that superheating of the steam may be better done in separate or adjoining parts of the boiler, but aside from the danger of overheating the parts exposed to high heat and containing only steam, the practice of superheating steam may be still considered an unsettled question of economy. If the heat generated in the furnace is not so far absorbed by the water in contact with the heating surfaces as to leave only sufficient heat to induce good chimney-draft, then it may be better to expose the feed-water to the waste heat as it passes to the chimney by means of coil feed-pipes in the flues leading from the boiler, rather than destroy the dry parts of the boiler or render them dangerously weak from overheating. The modern system of covering drums and domes with non-conducting material has greatly lessened the loss formerly experienced, but the complication and consequent cost of such devices are greatly against them, to say nothing of the difficulty of examinations and repairs, the importance of which is enhanced by every departure from the simplest construction. Coverings of steam boilers must be so made as to be easily removed for examination of those covered parts of the boiler that cannot be thoroughly examined inside. The covering must therefore be made in sections, which is not only expensive but inconvenient, and causes great delay in inspections and repairs.

The following diagrams, which were in process of preparation when the first section of this article went to press, are here introduced for the double purpose of illustrating the foregoing proposition and of showing what increase in size and modification of design of the horizontal cylindrical boiler will fully compensate for the omission of the separate or adjoining steam storage-room.

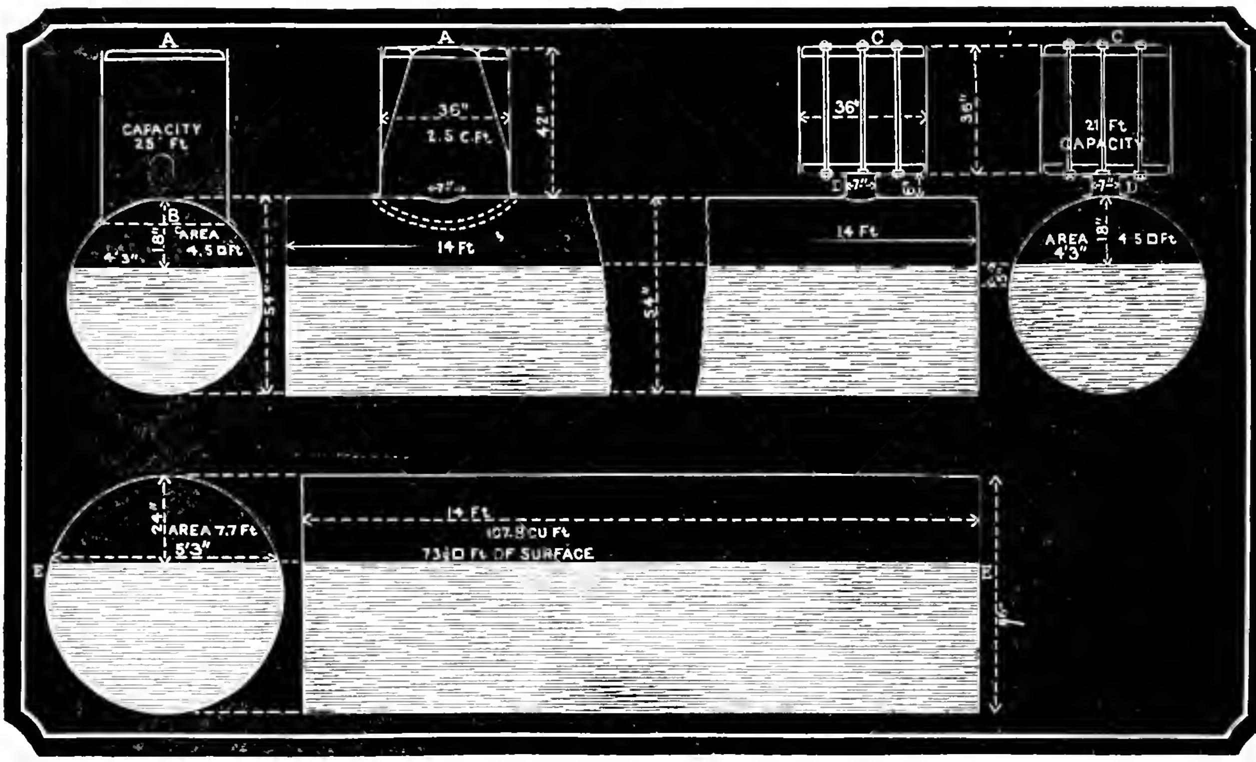


Fig. 1.

In the upper diagrams, fig. 1, are shown parts of two 54-inch diameter cylindrical boilers 14 feet long having domes of not unusual size attached by the best methods, by which 40 and 33 per centum of steam room is added, respectively, to the boilers at the assumed heights of water. In a plain cylinder boiler, meaning one containing no tubes or flues, which is so set in the masonry of the furnace as not to suffer from overheating by lowering the water-level, this way of increasing the steam-room naturally suggests itself, and a little calculation will show that about 5 inches would be quite sufficient in the samples chosen, viz., 54 inch by 14 ft. cylinder, lowering 5 inches, adds 40 per centum to the steam room. This method may be adopted in some cases without detriment in a plain cylinder as above, but when there are tubes in the boiler, one or more of the upper horizontal rows must be taken out.

This is often of advantage, although it may appear to reduce the efficiency of the boiler on account of the reduction of the heating area. But many boilers of the tubular type are so much overstocked with this second-rate heating surface, by huddling as many tubes as can possibly be got into the cylinder, and thus a much larger cross area of openings is provided than is needed for the passage of the hot gases, and they find their way through the upper ones leaving the extra ones to fill with ashes, and not only are they inefficient as heating surfaces but they are greatly detrimental to the circulation of the water upon which boiler efficiency and cleanliness so much depends. In many cases, then, the remaining tubes are far more efficient per unit of area. The disadvantage in lowering the water line, one that is more serious, is the reduction of the quantity of water, the reservoir of heat which effects a steadier supply of power, standing against which is the slight increase of the free surface of water from which the steam escapes;

this is to be considered further on in connection with the second method of compensating for the omission of the dome.

The lower part of fig. 1 shows a more desirable way of making up for the omission of the dome, by slightly changed and cheaper design, than the one involving the dome. It is simply an increase of the diameter of the cylinder as shown at E E, and it is desirable for reasons that will presently appear if they are not obvious on examining the diagram. In comparing the storage capacities for steam and water at any given height of water, the table found on page 101, vol. 1, will be found useful. For example, the cross area of the steam space in the upper set of boilers is found by multiplying the square of the diameter of the cylinder by the decimal .2288 which is found under 54″ in line 18. The diameter being for convenience taken in feet (if in inches then the product will be in square inches); thus, $4.5^2 \times .2288 = 4\frac{1}{2}$ square feet approximately; thus, $4\frac{1}{2} \times 14 = 63$ cubic feet in the steam room when the water stands 18 inches below the crown of the arc. The contents of the domes being added give respectively $63 + 25 = 88$, and $63+21 = 84$ cubic feet. In like manner the capacity of the steam room of the boiler E E, which is 66″ diameter and 14 feet long, may be obtained by multiplying 5.5^2 by the decimal found in the columns 66″ in the line 24 which is the height of the arc in inches. Thus $5.5^2 = 30$, which multiplied by .2574 gives 7.7 square feet, this by 14 gives 107.8 cubic feet, the capacity of the cylindrical segment. This is something more than the storage capacity of either of the samples having the domes. The fact that this slight change in design is in the direction of economy in the production of steam, as well as offering greater facility for examination and repairs, should be quite sufficient to insure its adoption; but when it is once realized that it is not only so but a cheaper and safer construction, hesitation in giving it the preference is not excusable in the purchaser. The larger cylinder should of course be made of stronger material just in proportion to its enlarged diameter; thus, if at any given pressure $\frac{5}{16}$ double riveted plates are known to be sufficient for the 54″ boiler, then the 66-inch should have about $\frac{3}{8}$.

$$\text{Thus, } \frac{.3125 \times 66}{54} = .381 = \tfrac{3}{8} \text{ nearly.}$$

The larger boiler considered as a tubular boiler of the same generative power will require only the same number of tubes of the same length, so that the comparative cost of the cylinder portion of the boiler may be roughly stated in weight of metal as $.3125 \times 54$ is to $.381 \times 66$, or nearly as 17 is to 25, and a little calculation will show that the cost of a dome will more than pay for the extra metal required for the larger cylinder.

Among the incidental advantages to be derived from the change in design are the larger quantity of water stored, whereby the fluctuations of pressure are greatly reduced, and also the larger surface of water from which the steam escapes into the steam reservoir.

The former advantage is known to every thoughtful engineer who has had the opportunity to compare sectional boilers containing only a few pounds of water with those having large storage capacity for power in the water room. Whether these samples of construction in figure 1 are considered as plain cylinder boilers or horizontal tubulars having equal volumes of tubes, the excess of water in the larger one will be the same in either case. Suppose for example they are first considered as plain cylinders; the smaller will contain approximately 158 cubic feet of water and the larger one will contain about 214 cubic feet, the difference being 56. Now let 60 3-inch tubes be introduced into each boiler. Their cubical volume is of about 42 cubic feet, which taken from each leaves 116 and 172 respectively, the difference being as before 56 cubic feet, which, taken at 62 lbs. per cubic foot, and at a temperature of 100° F. above the atmospheric boiling temperature, represents 347,200 available heat units more stored in the large than in the small boiler. I have called attention to this feature of the case at the risk of being accused of trying to prove an axiom, or to demonstrate that 2 and 2 are 4; because many intelligent boiler buyers are led into the belief by the seller, that steam may be generated more rapidly and more economically from small quantities of water, because forsooth steam is sooner realized, after lighting the fire under a boiler containing 500 pounds of water, than from one containing 5,000 pounds, furnaces being equal. This fallacy needs only to be pointed at to be exposed. The advantages realized in the increase of the water surface which was mentioned above, has perhaps a more intimate relation to the second part of this discussion, viz., the prevention of foaming by the use of domes, and it will therefore be considered further on.

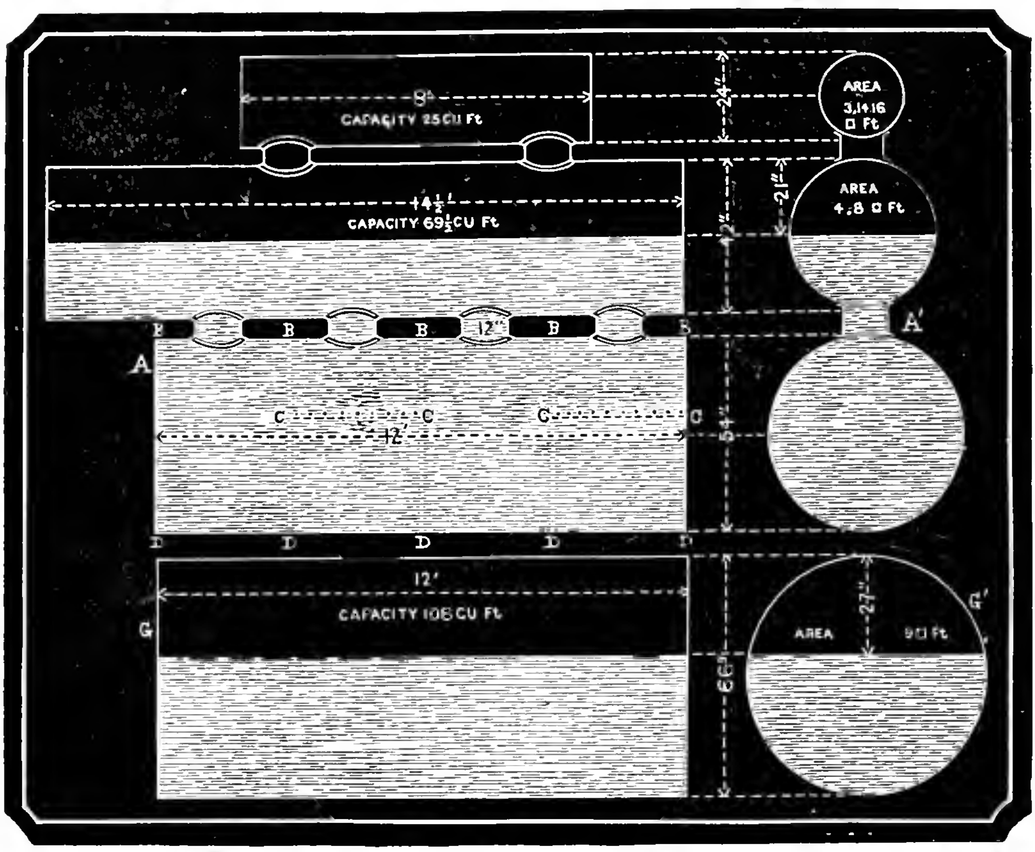


FIG. 2.

Passing now to the brief consideration of another form of storage room known as drums, and shown in figures 2 and 3, we can see, especially in fig. 2, the absurdity of separate store-rooms for steam attended with additional complication, cost, and danger. The boiler A A, fig. 2, is a type lately much used in a neighboring city and its vicinity, to which locality its use has been almost entirely confined, and it has acquired a reputation of being dangerous, which, added to the facts of its great first cost and questionable economic performance, should entirely prevent the propagation of this species of steam-generator.

The lower cylinder of the three composing the "double-decker," as this boiler is locally called, is filled with tubes 3″ to 3½″ diameter, extending from head to head, usually as many as 70 tubes 3½ inches diameter or a greater number of 3-inch tubes clustered into a 54-inch cylinder. The furnace grates are placed under one end of the lower cylinder, the left hand end in this case, and the furnace gases pass to the right under the cylinder, enter the tubes at C and return under the middle cylinder around the necks B B, etc., to the chimney flue at the right hand end. The middle cylinder contains no tubes and is usually half full of water.

In regard to the number and cross area of these tubes as compared with the grate area, so much difference of opinion exists among teachers in this line that we may well guess that the experiments upon which their rules are founded, vary considerably in the condition of intensity of chimney draft which is regulated by the height of the chimney and the temperature of the escaping gases. I will, for illustration, propose the following conditions, which are not much, if at all, different from American practice. Let the boiler A A, fig. 2, be of the following dimensions, as shown in the diagram: main cylinder 54 inches diameter by 12 feet long, containing 73 tubes $3\frac{1}{2}$ inches diameter, the internal diameter of the tubes being about 3.3 inches, gives each an area of opening about $8\frac{1}{2}$ square inches; total area of 73 tubes, 620 square inches. Let the boiler be set over a $4\frac{1}{4} \times 4\frac{1}{2}$ feet grate, or 20 square feet of great area = 2,880 square inches. Authorities and American practice for the proportion of chimney area for this grate vary from $\frac{1}{6}$ to $\frac{1}{12}$ of the latter, taking a mean: $\frac{1}{9}$ of 2,880 is 320, or about one-half the cross area found in these 73 tubes. The furnace gases, owing to their levity, find their way through about one-half — the upper half — of this bank of tubes, and, so far as mere thoroughfares for the gases, one-half or $\frac{5}{8}$ of their number would be ample, while, as a matter of heating surface, the

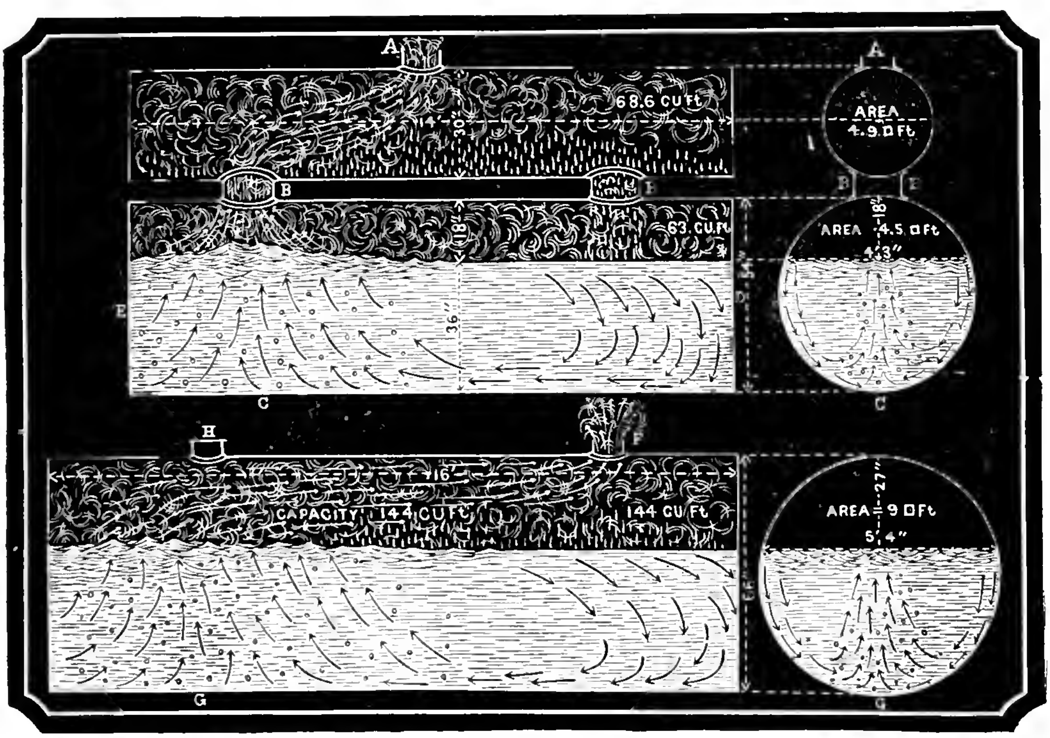


Fig. 3.

balance are not worth their cost. This has been demonstrated by a number of experiments made by the U. S. Government in plugging successive rows of extra tubes, thereby making an actual gain in economy of evaporation; and by the writer a still greater gain has been realized by fitting chokers or thimbles to the exit end of a number of banks of tubes. If I am not in error in this estimate of the "double-deckers'" efficiency per unit of tube surface, then the same, or perhaps better, results might be obtained from about $\frac{5}{8}$ as many tubes placed in the lower half of a 66-inch cylinder of about the same length, or certainly from one a little longer, say 16 or 18 feet long. A cheaper, more efficient, and safer boiler would thus be realized, having more storage capacity, which will be of a more conservative character. The facility with which the larger boiler G G, fig. 2, can be cleaned, examined, and repaired is a matter of great importance, and should always have weight in deciding what type of boiler to purchase.

We come now to the consideration of the second part of the subject of the use of domes, namely: their effect on the separation of water from the steam, and how it may be otherwise accomplished, or, which is better, how prevent foaming and lifting of the water with the steam.

The prevention of foaming should first engage our thoughts. The forms of generators having the largest free water surface are the ones least likely to promote concentrated ebullition, other things being equal, from which lifting of water usually arises. Reviewing the suggestions for doing away with domes and drums, it will be seen that this is one of the principal advantages to be gained by the increase of the size of the cylinder. Fig. 3 is intended to show a comparison of two nearly equal boilers in regard to the facility for prevention of foaming and the separation of the water from the steam in the event of a sudden reduction of pressure caused by a large draft of steam, the boilers being of the horizontal type, either plain or tubular, and the furnace being located below the left hand at G, fig. 3. The larger boiler has more efficiency, greater storage capacity at a much less first cost. It will be seen that in the larger sample there are two nozzles, one for the safety-valve over the fire end, and the other for the steam supply pipe, and the reason for locating them as in the diagram will be obvious on a little study of the figure. The white arrows indicate the direction of the steam on the way to the outlet pipe from which any lifted water may drop out as indicated by the pointed short lines.

The black arrows and bubbles show the circulation of the water, induced by the rising hot current over the fire. The distribution of the tubes so as not to impede the circulation of the water is a matter of considerable importance, both as regards delivery of the nascent steam from its surface, and also the deposition of sedimentary matter on the hottest fire surfaces. The limit of this article is already reached, but the subject is by no means exhausted.

The Circulation of Water in Steam Boilers.

BY ROBERT WILSON.

In speaking of the motion of the water that is set up in a steam boiler by the application of heat, the word circulation is generally used, as though only one kind of movement were assumed to take place, whereas there is, in most cases, not only a movement *in* the water, but also more than one movement *of* the water. We speak here of water as it is fed into boilers, that is, the water with its contained air, gases, vapor, or steam, upon the presence of which the mobility of the water so greatly depends.

The movement that takes place *in* the water, or the motion of the particles of the water in relation to one another, or the mutual changing places of the warmer particles below and the cooler particles above, always occurs when sufficient heat is applied to the under side of a vessel containing water. The movement *of* the water, or the motion of the body of water in relation to the sides of the vessel containing it, may or may not take place, but it never takes place without the movement *in* the water. It is the confusing of these two distinct kinds of movement by convection or circulation, or the failing to perceive their distinction, that has led to the failure of so many water-tube boilers of late years. It is no exaggeration to say that the efficiency and safety of a steam boiler depend as much upon the efficiency of the water circulation as they do upon the strength and disposal of the material of the boiler; it is, therefore, of the first importance to have a clear notion of what the circulation is.

Taking the simple process of heating water in a pan, if we could impart the heat simultaneously and uniformly to the whole bottom layer of water, there would probably be no convection or circulation at all. There might, however, be a slow conduction of heat through the contained gases and body of water, and consequently a slight increase of vaporization, previous to the whole body of water being lifted by the steam out of the pan. But as no such simultaneous and uniform imparting of heat can take place under the conditions of varying intensity of heat, uneven surface, and different thickness of material, and different internal and external conducting power at different points of the heating surface, it always happens that one particle or number of particles of air and water become more quickly heated than those around, and, therefore, increase in bulk. The expanded and lighter particles, being no longer able to balance and keep in their place the cooler particles, are forced upwards. If the temperature of the heated particles remained undiminished, these would rise vertically towards the surface with an accelerated velocity; but, as their heat is rapidly dissipated in their passage upwards amongst the cooler particles, their upward progress is gradually arrested, and they, in their turn, assist in pressing upwards the warmer particles below. They then descend and are reheated. The particles rise higher and higher upon each successive reheating, until at last they reach the surface, when the whole body of water becomes raised in temperature, and vaporization is sensibly promoted. When the temperature has been sufficiently raised, a more or less violent ebullition commences, accompanied by evaporation. Whether the particles ascend round the sides of the vessel and descend in the middle, or *vice versa*, will depend upon the relative temperatures at the sides and middle. But, in all cases where the heat is applied underneath, the reheating and cooling tend to take place in the same part of the vessel. This mutual changing place of the warmer and cooler particles of the water which precedes and is necessary for free evaporation might be called *intercirculation*; we will, however, call it by its popular name, "ebullition."

In a horizontal plane cylindrical boiler, half filled with water, if the temperature were practically uniform all along the heating surface, we should have only this ebullition going on along the whole length of the boiler. But in such boilers, heated by a furnace at one end, we have a much higher temperature over the furnace. This causes the water here to be more highly heated, the ebullition to be more violent, and the body of water more dilated than the body of water beyond. The water-level is consequently higher here. This difference of water-level causes a flow of water from the surface over the fire towards the back end of the boiler, and consequently a return flow of the cooler water to the front end. This from-end-to-end circulation, to which is due the carrying away of the insoluble matters left by the evaporation, and their deposition at the back end of the boiler, takes place in a greater or less degree, according to the violence of the ebullition in all horizontal boilers, and we may call it "*tidal*" circulation. Everything is here favorable to the evaporation and free escape of steam, and nothing more is required for the efficiency and safety of the boiler so far as the circulation of the water is concerned.

Were the boiler filled and kept full of water, and provided with outlets all along its upper surface for the steam to escape, this tidal circulation would be impeded, and we should have only the ebullition to produce evaporation. The interference with the free tidal circulation would, in many cases, have a very material effect upon the safe working of the boiler, as there would no longer be the same tendency to carry the precipitated matters away from the furnace, where by far the greatest amount of evaporation, and consequently precipitation of solid matter, takes place.

When, for the purpose of increasing the extent and efficiency of the heating surface, the large body of water is divided into smaller sections, connected by water-passages, another movement of the body of water is usually set up. In a Galloway boiler, for instance, there is, besides the ebullition, a movement of the water in some of the tapered tubes, which is due to the difference in the weight of two columns of water of the same height, but of different density, the lighter column being inside the tube, and the heavier outside. In the tubes just behind the bridge, which are exposed to the highest temperature, the water is more highly heated and more dilated than that in the water spaces at the sides of the boiler. The unbalanced weight of the latter causes the water in the tubes to rise, and so a movement is set up, which becomes a continuous circulation so long as the necessary conditions exist. This upward motion of the whole body of water in the tube we may call "*draught*" circulation, which goes on at the same time as and independently of the ebullition. It is this draught circulation that carries away the solid matters which are precipitated by the ebullition. Where there is simply ebullition the heated surfaces become coated with incrustation, when the nature of the feed water is such as to favor its formation. In Galloway boilers this is shown by the thickness of the incrustation in the tubes increasing with the diminution of the draught circulation as we recede from the furnace. The great accumulation of incrustation at the back end of these boilers is also, in some measure, due to the "tidal" circulation depositing the solid matters here which have been precipitated nearer the furnaces. When the "draught" circulation in a Galloway tube near the furnace is arrested by, for instance, a Hopkinson safety-valve float swaying a few inches above the mouth of the tube, incrustation rapidly forms, in spite of the ebullition that goes on, and which is usually, but wrongly, credited with the merit of preventing the scale from accumulating.

The shape of the tapered tube, with its greatest diameter at the top, while it favors the ebullition and the free escape of the steam-particles as they are formed on the sides of the tube, at the same time reduces the rapidity of the draught circulation as the square of the increase of diameter. Now, as the carrying away of the solid matter, which is deposited by the evaporation of the water, is mainly dependent upon the efficiency of the draught circulation, it follows that by reducing the draught efficiency the taper of the tube favors the formation and accumulation of incrustation, which impairs the efficiency of the heating surface of the tube. It would, therefore, appear that, in some cases, the tapering may actually tend to defeat the purpose for which the tube is introduced. It has hitherto been considered that a vertical taper tube is theoretically better calculated to promote the generation of steam than a vertical straight tube. But as the theory on which this conclusion is based does not take account of all the processes involved, its correctness is more than questionable. Of course the practical constructive advantages and facility for cleaning afforded by the taper shape must be taken into consideration, as well as the amount of taper in proportion to the length of the tube, the position of the tube in the boiler, and the nature of the feed water, in determining whether a taper tube is better than a straight one in any given case.

In some cases we might with advantage even reverse the taper in order to promote the draught circulation, upon which is dependent, in some measure, the warming of the large body of dead water in boilers without external flues, and having the fire-grate above the shell bottom. The warming of this dead water is also slowly effected by the tidal circulation and by the diffusion downwards of the heat from the furnace, which takes place when the heat is imparted to the body of water more rapidly than it can be carried away by the convection upwards which first takes place.

Where there are many vertical tubes, as in a Galloway boiler, it will depend upon the relative areas of the side water-spaces and of the tubes, the temperature of the gases in contact with the vertical and horizontal tubes at any given moment, and upon the condition of the heating surface, whether there will be an upward or downward current in the tubes near the back end of the boiler.

It is of the first importance in all water-tubes exposed to a high temperature, and having a diameter of, say not less than six inches, that the upward and downward currents due to the draught circulation should be separated, especially when the feed water is bad, as the heating surface near the battle-ground of the opposing currents is the most convenient place for the solid matters to settle and accumulate. In many Lancashire boilers, where the side and middle water-spaces are too narrow to allow a free passage for the upward and downward currents that would otherwise be established, the addition of vertical water tubes, by which the water can pass upwards near the furnace and down at the back end, has a marked effect upon the steaming properties and durability of the boiler.

Instead of a boiler of large section half filled with water, let us take a sectional boiler of four tubes, say six inches in diameter, forming a rectangle with horizontal sides, say eight feet long, and vertical ends five feet high, provided with an escape for the steam at the top of the ends produced. On applying heat to the bottom tube of this boiler, containing water to half way up the ends, ebullition will take place first in the hottest part of the bottom horizontal tubes. As this tube is full, the water can expand only horizontally.

There are two obvious methods for promoting this circulation, where the tubes are not all vertical or inclined, viz., either by providing vertical water-ways between the horizontal tubes, and connecting them by one or more horizontal tubes joined to the end tubes below the water level, or by inclining the horizontal tubes, and connecting the vertical tubes by one or more inclined tubes below the water level. By either method we complete the circuit, and, so long as the water is more highly heated in one vertical water-way than another, it will ascend in one and descend down the other, and so long as the water and steam-ways are not too restricted, we shall have a continuous circulation which is not dependent upon the evaporation for its maintenance.

(To be continued.)

In conversation with a St. Louis newspaper reporter, a few days ago, Prof. Wise, the aeronaut, expressed his views of the possibilities of ballooning, as follows: "Balloons may be made of boiler iron if built large enough. You know it is the battle of cubes and surfaces. When the surface is doubled the cube is quadrupled, and a balloon of 400 feet diameter of copper boiler plate will lift up a man-of-war ship and sail away with it. With such a balloon, stocked with bombs and other destructive munitions of war, think what consternation could be carried into a besieged camp. But the mission of the balloon will be more for scientific explorations. That overshadowing science called meteorology will yet provide its definition in the use of the balloon."

The annual report of the National Boiler Insurance Company of Manchester, England, for 1880, is received, and contains much valuable information, drawn from the year's experience. We learn from it that during the year there were 28 explosions of boilers in Great Britain, by which 69 persons were killed and 82 wounded. The explosions in the kingdom from July, 1864, to December 31, 1880, were 854, by which 1,064 persons were killed and 1,730 injured.

The *Mechanical Engineer* of New York, published by Egbert P. Watson & Son, is a very valuable addition to the engineering literature of the day. It treats subjects in a practical way, and so that any one with a fair mechanical education can understand them. We expect to see it fill a large place.

Mr. H. F. Smith, a graduate of the Lowell Machine Company, and more recently connected with the Willimantic Linen Company, has been employed by The Hartford Steam Boiler Inspection and Insurance Company, as special agent and draughtsman.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES — VOL. II. HARTFORD, CONN., JUNE, 1881. No. 6.

The Explosion of a Flue Boiler,

WITH A BRIEF DESCRIPTION OF THE CAUSES ASSIGNED.

BY F. B. ALLEN, M.E.

During the month of December, 1877, an explosion occurred in the city of ——— N. Y., that at the time attracted considerable local attention, from the fact perhaps that the boilers were in the same setting (Fig. 1) with an open steam-pipe connection between them, without valves or cocks by which that connection could be closed, and the pressure increased on one boiler beyond the limits of its strength.

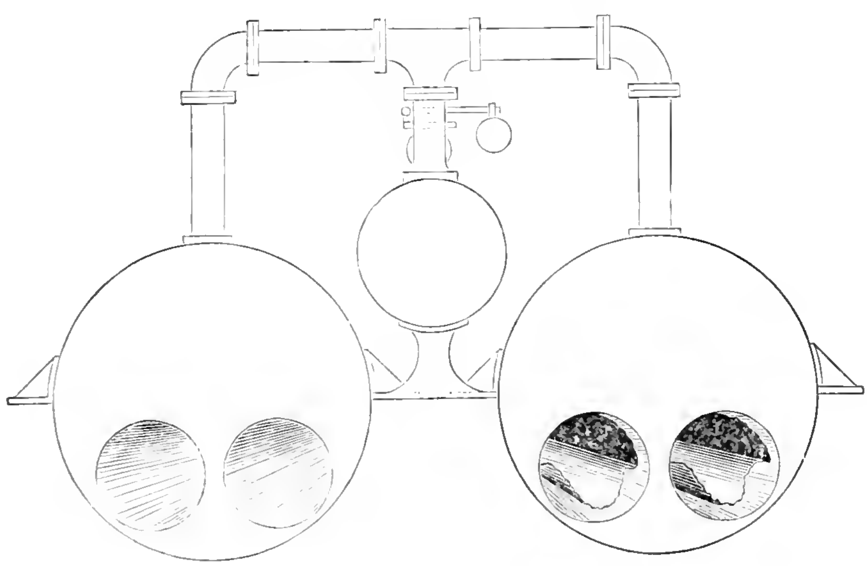


FIG. 1.

The factory in which they were used had been idle for some days previous to take stock and make some necessary repairs, and little steam was needed. The fires were ordered to be kept very light, furnishing only sufficient steam to operate the pumps, and prevent freezing up — the pressure necessary to do this was but 20 lbs. — while the usual working pressure was 60 lbs. Under these circumstances it was claimed, explosion occurred in No. 2 boiler from the collapsing of its flues. Fortunately no lives were lost, therefore no official investigation was required, and so far as known by the writer, no satisfactory explanation was ever offered.

The boilers were two in number, of the horizontal flue pattern, 5′ × 30′, externally fired, containing two twenty-inch flues (2-20″), the shells were of $\frac{3}{8}$-inch iron, single-riveted, material and workmanship of fair quality, concerning their strength we shall say more hereafter. They were built to order, and have been in use about five years by the concern, an old-established one, doing a large manufacturing business, having ample means to buy the best of everything they required, no doubt they were willing to pay for a good article, or what they were led to believe was such, especially in one so important as a steam-boiler.

Referring to Fig. 1, it will be seen the steam-drum, 28 inches in diameter by 25 feet long, was situate between the boilers supported upon the middle wall of the setting, the steam-pipes ——— ——— connected the boilers and the drum at both ends, *one safety-valve* of the common lever pattern of four inches diameter was attached to the drum, as were also the steam-pipes to the engine and pumps. Aided by these details it is hoped the reader will have obtained a general knowledge of the boilers, setting, and connections, which are important in studying the possibilities of danger which they permitted — perhaps invited — our purpose in studying the history of this case.

It appears from the data furnished, the boilers were single-riveted upon their longitudinal seams, while the best practice for a number of years past has been to have them double riveted when of so large diameter. the flues of light quarter-inch iron ($\frac{1}{4}$) were dangerously weak for their size, viz., twenty (20) inches in diameter. It appeared that they collapsed near the middle of their length, and extended to within a short distance of each head, rupturing at front end — the effect of which was to unseat both the boilers, damaging them so badly they were not afterwards repaired, destroyed the setting, and injured the boiler-house and other buildings, the loss in all amounting to some ($5,000) five thousand dollars. It was apparent from an examination of the collapsed flues that they had been overheated upon their most exposed part; the manner in which they yielded to the softening effects of this heat, flattening down on their top side, would confirm that opinion. It is a matter of conjecture as to what led to the overheating of these flues — whether neglect in attending to the feed, leaky blow-out, or by "kicking" into the adjoining boiler through the connections. I was informed each feed had its globe and check-valve; if this was true, it is not likely it could have occurred in that way. At the time of the collapse, 2 A. M., the boilers were in charge of the night watchman, who appeared dazed by the occurrence, but resolutely insisted it was through no fault of his. Possibly the arrangement of steam connections between the boilers would, under certain conditions, syphon the contents of one boiler into that of the other, if, for instance, one was heavily, and the other lightly fired, or by the opening of one damper by which its fire was greatly accelerated, with the steam outlets from the drum shut off as they were admitted to be at the time when water and steam from one boiler is violently driven over into that of the other, it is accompanied by a concussive jar, which does more or less damage according to the circumstances, not sufficient it is thought to have produced the effect described herein.

The necessity for attaching a safety-valve of sufficient area directly to the shell of each boiler without intervening valves has been repeatedly urged in these columns, and the large number of boiler explosions that are traced to imperfectly connected safety-valves, or those insufficient in area, prove this advice cannot safely be disregarded. Let us see what would have been a safety-valve of sufficient area (it being assumed it has the lift and other requisites of a good valve). We have in round numbers about 549 sq. ft. of heating surface in each boiler, according to the rules of the U. S. steamboat inspection service, the only official authority in this country, this would have required a safety-valve of not less than five inches (5) for each boiler, while the fact was previously stated, there was but *one four-inch (4") safety-valve for both boilers*, with an area of less than one-third ($\frac{1}{3}$) that actually required, and that too not fully effective owing to its location upon the steam drum.

The element of mystery in this case, as in many others, was the pressure of steam at the time of explosion. In a recent case 3 lbs. of steam being the pressure last observed some five (5) hours before, with fires banked, damper closed, and furnace doors open, it was assumed, and sought to be proved that the explosion occurred at that insignificant pressure, forgetting that in a rational explanation of an unusual occurrence the cause shall at least be proved sufficient to account for the effect produced. Engineers and firemen are but human, and in common with the rest of mankind, occasionally leave undone important matters of every-day routine. A study of the chart from a recording gauge, will materially assist in dispelling the mystery (so called) surrounding boiler-explosions that occur at night and early morning. The reading of one of these charts shows that fires were banked at 6 P. M. for the night, *the steam pressure gradually accumulated after* 9.30 P. M., *until* 1 A. M., *when it indicated* 66 *lbs.*— remaining at about that pressure until 6.45 A. M. when the engineer came, cleaned his fire, and possibly went to breakfast. At 7 A. M., it had reached 120 lbs. as recorded upon the chart. (Edson Recording Steam Gauge Charts, 43–45.) An illustration from my own experience may still further enlighten us concerning these mysterious occurrences. While at work upon a night repair job, my attention was attracted to an engine upon an adjoining "pit," that but an hour before had been put away for the night. Steam was leaking from a number of places upon the seams about the back-head. Taking my torch to examine the steam-gauge I was surprised and alarmed to find it showed 180 lbs., the limit of its graduation, with the pointer jammed fast against the stop-pin. Easing the spring-balance, and allowing the valve to blow lightly, it was a minute or two before the pointer began its downward movement. Upon investigation, it transpired the fireman, in violation of orders, had put away his engine with coals in the fire-box. "He was in a hurry," he said, "and didn't believe there was enough to amount to anything." Had an explosion occurred, what a mystery this case would have been, dwelling upon the fact that upon the engine during the day previous the working pressure had been 120 lbs., that it was filled with water and properly cared for, having but 80 lbs. steam when put away, probably decreased to 50 lbs. in a short time after — at some such pressure it explodes. Who could have revealed to us this terrible mystery? Yet how simple the explanation. Neglect, the fruitful cause of a majority of explosions. In the Stevens' Experiments at Sandy Hook, N. Y., in one of the boilers a wood fire giving less heat than coal in an equal time, in thirteen minutes the pressure was raised from 30 to 83½ lbs., the pressure at which explosion occurred. Proving that a few minutes' absence of the engineer, or neglect, coupled with an inoperative safety-valve, are all that is necessary to produce a most destructive explosion. (Loc., vol. I, new series, pp. 64, 65.)

Judged in the light of experience, this explosion was probably chargeable to the neglect of the night watchman who failed to keep up the water supply in No. 2 boiler, the tops of the flues were uncovered, and becoming overheated, they collapsed with the effect previously described. The pressure required to do this would not be an excessive one, owing to the weak construction of the flues. The safety-valve was inadequate for the purpose, and its attachments made it unreliable. At the time of explosion the steam-pressure was probably in excess of its load of sixty (60) lbs.

Inspectors' Reports.

April, 1881.

During the month of April, 1881, there were made by the company's inspectors 1,819 visits of inspection, the whole number of boilers viewed being 3,960, of which number 1,593 were examined both externally and internally, and 320 were subjected to hydraulic pressure. The total number of defects found was 1,739, of which 528 were considered dangerous. The defects in detail were as follows: Furnaces out of shape, 91 — 19 dangerous; fractures, 161 — 94 dangerous; burned plates, 98 — 40 dangerous; blistered plates, 239 — 35 dangerous; cases of deposit of sediment, 283 — 72 dangerous; cases of incrustation and scale, 353 — 63 dangerous; cases of external corrosion, 104 — 48 dangerous; cases of internal corrosion, 104 — 48 dangerous; cases of internal grooving, 27 — 21 dangerous; water-gauges defective, 39 — 15 dangerous; blow-out defective, 26 —

14 dangerous; safety-valves overloaded, 33 — 23 dangerous, one of which was found stuck tight; pressure gauges defective, 159 — 32 dangerous: variation from -20 to + 60 pounds per square inch; boilers without gauges, 74; cases of deficiency of water, 5 — 3 dangerous; broken braces and stays, 25 — 13 dangerous; 39 boilers and 1 mud drum were condemned.

Boiler Explosions.

Month of May, 1881.

Lumber-Mill (65).— By the explosion of a boiler, belonging to S. T. Zelorie, near Palmetto, Ga., May 4th, two men were killed, and several severely injured.

Planing-Mill (66).—The boiler in William Laws & Co's planing mill, Galveston, Texas, exploded on the afternoon of May 14th, completely tearing out one side of the factory. The building was badly wrecked. John Harrison, the engineer, was buried underneath the fallen debris. He was rescued, severely scalded. James Dougherty was blown across the building and was severely injured on the head and body by the flying bricks; he was also badly scalded. Mr. Laws was knocked down by the force of the explosion.

——Mill (67).— A boiler in Wither's mill at Rudd, Wis., exploded May 16th, demolishing the mill and killing Luke Lawry and fatally injuring another man.

Saw-Mill (68).— The Maryland Steam Saw-mill, four miles from Oakland, was blown to atoms, Saturday, May 21st, by the explosion of a boiler. Marshall Butler, the fireman, was blown 600 or 700 feet and instantly killed. William Browning was seriously injured and eight or ten others were slightly injured.

Foundry (69).— At 5 o'clock on the afternoon of May 24th, the boiler in the foundry of T. S. Risk & Co., Memphis, Tenn., exploded, killing W. H. Holder and Edward Hopkins and seriously injuring Frank Cubbins, John Adams, and John Hoyle. The jury of inquest returned a verdict of gross carelessness on the part of the owners for employing an incompetent engineer. The cylinder of the engine was blown over the county jail and through a brick wall a hundred yards distant. The engineer in charge at the time of the accident was a youth of 15.

Locomotive (70).— On Thursday morning, May 26th, a train on the Illinois Central was approaching Chicago at the rate of thirty miles an hour, and when within ten miles of Pullman the locomotive exploded with a terrific report. The bell, whistle, and smoke-stack were blown 500 yards away, and the boiler was completely demolished. In the cab at the time were engineer James Baute, fireman Joseph Fense, and the train boy. The two latter were thrown with great force to the rear end of the tender, but Baute held to the throttle and kept his seat until the train was stopped, although nearly everything about him was blown away. The engine was made a complete wreck, and the rear coach was so badly damaged as to be unfit for use.

Locomotive (71).— The boiler of a Nashville & Chattanooga locomotive exploded in Chattanooga, Saturday morning, May 28th. The destruction was terrific. The fireman, Charles Handeman, was blown fifty yards and instantly killed. The engineer had just stepped behind the tender and escaped. A piece of iron weighing nine pounds was thrown one-half a mile, and struck J. C. Finch, a car inspector, in the shoulder, causing death. One piece of iron weighing 200 pounds passed through two cars loaded with corn, and then knocked down the corner of a house. Cause, over-pressure of steam.

Saw-Mill (72).— At Caseyville, Kentucky, May 30th, the boiler to a portable saw-mill exploded, killing James Read and William Read instantly, and seriously injuring Samuel Read.

The Locomotive.

HARTFORD, JUNE, 1881.

Holding Power of Tubes in Steam-Boilers.

In our May issue we discussed the holding power of tubes when rolled into the tube sheet with the Dudgeon Expander, and showed from experiment that when the work was well done the holding power was something more than five times the ordinary internal pressure tending to drive the tube sheet outwards. So much depends upon the proper use of the Dudgeon Expander that some mechanical engineers are quite reluctant to accept the theory that all tubes thus rolled in are equally effective in sustaining the head or tube sheet. This criticism is in a measure true, and hence all boiler-makers who have pride in their work and regard for their reputation should know that this work is well done. The riveting over of the ends of the tubes is quite generally practiced, and when well done makes a very strong joint, but those who are familiar with this kind of work know that in many cases the ends of the tubes are frayed out and split, and until the "thumb tool" is brought to bear the job has a very unpromising look. Such work yields readily to the action of the heated gases, and after a time the riveting or beading fractures and crumbles off, and very little strength remains. This fraying and cracking is sometimes attributed to a want of proper annealing of the ends

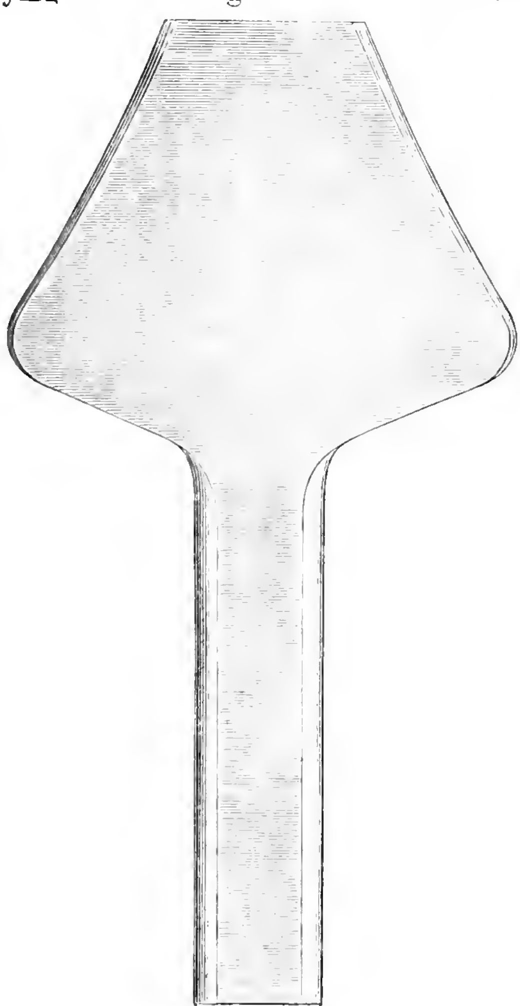


Fig. 1.

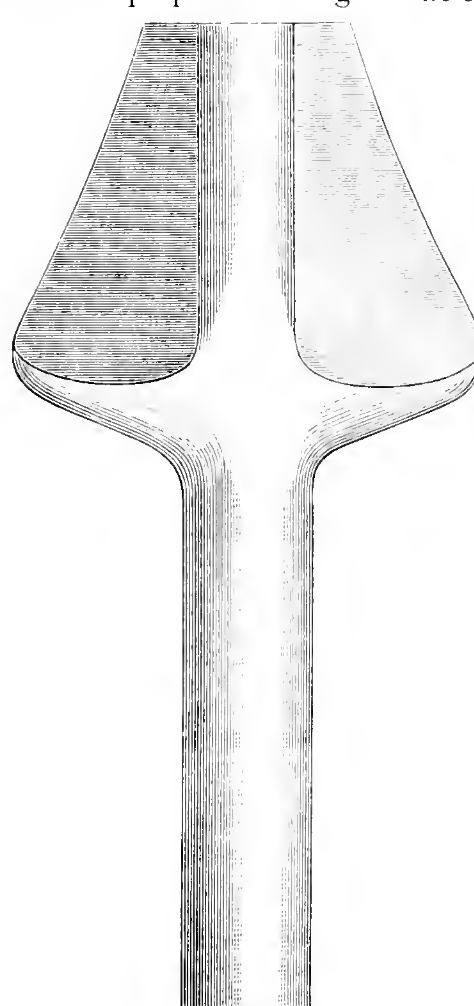


Fig. 2.

of the tubes, but it is quite as often the result of unskilled workmanship. We have seen it so often that we are never sure that it is well done.

Another method of fastening tubes into the tube sheet, and one that, so far as we have investigated, works well, the test being boilers in use, is to adjust the tubes so that they shall project slightly beyond the tube sheet. Roll them in with the Dudgeon Expander and then with one of the tools shown in Figs. 1 and 2, flare, or further expand the projecting ends. Figs. 3 and 4 show the above tools in cross section.

Little explanation of the manner of using them is necessary. After the tubes are rolled in, either of the above tools can be used for expanding the ends. Some prefer the tool with two points of contact, and others use the one with three. The tool is inserted into the end of the tube and driven with a hammer until the end

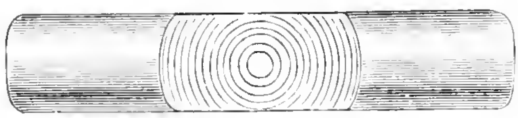


FIG. 3.

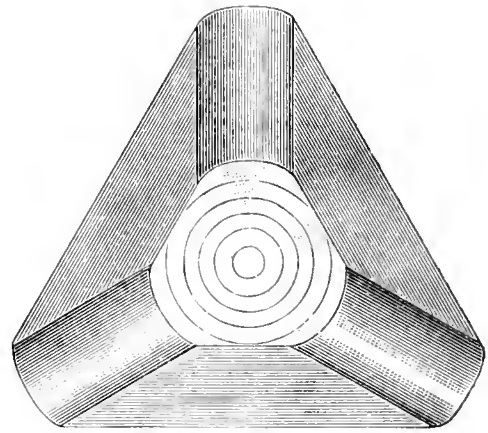


FIG. 4.

of the tube is brought solid against the tube sheet. Only light blows are required, and the workman can readily tell when the expanding is sufficiently done. Fig. 5 shows a tube which has been expanded by this method.

FIG. 5.

In order to ascertain what the holding power of tubes set in this manner would be, we arranged with H. B. Beach & Sons, boiler-makers in this city, to prepare for us two (2) specimens for test. They were tubes three inches external diameter, rolled into $\frac{3}{8}$-inch plate and expanded as described above. These specimens were handed to Mr. Charles B. Richards, Consulting Engineer at Colt's Armory, in this city, with the request that he submit them to the required test. The following is Mr. Richards' report:

Report by the Colt's Patent Fire Arms Manufacturing Company of tests of the holding strength of two boiler tubes expanded into iron plates. The samples were received October 8th, from Mr. J. M. Allen, and were tested for him.

The external diameter of the body of the tube was three inches, and the thickness

0.109 of an inch. One end of the tube was fastened in an iron plate $\frac{3}{8}$ of an inch thick and 6 inches square. The tube was fastened in the plate by being expanded, and the end of the tube, which was projected $\frac{3}{16}$ of an inch beyond the plate, was flared so that the external diameter of the extreme end was 3.2 inches, while the diameter of the tube where it entered the plate was expanded to 3.1 inches in diameter.

The test was made by observing the stress required to draw the tube out of the plate, but the tube was not wholly removed from the plate in specimen No. 1,079.

Both samples were originally alike, so that the description of one of them answers for both.

The stress which was sustained without the tube yielding in the plate was

For specimen 1,078, 20,000 pounds.
For specimen 1,079, 18,500 pounds.

The observed stress which first produced yielding was

For 1,078, 20,500 pounds.
For 1,079, 19,000 pounds.

And the observed stress which occasioned failure was

For 1,078, 21,000 pounds.
For 1,079, 19,500 pounds.

The force was applied parallel to the axis of the tube, and the plate surfaces were held in planes at a right angle to the tube axis.

C. B. RICHARDS, *Engineer.*

OFFICE OF COLT'S PATENT FIRE ARMS MANUFACTURING CO., HARTFORD, Oct. 9, 1880.

From the foregoing, it will be seen that the observed stress which first produced yielding was 20,500 lbs., and 19,000 lbs. As in the problem in our last issue, so now. To ascertain what the holding power of the tubes in an ordinary tubular boiler 48 inches in diameter would be, we have to multiply the holding power of one tube by the number of tubes.

The following figure represents the tube-head of a 48-inch boiler.

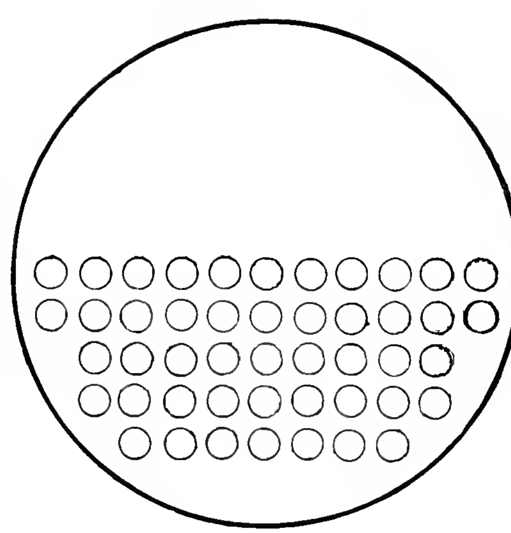


FIG. 6.

We will assume the lowest result of the experiments, viz., 19,000 lbs., as the holding power of one tube. In the above tube head there are 47 tubes, and $47 \times 19{,}000 = 893{,}000$ lbs., the holding power of all the tubes. It will be seen that these tubes are in the lower half of the boiler. The upper half is supposed to be thoroughly braced and stayed by stay rods running back on the body-sheets of the boiler. Consequently the tubes furnish the support for the lower half of the tube head. (We are not now taking into account the support derived from the joining of the flange of the head to the body of the boiler.) To ascertain the actual resistance of internal steam-pressure to be overcome and provided for, we first ascertain the area of the head in inches, and multiply it by the internal pressure per square inch. The area in square inches of a tube-head 48 inches in diameter is 1,809.6 square inches. But we have already stated that the upper half is supported by braces and stays running back on to the body-sheets of the boiler, therefore only half the head is dependent upon the tubes for support, $1{,}809.6 \div 2 = 904.8$ square inches. Again we find that the lower half of the head is largely taken up by the tubes, consequently the area upon which the internal pressure can act must be further reduced by the area of the tubes. The area of a 3-inch tube is 7.069 sqr. inches, which multiplied by 47 = 332.243 sqr. inches, 904.8 — 332.243 = 572.557 sqr. inches, the area of lower half of head upon which the internal pressure would act. We will assume the internal pressure to be 80 lbs. to the sqr. inch, then 572.557 × 80 = 45,804.56 lbs., to sustain which we have the holding power of the tubes, 893,000 lbs., or nearly twenty (20) times the internal pressure on the lower half of the tube-head. This it must be understood, does not take into account the fact that the tube-head is firmly secured to the body-sheets of the boiler by its flange besides. As we have already said, boilers with tubes set in this way have been under our care for some years, and we have seen nothing to lead us to apprehend any trouble. The ends have given little or no trouble by being subjected to the heated gases. We would not recommend a projection of the tube beyond the tube-sheet of more than $\frac{1}{8}$ an inch before expanding.

Resistance of Flues and Tubes to External, or Collapsing Pressure.

As many accidents to, and explosions of, steam-boilers, can be traced directly to deficiency of strength in flues and tubes, the determination of the conditions governing their stability as structures, and ultimate strength, or resistance to an external fluid pressure, becomes a matter of very great importance. This becomes still more apparent when we learn that flues as ordinarily constructed, and subjected to the same deteriorating influence as other parts of the boiler, do not possess, originally, more than one-third or one-half of the strength of the shells in which they are placed. If it were possible to construct a flue of perfectly circular section, uniform thickness, and homogeneity of material, the problem of determining its ultimate resistance to an uniform external pressure would be very easy indeed, and might be calculated with certainty and accuracy. Such a flue would, if subjected to an uniform external pressure, have no tendency whatever to change its circular form, and could yield only by crushing the material of which it might be composed. Its resistance to yielding would be expressed by the following simple formula: $P = \frac{tf}{r}$; where P = pressure per sqr. inch required to produce fracture, t = thickness of shell, f the resistance per square inch to crushing of the material of which the flue might be made, and r the radius of the flue. Thus we see that the only elements affecting its strength would be its diameter, thickness, and resistance to crushing of the material of which it might be composed. It is scarcely necessary to state, however, that the above-mentioned conditions can never be fulfilled in practice. Indeed, we may go still further and say, that they cannot be even approximately fulfilled. The reason, however, does not arise from any lack of knowledge or skill on the part of boiler makers, but is because the cylindrical form is inherently unfitted to sustain external pressure. When a hollow cylinder is subjected to an uniform *internal* pressure, the tendency of the pressure is to preserve the perfect cylindrical form and restore it if it is distorted by any extraneous force. The cylindrical form is, under these conditions, one of *stable equilibrium*, and well adapted, so far as the form is concerned, to fulfill the purposes for which it is designed. When, on the other hand, a hollow cylinder is subjected to an uniform *external* pressure, the tendency of the pressure is not to correct, but to still further increase any inaccuracy of form which the cylinder may have had originally, or which may be caused by any extraneous force. The cylindrical form, under these conditions, is one of *unstable equilibrium*, and is therefore ill adapted to fulfil the purpose for which it is designed. Thus it will be seen, that in an ordinary flue built up from plates by riveting, it is impossible to attain the circular form, and the conditions governing the strength are totally different from those that enter into calculations concerning perfect cylinders; and investigations relating to their strength must take the form of experiments, on flues of different dimensions, as they are usually met with in practice. The experimental investigations have revealed the fact that, *generally* the strength varies directly as a certain power of the thickness of the shell, inversely as the diameter and length, and that, outside of this, the strength is greatly influenced by the kind of joints used, and their number, the end fastenings, and the variation from the circular form which may be due to particular methods of construction, or imperfect workmanship. It will be seen from this that the conditions are very complex, and that any investigation of the subject by purely mathematical methods, will be utterly useless. That this is so, is abundantly proved by the very great discrepancy in the published results of the labors on this subject, by such eminent mathematicians as Belpaire, Love, Grashof, and others. Experiments have demonstrated that it is impossible, in practice, to crush the shells of thin flues, for they always give way by collapsing, long before a pressure is reached, which would injure the material of which the flue is composed, by direct crushing. For the first definite knowledge on this subject, we are indebted to the very valuable series of experiments made by Sir Wm. Fairbairn. These experiments, however, were made on flues and tubes much smaller, shorter, and thinner than those generally met with in boilers in practical use, and experience has shown that the formulae deduced by him from the results of his experiments should be somewhat modified for practical use. Of these experiments and their results, and those which have since been made by others, we shall speak in a future number.

H. F. S.

The Circulation of Water in Steam Boilers.

BY ROBERT WILSON.

[Continued from page 83.]

Should, however, the area for the escape of the steam at the top of the vertical waterways be too restricted, there will be a tendency for the steam, which will accumulate in the tube where it is most rapidly formed, to arrest the draught circulation, and force the water out of the other tubes. In a water-tube boiler consisting of a number of small boilers, such as we have just been describing, unless the area for the passage of steam from one section to another be of sufficient size, the more rapid generation of steam in one section may tend to force the water out of a neighboring section and lead to overheating. The determination of an adequate area for the steam-passages becomes, therefore, as important as that of sufficient safety-valve area. It may be taken as a rule, subject to qualification, that the area for the escape of steam from one section to another, and from the various sections to the common steam chamber, should not be less than one-quarter of a square inch for every foot of heating surface.

In a boiler with inclined tubes, the greater the inclination of these, up to a certain point, the more rapid will be the draught circulation. It is also obvious that inclining the tubes downwards from the fire will improve the draught circulation more than inclining them upwards from the fire.

With a view to obtain a large heating surface, there are generally a number of the inclined tubes one above the other, forming a vertical row, connected at their ends by vertical or nearly vertical tubes or passages. This increase in the number of tubes at once alters the disposition of the circulation. Let us assume, in the first place, that the tubes are inclined downwards from the fire, and that the bottom tube and that next above it are heated, if not nearly alike, at any rate very greatly in excess of the tubes above them. There will then be a tendency for the heavier water in the back water-way and in the upper tubes to force the lighter water up the two bottom tubes, and so the draught circulation may be carried on. Should, however, the temperature of the water in the second tube (counting from the bottom) be lower than that in the bottom tube there will be a tendency to form a circuit between these two tubes, the water in the second tube descending. Again, if the water in the third tube be colder than that in the second tube, the downward tendency in the second tube will be resisted, and so on with the rest. There may be a number of unbalanced columns of water, and a movement can only take place in the direction given by the columns that preponderate. It is difficult to decide in many cases which will be the preponderating columns. In fact, it may so happen, as it very often does, that the draught circulation is completely stopped, the evaporation proceeding only from the ebullition in each tube, a very hazardous process. By allowing only the two lowest or three lowest tubes to be in the furnace, and providing sufficient water-way at the back and front ends of the tubes, a draught circulation may be maintained between the tubes in the furnace and those out of the furnace. Means must, however, be provided to guide the ascending hot water and steam clear of the water descending to take their place.

It is certainly worth while to sacrifice a portion of the heating surface, if by so doing we can maintain a draught circulation, and so increase the efficiency of the heating surface we retain, and insure the durability and safety of the boiler. Had this point been attended to, some of the costly experiments with water tube boilers would have not been such decided failures as they proved. The simple expedient of taking a pipe from the top to the bottom of each section outside the boiler proper would have saved more than one water-tube boiler from failure, and others would have been saved by properly connecting the different sections above and below.

When, instead of inclined, we use horizontal tubes, we can establish a good draught circulation by multiplying the vertical connections and keeping the temperature in one end of the system lower than in the other, or by keeping the temperature in the middle higher than in the ends. When the heating surface consists chiefly of vertical tubes, it is important that ample provision should be made for a draught circulation, especially when the tubes are of considerable length compared with their diameter, and that the ebullition alone should not be depended upon for evaporation, as where no draught circulation takes place, the deposits will remain in the tubes where they are precipitated from the water.

In some arrangements the draught circulation may be so violent as to induce priming, when it will require to be checked. In all water tube boilers the best way to prevent the draught circulation affecting the dryness of the steam is to allow ample space and time for the steam to escape quietly from the surface of the water, and this can only be done by having a large surface for evaporation and a large space for the steam to accumulate.

In all water-tube boilers having horizontal or inclined tubes, and where the furnace tubes are separated from the upper tubes containing only steam by horizontal plates which direct the current of hot gases, there is always a risk of these plates getting out of order and allowing the flame, in seeking its nearest way to the chimney, to impinge against the dry tubes and bring about their failure. This circumstance has been the cause of more than one explosion of a water tube boiler, and is too often lost sight of both by those who design and make, and by those who use these boilers.

The following appear to be the points that require special attention in designing water tube boilers, to insure their satisfactory working and durability.

1. To keep the joints out of the fire.

2. To protect the furnace tubes from the sudden impingement of cold air upon them on opening the fire-door.

3. To provide against the delivery of the cold feed direct into the furnace tubes.

4. To provide means for a proper draught circulation in order to carry away the steam from the heating surfaces.

5. To provide passages of ample size for the upward currents of steam and water, which must not interfere with the downward currents of water.

6. To provide passages of ample size for the steam and water between the various sections of the boiler, in order to equalize the pressure and water level in all.

7. To provide ample surface for the steam to leave the water quietly.

8. To provide a sufficiently large reservoir for the steam in order to prevent the water being drawn out of its proper place by suddenly opening a steam or safety valve.

9. To provide against the flame taking a short cut to the chimney and impinging against the tubes containing steam only.

The Philadelphia Record of May 12th, gives the following account of a run from Philadelphia to Jersey City by a Pennsylvania train drawn by locomotive No. 10.

"The train from Washington was fifteen minutes behind time in reaching the West Philadelphia depot, where the big, new locomotive adoringly named by railroaders 'long-legged 10' was snorting under an enormous steam pressure. The Washington section was soon added to the other cars and a string of seven cars started out of the depot on a gentle roll. As the last car swung around the Zoological Garden the speed had increased to twenty miles an hour, and as the wheels turned to cross the northern end of the city the mile-posts commenced to pass at the rate of one in two minutes. When Frankford was reached the trees and fence-posts seemed to skip back with increased speed, and the register showed forty-five miles an hour. Then the engineer, patting his pet on the throttle, let loose his hold and the big thing started out to make up for lost time. Schenck's Station was passed at the rate of sixty-five miles an hour, but so easy was the riding that none of the 400 passengers knew they were shooting over the ground at the pace of more than one hundred feet a second. As Bristol was sighted the train slowed up with a series of jerks, and passed the station at what seemed to the passengers to be a lazy swing, but which was, in fact, a speed of forty-five miles an hour. For a few minutes there was no perceptible change in the rate, except, perhaps, that a gentle pull showed the locomotive was improving its time. Tullytown whizzed past at a sixty mile pace. All this while the traveling was up-grade. As Trenton was sighted the mile-posts came along in fifty-seven seconds; the bridge over the Delaware was crossed, and Trenton was entered at the rate of forty miles an hour. Four of the lost fifteen minutes had been gained on the stretch from Philadelphia, and after a stop of two and a half minutes to take in passengers, the big thing moved off again across the country. It was now a difficult task to pass from mile post to post in less than eighty seconds. After the third mile had been reached the time between posts fell to seventy seconds. Lawrence was passed at a sixty mile gait, and Princeton Junction followed at the same pace. Then the speed increased to sixty-five miles an hour until Monmouth Junction was reached. Here the big engine was slowed down to fifty-five miles while taking up water from a track-tank; then twelve miles were gone over in twelve minutes. Down grades now helped to accelerate the impetus of the huge mass, and the mile-posts before reaching New Brunswick flew by in fifty-five seconds. At New Brunswick quite a crowd was gathered to see the monster engine whiz through the city at the rate of forty miles an hour. Menlo Park danced by with a sunlight flash from the row of glass globes covering the electric lamps that line the track, and within the next five minutes the speed of the train increased on a straightaway dash to seventy miles an hour. Rahway, Newark, and the Meadows were skimmed over, and the immense train dashed into the depot on time, having covered eighty-nine miles in ninety-five minutes, being an average of fifty-six and a quarter miles per hour the entire distance, stops inclusive."

Keely seems to be reasonably well settled at last. This time it is a motor for electric generators, the location Cincinnati, and Col. Minor the individual. The *Troy Daily Times* graphically describes it (the motor) as "a cube of fifty inches dimensions, with two cylinders 7 by 7 inches."

The description further refers to a "Maltese cross," a "cut off bar," and other accessories. The engine is said to be capable of running at 300 to 600 revolutions per minute, and by the combination of its two pistons with the Maltese cross, the cut-off bar and a yoke, "the yoke is given a kind of pendulum motion, throwing the power at all times on a certain point of the shaft, preventing the engines getting on the center, and creating an even revolution." Any description of this motor, however lucid, pales before the account of its performance. In other modern motors, designed to get something for nothing, there is abundant evidence of some mysterious agency at work — something suggestive of the miraculous, and which won't be investigated.

There appears to be nothing of the sort here. True, we quote, "This engine is capable of developing a power which sets aside all theories, and bids defiance to all established rules for calculation"; but that is nothing — comparatively — so long as it is done legitimately. We have become so accustomed of late to seeing theories set aside and rules defied that it comes quite in the course of nature. There is not at the present time the slightest objection to getting outside physical laws, provided you show the world what you overturn them with. What follows relieves the whole subject of anything mysterious. We again quote: "This engine" (note, that engine is a much better word than motor) "with 100 pounds steam pressure and 360 revolutions per minute, will have 1,000 horse-power and by trials it has been demonstrated that seven bushels of coal are sufficient to run it ten hours." Here is the whole matter clearly and sharply defined: two cylinders, each 7″ by 7″, at 360 revolutions and 100 pounds steam pressure, developing 1,000 horse-power with a consumption of about $\frac{7}{100}$ pound of coal per horse-power. That statement appeals to the party who pays the coal bill. With this knowledge at hand, of what further interest is any particular combination of yokes and Maltese crosses? What does he care about the result being more than theoretically perfect? Was not the motor designed to "set aside all theories"? Why should he submit a thing to vulgar calculation that was built to defy calculation? What a field for speculation! not the sort of speculation which is concluded by the dollar-and-cent consideration, but the real genuine, philosophical disquisition. Consider this motor as in its infancy, and let its progress be as rapid as that of the present (or past) type of the steam engine has been, and to what extent must that $\frac{7}{100}$ pound of coal be reduced to express the economy rating of this motor ten years hence? Who can conceive the great moral and commercial significance of every man's owning and operating a 1,000 horse-power engine, when he can buy a pair of 7″ cylinders — with a Maltese cross and a few unimportant belongings — and pay for a bushel of coal? What a blow this will be to coal monopolies, and what is to become of predicted coal famines, are questions that suggest themselves. We shall hear no more of utilizing Niagara. No sane man would invest upon any scheme for bottling up electricity with 1,000 horse-power steam engines, or motors smaller than a country wood-box, and guaranteed to run indefinitely on a shovelful or two of coal.—*American Machinist.*

"A recent German patent employs two boilers, one of which uses steam at a much higher pressure than the other. High pressure steam is used in connection with the injector to carry a portion of the exhaust steam from the engine into the low pressure boiler." This is the description which reaches us. It would seem to be a peculiar combination and much like a man's lifting himself over a fence by taking hold of his bootstraps. — *Boston Journal of Commerce.*

The term "cast iron" suggests, at once, masses of the metal of considerable weight and whatever the form. We are accustomed to see cast iron in forms difficult to produce by forging processes and bearing a relation to wrought iron similar to that of the heavy timbers of a building to its joiner work or the frame of a structure to its attachments.

There is a class of cast-iron work that formerly was imported more extensively than now which gave us minute articles of use, and even ornamental appendages to dress, so light in weight and so apparently fragile in form as to suggest fine hand labor. It was once supposed that we had no material or means to reproduce such diminutive and fragile articles from cast iron. But recent improvements, both in material and manipulation, prove that we can almost equal the delicacy of what is known as "Berlin iron."

Fine charcoal iron possesses wonderful properties of fluidity when in a molten state; it finds its way into the smallest interstices of the mould and comes out cooled, a definite reproduction of the imprint of the pattern. So exact is this reproduction that bare lines, to be represented only by very fine wire in diameter, come from the mould perfect in form and quite tenacious in texture. Articles of cast iron, cast in a mould of sand, which require fifty or a hundred to balance a quarter pound weight, are as readily produced here as articles weighing pounds, and much more readily than those weighing proportions of tons.

It may be doubted if any metal is capable of producing more diminutive objects than iron. Lead has been used in making filmy ornaments and toys, being cast, while in an almost boiling state, into hard metal moulds which were instantly compressed to expel the super-abundant metal; but the same trick is possible with iron, but is not made a business because films of iron would crumble almost at a touch. Still the iron is there and is capable of the fluidity of lead, even if it does not possess its tenacity when cold.

As instances of the possibilities of charcoal iron in castings, let any one examine the delicate shoe buckles and belt buckles, the shawl clasps and ornamental hair pins called steel, which bear a burnished surface rivaling that of silver. He will find that they are of cast iron, very brittle, and showing a bright iron fracture. Millions of these articles are made in this country, and they are cast in sand moulds, just the same as masses of iron are cast, and they come out as perfect — more perfect — than the heavier castings.

In short, the possibilities of cast iron range from the utmost capacity of adjoining cupolas, capable of melting thirty tons, to the hand ladle that with ten pounds of metal pours for a thousand separate articles.— *Journal of Commerce.*

The "City of Rome," of the Inman Steamship Line, which has just been launched, is, after the Great Eastern, the largest steamship in the world. Her length, over all, is 610 feet, length between perpendiculars 586 feet, extreme breadth 52 feet 3 inches, depth of hold 37 feet, tonnage 8,826 tons, and indicated horse power 10,000. The vessel is to be rigged with four masts. There are a large number of water-tight bulkheads, each extending to the main deck, the largest of them being only 60 feet long. If one of these were filled with water, the trim of the vessel would not be materially affected. The vessel has a single screw propeller, 24 feet diameter, driven by three sets of inverted "tandem" engines working on three cranks, disposed at an angle of 120 degrees with one another. The screw shafting was made in sections. Each length was made from a hollow cylindrical ingot of steel, which while in the molten state, was subjected to a heavy hydraulic pressure. The ingot was afterwards reheated and placed on a mandrel; then forged, and drawn by hydraulic pressure until it finally assumed the form of a double collared shaft. The vessel is intended to make 18 knots an hour, and will run between New York and Liverpool.— *American Machinist.*

AT a meeting of the IRON AND STEEL INSTITUTE, held recently in London, Mr. Parker read a paper on the "Relative corrosion of iron and steel," which we copy from *Engineering*. Mr. Parker gave a description of tests which he made on discs, 4½ in. in diameter by ¼ inch thick, of iron and steel plates of various makes and qualities. Seven varieties of iron and four of steel were experimented on, twelve discs from each brand being used, of which six were turned bright all over, and six only turned at the edges, the scale being kept as intact as possible. They were accurately weighed and divided into six series, each containing twenty-two discs, and they were strung together on a rod covered with a glass tube, glass ferrules being also placed between each disc to prevent contact and thus insure the absence of any galvanic action due to contact. One series was hung on the roof of a London building, a second was placed under water at the Brighton Pier, a third was fastened under the engine-room floors of a vessel trading to the east, so as to be continuously exposed to the action of the bilge water, and the remaining three sets were hung about 12 in. below the water level in marine boilers of vessels, the two first of which traded to India (one having zinc used in her boilers), while the third vessel ran between London and Newcastle. On the completion of the trials the discs were carefully cleaned by scraping and brushing, and were reweighed, the results being tabulated, from which it appeared that the corrosion of the steel is but very slightly greater than that of the iron. The author concluded by stating that he did not consider undue importance should be attached to any experiments of the kind made on a small scale, and that the most they could be expected to do was to indicate tendencies and perhaps suggest remedies and precautions earlier than actual experience, which would take some years to accumulate.—*Journal of Commerce.*

THE STEEL COMPANY OF SCOTLAND has published the following rules: "(1) Welding: In welding mild steel plates, it is not necessary to heat them to the same high temperature as in the case of iron. Instead of a 'welding heat,' a bright yellow heat is sufficient; and if flux is required, it need only be three parts clean sand to one part common salt, moistened and thrown on the parts in the fire. In making the weld, the fuel used should be free from sulphur, otherwise red shortness may result. (2) Flanging: In flanging, care should be taken in the local heating that the parts are not overheated, and that no hammering or work is put upon them while at a black heat; further the plate should be protected from chills, if it is not convenient to keep it warm. (3) Annealing: After completing either welding or flanging, the whole piece should be heated to a cherry-red heat, and slowly cooled. (4) Orders: In ordering steel plates, care should be taken to state the purpose for which they are to be used."

TIN IN AUSTRALIA AND OTHER COUNTRIES.—A German pamphlet by Dr. Eduard Reyer, on "Tin in Australia and Tasmania" (Vienna, 1880), gives some interesting facts relating to the production of tin in different countries outside of Europe. The mining of this metal has become an industry of considerable importance in the Australian colonies. The amount exported from Victoria to England rose from an average of about 130 tons a year between 1860 and 1869, to 2,500 tons in 1877; the production in New South Wales increased from 50 tons in 1872 to 7,000 tons in 1877. Four thousand tons were produced in Queensland in 1874; and the whole amount exported from Australia to England in the first five months of 1877, 1878, and 1879, was respectively 4,300, 4,100, and 2,900 tons. About 4,500 tons were produced in Tasmania in 1877; 4,100 were exported in the first five months of 1878, and 3,300 tons in the corresponding period of 1879. The ore occurs in Australia on the flanks of the mountains which run parallel to the eastern coast, in granite of the Devonian age, and has so far been got by washing from the sediment in the valleys. In Tasmania it is found in the quartz-porphyry of

Mount Bischoff, and is likewise obtained by washing. Tin is found in several of the southwestern provinces of China, but it is not so largely produced in that country that considerable quantities are not imported from abroad; it was formerly sent from Java to England: it was extensively mined in the province of Khorassan in Persia; is mentioned as having been formerly produced in Algeria; and is now produced in the Cape Colony at a rate represented by an exportation of about one hundred tons a year. It is found in small quantities or traces in several places in the United States, as in Maine, New Hampshire, Connecticut, Pennsylvania, Virginia, North Carolina, Missouri, and California, and in parts of Mexico, but the whole production of North America is hardly worth speaking of. It is, however, a definite article of production and export in some South American States, as Peru, Chili, and Bolivia; it exists in the province of Minas Geraes in Brazil; and several abandoned tin-mines are mentioned in the Spanish West Indies.—*Popular Science Monthly.*

Old Bridges in China.—The most remarkable evidence of the mechanical skill and science of the Chinese at an early period is to be found in their suspension bridges, the invention of which is assigned to the Ham dynasty. According to the concurrent testimony of all their historical and geographical writers, Sangleang, the commander of the army under Kaou-tsoo, the first of the Hams, undertook and completed the formation of roads through the mountainous province of the Shensa to the west of the capital. Hitherto, its lofty hills and deep valleys had rendered communication difficult and circuitous. With a body of one hundred thousand laborors he cut passages over the mountains, throwing the removed soil into the valleys, and where this was not sufficient to raise the road to the required height he constructed bridges, which rested on pillars or abutments. In another place he conceived and accomplished the daring project of suspending a bridge from one mountain to another over a deep chasm. The bridges, which are called by the Chinese writers, very appropriately, flying bridges, and are represented to be numerous at the present day, are sometimes so high that they cannot be traversed without alarm. One still exists in Shensa, stretching 400 feet from mountain to mountain over a chasm of over 500 feet. Most of these flying bridges are so wide that four horsemen can ride on them abreast, and balustrades are placed on each side to protect travelers. It is by no means improbable (as Mr. Pautheier suggested) that as the missionaries to China made known the fact over a century and a half ago that the Chinese had suspension bridges, and that many of them were made of iron, the hint may have been taken from thence for similar construction by European engineers.—*Iron Age.*

The midsummer meeting of the American Society of Mechanical Engineers is announced to occur at Altoona, Pa., on the 10th, 11th, and 12th of August. The neighborhood of the immense shops of the Pennsylvania Railroad Company located at that place, and the elevated location of the town (which is situated well up on the Allegheny Mountains, has excellent hotel accommodations, and is noted as a summer resort) will doubtless serve to make the forthcoming session of the society a specially attractive one in many respects. It is understood that the Pennsylvania Railroad Company will tender suitable courtesies, including a special train for the purpose of visiting the great iron works of the Cambria Iron Company, at Johnstown, Pa.

Engineering says "that at the exhibition now being held in Japan, an interesting feature is the successful use in the machinery hall of paper belting. The Japanese have long been celebrated for their manufacture of some exceedingly tough descriptions of paper, and it is stated that the paper belting to which we have just referred has been tested and found much stronger than ordinary leather. Now that machinery is rapidly making its way into Japan the manufacture of this paper belting is of special interest to the country, as from the want of proper tanning good leather is not made by the Japanese."

The Locomotive.

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The Gaffney & Co. Boiler Explosion.

BY F. B. ALLEN.

[This article was originally prepared for the *American Machinist*, and appeared in its columns July 23d. Some additions have since been made by the writer relative to the cast-iron head.]

On June 1st, 1881, one of three steam boilers upon premises of Messrs. Gaffney & Co., Philadelphia, Pa., exploded, killing three persons and injuring a number of others. The front boiler head was shattered into four pieces, the line of fracture passing through the man-hole opening radially, and circumferentially through that part of the head adjacent to where the metal had been reinforced by the thickening up of the flange near its rim. The flange and head seam remained intact (see Figs. 1 and 4). The force of the explosion destroyed the setting and projected the boiler in almost a direct line, and demolished the building in which it was placed, carrying away all obstacles in its path. It landed some 500 feet distant from its starting point.

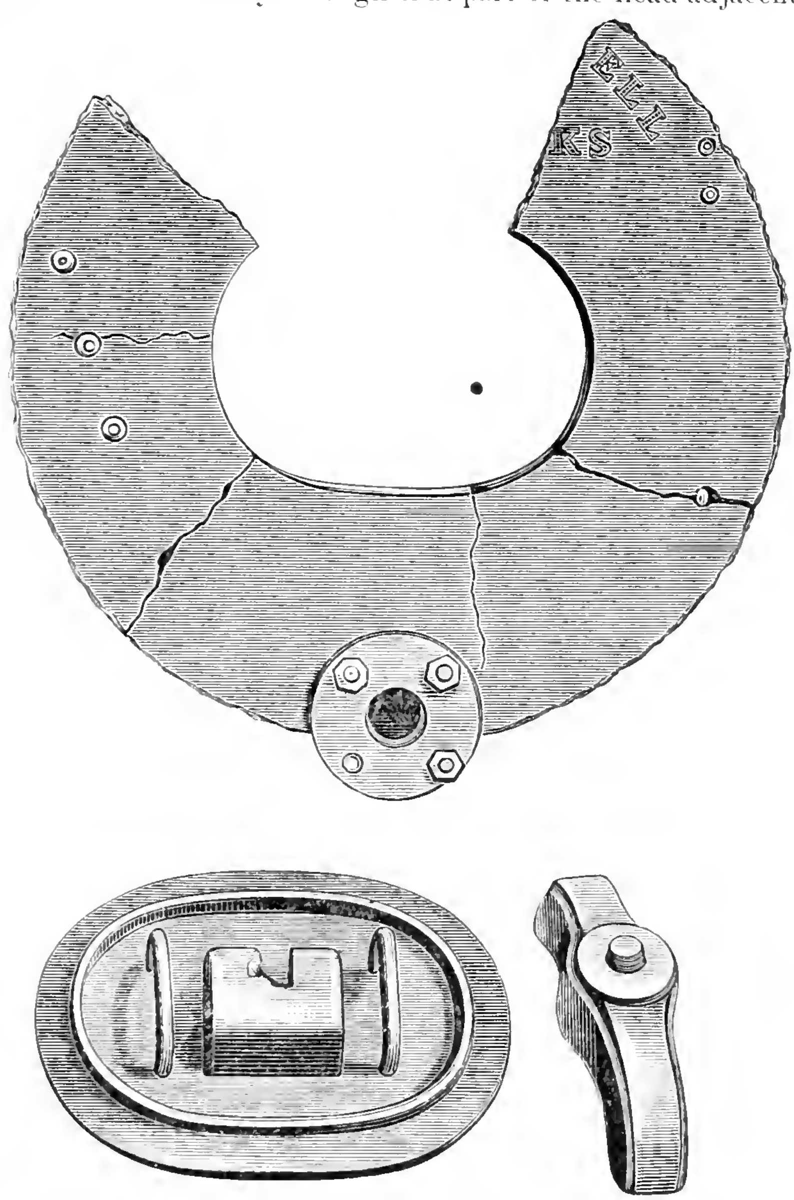

Fig. 1.

The exploded boiler, known as No. 3, was of the plain cylinder construction, 3 feet diameter by 30 feet long, shell of full quarter-inch iron, plainly stamped in many places "Best Flange," T. S., 50,000 pounds. It was furnished to the boiler makers, Sidebotham & Powell, Frankford, Philadelphia, by W. L. Bailey of Thorndale Iron Works, Pa. The heads were flat cast iron $1\frac{7}{8}''$ thick, filleted at flange. The man-hole in front head was $11'' \times 15''$, strengthened by a boss surrounding it $1\frac{3}{8}''$ wide by $2\frac{1}{4}''$ thick. The feed entered through nozzle in front head, which also served as a blow off.

This boiler was built for a working pressure of 80 pounds steam, and placed in brick setting along side of Nos. 1 and 2 boilers by the same builders. It was in all respects a duplicate of the others, though built for a working pressure of 80 pounds, and subjected in the shop on completion to a hydrostatic pressure of 115 pounds by its makers. The pressure never exceeded 65 pounds.

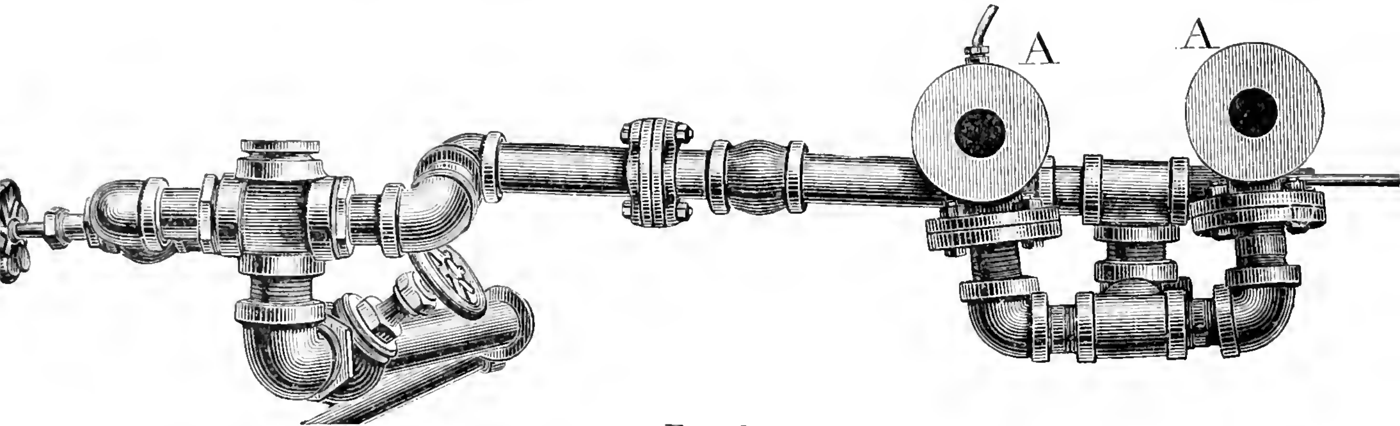

FIG. 2.

Fig. 1 shows the fractured head, man-hole plate, and guard. One of the four pieces of the head was taken away by direction of the coroner, to be tested. Fig. 2 shows the safety valve and steam pipe connections. Figs. 3 and 5, show pipe connections, in which *A*, *A* represent the safety valves; *B*, stop valve; *C*, steam gauge pipe; *D*, main steam pipe; *E*, steam nozzle; *G*, stop valve, from the other two boilers; *H*, main feed pipe for all the boilers; and *K*, independent feed pipe for No. 3 boiler. In all the cuts like letters refer to the same parts.

The pipe connections were so arranged that all the boilers could be used together

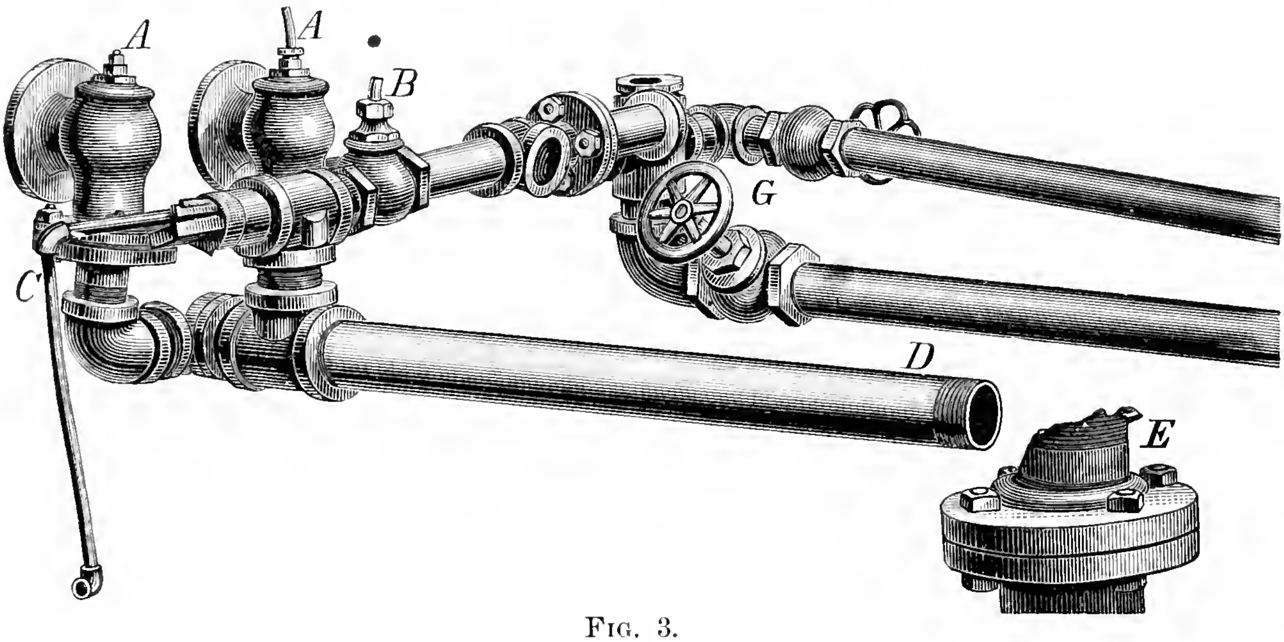

FIG. 3.

when required to work at full capacity; or No. 3 boiler could be used singly if a less quantity of steam was needed. It had two common lever safety valves $1\frac{7}{8}''$ in diameter, each independent of the other, attached to a forked connection of the steam pipe direct from the boiler without intervening valves (see Figs. 2 and 3). It had a separate steam gauge attached to the steam pipe shown at *C* in cut. There were three common gauge cocks and a glass water gauge upon the boiler front. The water gauge, it is reported, was inoperative, the glass having been broken a few days previous. A No. 6 Rue Injector was used for feeding all the boilers. It was ample for the purpose, and gave no trouble.

The feed connections for No. 3 boiler are shown in Fig. 5.

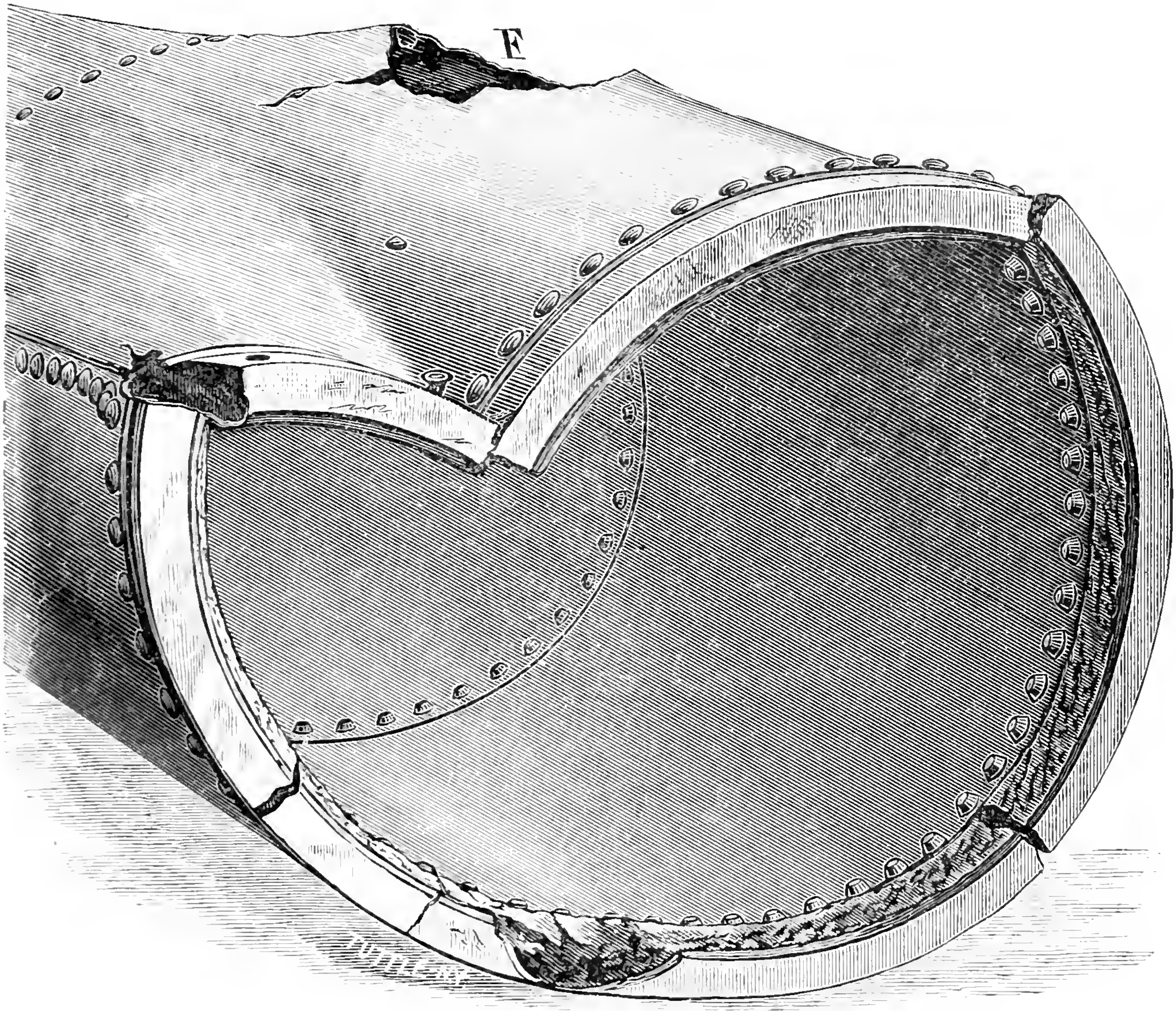

FIG. 4.

This boiler was internally and externally examined by an inspector of the Hartford Steam Boiler Inspection and Insurance Co., on March 2d, and a few days thereafter, when the pipe connections were completed, he subjected it to a hydrostatic test of 95 pounds per square inch, as required by city ordinance. The examination and test were both satisfactory, and it was accepted and insured by that company for a pressure of 70 pounds, at which pressure the two safety valve levers were cut off to prevent increase of valve load by shifting of weight, and the weights were set back so the valves both blowed freely at 65 pounds. At the time of this inspection, and for some eighteen months previous, the other two boilers had been in the care of a competent, experienced man, who regarded it as his first duty to take proper care of his charge, and, when not engaged in that work, assisted in other work as required. He was removed some ten days before the explosion, and the care of the boilers then devolved upon one of the workmen from the dye-house, who, it is believed, was untrustworthy in character, intemperate in his habits, and without mechanical qualification for the position. Of this change of engineers, the Hartford Company had no knowledge until after the explosion.

For some reason, possibly the absence of workmen and the celebration of Decoration Day, the usual quantity of steam was not required, and No. 3 boiler had been out of service, but was fired up by the night watchman (who took care of the boilers at night) about 7 o'clock P.M., May 31st. He had steam before midnight. Nothing of note occurred during the morning, but just before 12 o'clock noon, as was their custom, the fires were cleaned and covered with fresh coal, after which the engineer went to dinner. He returned to his work and was engaged about the fire-room when the explosion occurred, about 12.45 P.M. He was buried under some of the debris, scalded and bruised. After his rescue and removal to the hospital, the deputy coroner called upon him for a statement as to what he was doing at the time.

His first statement was that he was engaged in wetting down the ashes. A few days after he denied this and said he was stooping down looking into the furnace at the

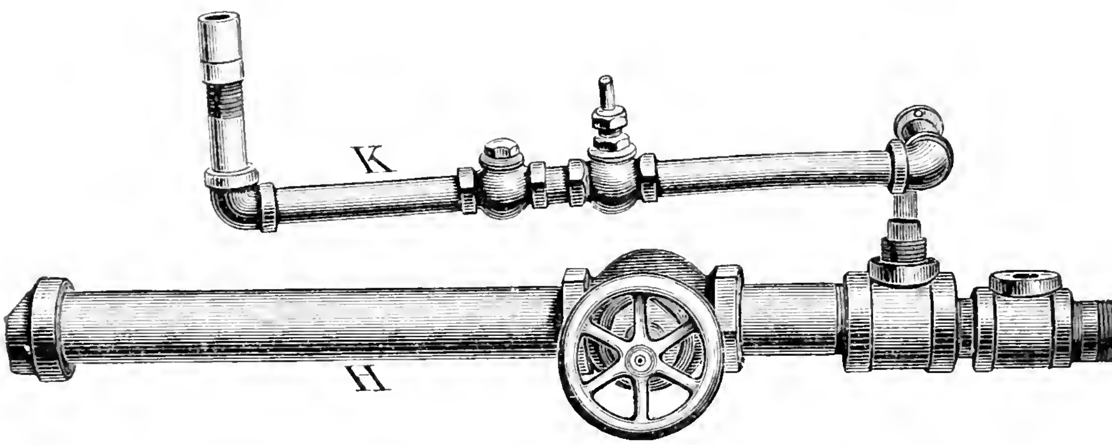

FIG. 5.

time. This last statement may be seriously doubted, in view of the complete destruction of everything in front of the exploded boiler.

The speculations and theories as to the cause of this explosion were numerous, the most important of which I purpose examining, endeavoring to ascertain how far they may be confirmed or disproved by the surrounding circumstances, and by the mute testimony of the wrecked boiler, by far the most convincing and conclusive to the thoughtful engineer, subject, of course, to our errors in interpreting its story.

As to low water, that there is no foundation for such a belief is evident upon an examination of the shell of the boiler, which bore no indications of over-heating.

Was there an intervening valve between the safety valves and the boiler? This is also answered in the negative by the arrangement of pipe connections in Figs. 2 and 3. These pipes and fittings were taken from the ruins, put together, verified by measurement, and admitted to be correct by the steam fitter who put them up.

What was the effect of dashing cold water from a hose upon the cast iron boiler head, heated to a temperature due to the steam pressure upon its interior surface? It will, I think, be readily admitted that this would be a dangerous and unwise thing to do. Remarkable cases might be cited in proof of this; but whether sufficient to have caused a sudden contraction and shattering of the boiler head is a mooted question that, I think, cannot be settled in the absence of other important data.

Was there any distortion in the castings or defect in the fittings of the man-hole plate, or any trouble in making a joint when it was put on? Very disastrous explosions have been occasioned by defects of this kind. To ascertain if it had anything to do with this case, was one of the first points to be determined by my examination. The seating of the man-hole plate was a planed surface; the plate was not planed and it seldom is. It was not a rough casting, except in the sense that it had not been planed or faced; on the contrary it was a fair surface and free from any roughness. Careful observation by straight edges placed in various positions upon the face of the plate, proved conclusively that there was no "wind" or distortion in it. With a rubber gasket interposed, and the joint made by an experienced man, it would make a tight joint every time.

Careful inquiry of the boiler-makers who first put on the plate in their shop at the time of the hydrostatic test, and the former engineer who replaced it, after the internal inspection (it was not afterwards removed), all agreed that no trouble occurred in making the joint, and that there was no occasion for excessive screwing up.

We may next consider the strength of the cast-iron head. During the time the writer was engaged in his investigations at the scene of the disaster, he had the honor of meeting a number of practical constructing engineers of that city, and others, strangers, who, like himself, came to study, and possibly to profit by the experience thus acquired. It was their opinion, as far as he heard it expressed, that the cast-iron head of No. 3 boiler was, to outward appearances, possessed of the requisite strength for a greater pressure than that allowed by the Hartford Boiler Inspector, and when they were informed that it had so recently, on two occasions, withstood without indications of weakness the proof pressures applied, it was agreed that an inspector had no other alternative than to accept such boiler and certify to its safety.

If our reasoning is correct and the foregoing theories are not confirmed by the facts, have we any clue to the cause? I think we have, and that it is an over-pressure of steam — for the following reasons: When No. 3 boiler was stopped off a few days preceding the explosion, it was necessary to close the valve "B" (Fig. 3), upon the pipe that connected it with the other two boilers. After the explosion it was recovered from the ruins and found to be *closed*, the wheel knocked off and its spindle bent over close up to the packing nut, demonstrating, beyond a doubt, that it was in that condition at the time of explosion. With the valve "B" (Fig. 3) closed as described, there were two outlets for the steam. One to the dye-house and the other to the safety valve. These outlets to the works were probably closed at noon when the men went to dinner. The steam would then accumulate, having no outlet, if, for any reason, the safety valves were inoperative. It will be recollected they were independent in action, their mitre was such that the bearing did not exceed three-sixteenths of an inch, the valve resting on the top of its seat. They were not as liable to "stick" as a majority of safety valves in use. The fitting of the spindles and guides seemed to have been done in a workmanlike manner. Of course they were battered and bruised by the explosion, and allowance had to be made for that. Other things being equal, the danger of safety valves setting fast in their seats would be greater after they had been out of service for several days than when in use.

In this case, while there was but little probability of the safety valves "A" "A" sticking — owing to the unusual precautions observed in having two safety valves when but one is ordinarily employed — there was a possibility of their doing so, if not eased off their seats after steam was up. There is not a particle of evidence to show that this was done, or that the man at that time in charge of the boilers understood his business sufficiently to realize the necessity for it.

Much criticism has been provoked concerning the strength of cast iron boiler heads, from the fact of the circumferential fracture (Figs. 1 and 4) revealing a place in the interior of the casting where the iron was "spongy," or weakened by "blow holes." This seems to have come like a new revelation to these critics. But, as a matter of fact, did we not know before that cast iron was peculiarly liable to such action? The initial fracture in this head occurred around the man-hole plate, it seems evident, and in accordance with a well established law, it followed a line of weakness in running around the rim of the flange. (Figs. 1 and 4.) The path of the boiler's projection, and the fact that one of the victims met his death upon his own door-step, killed, it was reported, by the guard of the man-hole plate striking him in its flight, in a line from where the boiler started, and in the opposite direction, is a confirmation of that opinion.

The foregoing statements of facts obtained by careful examination of the various details of boiler and fittings, point unmistakably to the necessity for having properly qualified attendants in charge of steam boilers. It will avail but little, no matter how many safety appliances are attached to a boiler, if the management be in the hands of a negligent or incompetent person, who does not prove the efficiency of such appliances daily. He may understand firing and keeping the requisite quantity of water in the boiler, and yet be a dangerous man, if that be the extent of his knowledge. An intemperate man ought under no circumstances to be trusted with the care and management of steam boilers. It is peculiar that the latter circumstance, which I regard as the solution of the problem in this explosion, should have been dismissed with but very brief mention in the coroner's verdict. While disregarding the facts and evidence before them, they censure the Boiler Insurance Company in the following terms: "The inquest consider that the Hartford Boiler Inspection and Insurance Company are especially censurable for the incompetence and negligence of its agents who inspected and certified to the safety of this boiler." They do not tell us wherein this alleged incompetence or negligence consists. Loud calls are now being made through the technical press that these gentlemen of the jury take the public into their confidence. Their verdict is flatly contradicted by their principal witness. I refer to the testimony of Mr. John Overn, Chief Inspector of Boilers for the City of Philadelphia. He said: "In the inspection the boiler conformed to all the requirements of the city ordinances; the head was apparently good as was the boiler. I know the inspector who tested this boiler, and consider him a remarkably competent inspector; would have passed this boiler and allowed 80 lbs. upon it." Further comment seems unnecessary.

Inspectors' Reports, May, 1881.

The record of this department for the month of May, shows a most gratifying state of affairs. The number of visits of inspection made was 2,035, during which 4,027 boilers were examined, 1,774 of which were thoroughly inspected, both externally and internally. The Hydrostatic test was applied to 394 boilers, mainly new ones in the yards of the makers. The whole number of defects found was 1,903, of which number 567 were considered dangerous and in a condition requiring immediate attention. The detailed statement of defects is as follows: Furnaces out of shape, 125 — 28 dangerous; fractures, 215 — 153 dangerous; burned plates, 89 — 40 dangerous; blistered plates, 231 — 40 dangerous; cases of deposit of sediment, 293 — 53 dangerous; cases of incrustation and scale, 446 — 51 dangerous; cases of external corrosion, 113 — 32 dangerous; cases of internal corrosion, 77 — 32 dangerous; cases of internal grooving, 22 — 16 dangerous; water gauges defective, 59 — 39 dangerous; blow out defective, 21 — 9 dangerous; safety valves overloaded, 18 — 7 dangerous; pressure gauges defective, 140 — 28 dangerous; boilers without gauges, 62 — 1 dangerous; cases of deficiency of water, 17 — 15 dangerous; broken braces and stays, 30 — 17 dangerous; seams leaking, 2. 40 boilers were condemned, being considered unfit for further use.

In examining the condition of the fixtures on boilers, it is surprising to see the state in which they are sometimes found. It will be seen from the preceding list of defects that no less than 59 water gauges were defective, and 39 of them were considered dangerous. Now a water gauge is a very simple contrivance, and at the same time it is one of the most important, if not *the* most important fixture pertaining to a boiler; and when we find that one per cent. of all boilers (and probably more for the ratio of defects is undoubtedly greater, among boilers which are not inspected regularly) are in a dangerous condition from that one cause alone, it becomes a matter of surprise that comparatively so few explosions occur. It would seem as though self-interest, if nothing else, would lead the owners of boilers to look after such things more closely than they do, and to insist upon all the fixtures being kept in first-class condition, but it does not seem to in this case. It is clearly a case of "penny-wise and pound-foolish."

Boiler Explosions.

Dye-Works (73). — A dreadful boiler explosion occurred in the northern part of Philadelphia, Pa., known as Kensington, on June 1st, resulting in killing three men and wounding seven others. Hundreds of working people living in the neighborhood were startled by a loud explosion about noon, followed by the crash of falling walls. It was soon discovered that a boiler in the drying-room of the dyeing establishment of Messrs. Gaffney & Nolan on Collins street, between Lehigh avenue and Huntington street, had exploded. There were three boilers in the basement of the drying-room, and it was one of these which exploded. The boiler exploded was a new one, and was made by Sidebotham & Powell of Frankford. The distance traversed by the exploded boiler was at least 400 feet. Frederick Dasher, Frank Harbison, and John Harbison were killed. Dennis Scully, fireman, Nellie Duffy, aged nine years, Michael Duffy, aged four years, Theodore Cody, Louis Lehr, Hannah Dooley, and Robert Bradley were injured.

Factory (74.) — The steam boiler in the Lewis lobster factory at Petpeswick, thirty miles east of Halifax, N. S., exploded on Thursday night, June 2d, killing Charles W. Kinlay, and badly injuring Samuel Turner, Thomas Young, Abram Bayers, and John McKay.

Tug-Boat (75). — About half past six o'clock, June 3d, while the tug-boat Jacob Brandow was on her way to New York from the lower bay, having in tow several scows of the Street Cleaning Department, a sheet of the boiler blew out. The escaping steam blew the engineer of the tug, William Card, overboard, and he was drowned. His son, Judson, who was employed as fireman on the vessel, was scalded, and taken to the Seamen's Hospital, Staten Island. The engineer was forty-five years of age.

Elevator (76). — A frightful explosion took place at Arkansas City on June 4th. A new elevator engine exploded, killing the engineer, John McCullough, badly wounding Pat Balland, the fireman, Amos Ransey and Jake Wallace, carpenters. The cause of the accident was an insufficiency of water in the boiler, and the carelessness of the engineer. After the boiler exploded and went out through the roof, nothing more was seen of it, and it is supposed that it fell into the river.

Steamboat (77). — The steamboats St. Johns and John H. Hanna left New Orleans at five o'clock on the afternoon of June 8th for up the river, and immediately commenced racing. At seven o'clock the latter boat exploded her middle flue, scalding fourteen hands, all colored. Two others jumped overboard and were drowned. Two of the scalded men were firemen standing in front of the boiler at the time; the others were roustabouts at supper in the ward room. Of the injured men one died at the landing upon arrival, and five died in the charity hospital during the night. Four others cannot live through the day. Only two can possibly recover of the fourteen injured. The following persons scalded by the explosion have died: John Logan, Henry Davis, Henry Wallace, George Johnson, and Jack Bates. After the explosion, John Britton jumped overboard and was drowned. George Gibbs, John Wallis, Stephen Thomas, and Paul

Miner are not expected to recover. All the above-named are colored. It is generally understood that the boats were racing at the time of the explosion.

IRON BRIDGE WORKS (78).—A boiler at the Champion Iron Bridge Works, at Wilmington, exploded on the 9th inst., severely injuring Willie Ellis, a young boy employed at the works. The main building was considerably damaged.

ROLLING-MILL (79).—Atkins & Brothers' rolling-mill, situated one mile from Pottsville, Pa., was the scene of a most terrible boiler explosion, on June 10th. Twelve men employed in the mill were injured with more or less severity, three or four of whom cannot recover. At noon a hissing noise was noticed as coming from the direction of the boilers, and almost simultaneously with that noise the explosion followed. The report was deafening, it being heard by people at a great distance. The shock was felt most at the puddle furnaces at the girder mill, where the boilers were located. When the clouds of dust and steam caused by the explosion had cleared away the sight was a sickening one. Daniel Moran, a puddler, was horribly scalded. James O'Neill, a helper, was scalded on his hands, face, and breast. He cannot recover. Louis Blakencorn, a puddler, was badly cut on the back and terribly scalded. He died while being taken home. Jerry Reed, James Williams, Henry Lorsberger, Augustus Applestatt, Hiram Davis, John Rodgers, Andy Smith, and Edward Connelly, were badly injured.

STEAMER (80).—About five o'clock on the morning of June 12th, as the large and powerful wrecking steamer B. and J. Baker, Captain O. S. Baker commanding, was lying at anchor four miles below Cape Henry, the boiler exploded and three men — the chief engineer, his assistant, and fireman — were killed and two deck hands badly scalded. The names of the killed are:— James Turner, Sam. Ward, and Frank Wilson. The two first were instantly killed, and the third died in about an hour. The wounded are:— H. Peoples and P. Hodges. The Baker was on her way to work on the wreck of the schooner David J. Keeting. Her upper joiner work and timbers are considerably damaged. No cause is assigned for the explosion.

HEATER (81).—A patent water-back burst from the boiler at the Buffalo Grape Sugar works, on the morning of June 13th, severely scalding three men.

DONKEY ENGINE (82).—The Inman line's steamship City of Rome was launched at Barrow, June 14th. There was a large and distinguished company present and great enthusiasm prevailed. Just before the launch of the steamer, the boiler of the donkey engine on her deck exploded, killing three persons and injuring ten others, several of them very seriously.

MILL (83).—A boiler at Turner Richardson's mill, eight miles north of Wills Point, Texas, exploded June 18th. Bill Loden, the engineer, was blown to atoms, an old man named Green was struck by a mill stone and mangled beyond recognition. Turner Richardson and J. D. Muff were injured.

DUMMY ENGINE (84).—The boiler of a dummy engine used for unloading a Philadelphia coal vessel exploded at the depot wharf, Medford, Mass., June 21st, with terrible effect. The schooner Plowboy, of Barnstable, and several buildings in the vicinity were badly shattered, and William Bennett, a Charlestown stevedore, was mutilated beyond recognition. George Green, another workman, was so badly scalded that he died soon after. Four others were so badly injured that recovery is impossible.

SAW-MILL (85).—Bridges & Walking's saw-mill, near Millersville, Tenn., was destroyed, June 24, by the explosion of the boiler. R. H. Bruce and A. J. Pike were killed.

STEAMBOAT (86).—The steamer Phæton, while racing with the steamer Handy, June 28th, exploded her boilers, and the boat was torn to pieces. The chimneys of the Handy were blown off. Both boats were filled with passengers. The names of the killed are: — Cash Naylor, engineer; Samuel Reynolds, porter; Joseph Carr, deck hand (colored); and Joseph Miller, deck sweeper. A passenger whose name is unknown is also supposed to have been lost. Among the injured are D. B. Smith, Bascom Cooper, Mr. McArthur, Tim. Seevers, fireman (fatally), and John Conn. Most of those injured are but slightly hurt. The Phæton was a small, side-wheel steamer, valued at $5,000, in local trade between Vanceburg and Manchester.

Saw-Mill (87).— A. B. Williams, an engineer, was killed, June 28th, by the explosion of a boiler in a saw-mill at Grant City, Mo.

A Brooklyn, N. Y., man has just invented, and we presume has patented, a bran-new theory of the explosion of steam boilers, which he thus sets forth in the columns of the daily papers: "The space above the water being filled with steam, and the pressure momentarily increasing, the central column of steam becomes inverted, and, pressing upon the surface of the water, acts like a wedge, dividing the water in the center, and pressing it against the sides of the boiler, thereby producing immense pressure at given points instead of that uniformity which the ordinary test effects. Consequently, the wedge of steam divides the water before it until the boiler is rent in pieces."

This theory is startling in its novelty and well calculated to strike terror into the bravest heart by its terrible efficiency. Something should be done immediately. Public safety demands it. Somebody should immediately put a contrivance upon the market to nullify the action of the aforesaid "wedge." We can only offer a few suggestions. Boilers should be built without "given points." Then it is evident the "wedge" would have nothing to act upon, and would probably get disgusted and leave the boiler after a short time spent in vain endeavors to get a "grip" by which it could "rend it in pieces." This is an important point, and should not be overlooked. If this is not practicable some law should be at once passed, and rigidly enforced, limiting the acuteness of the "wedge," or, perhaps it would be better to insist upon having it inverted, in which case it would be unable to exert any force upon the sides of the boiler, and would consequently be harmless. Or the upper part of the boiler could be filled with water, thus compelling the steam to confine its operations to the lower part. The inventor does not state whether a "wedge" would be formed in this case or not. Will he please enlighten an anxious community of steam-users on this point? Or in case we should be unable to get rid of this pestiferous and explosive "wedge" by any means at our command we might perhaps make use of it in some way. A boiler fitted with a new and improved system of "wedges" of great acuteness and consequent power might be employed to drive the new motor invented a short time ago and described last month. A combination of the "cube of fifty inches dimensions," with a properly regulated "Maltese cross," and "cut-off bar," with a "yoke given a kind of pendulum motion" by means of "cuneiform steam," would revolutionize the steam-engine business.

Engineering, of date June 24th, contains the conclusion of a very interesting series of articles on Riveted Joints, by Prof. A. B. W. Kennedy, showing the results of some very elaborate experiments made by him to determine the proper proportions for joints of maximum efficiency, in steel plates with steel rivets. The subject is one of great interest in view of the increasing use of steel plates for boilers. We shall, at an early date as possible, investigate the subject and lay the result before our readers in tabulated form.

The Locomotive.

HARTFORD, JULY, 1881.

The Gaffney & Co. Boiler Explosion.

In another part of this issue of the LOCOMOTIVE will be found a very clear and concise account, fully illustrated, of the explosion which occurred at the dye-works of Messrs. Gaffney & Co., Philadelphia, on the first day of last June. To this article we refer our readers for the details of the explosion, and its attendant circumstances. It had not been, originally, our intention to comment editorially upon the matter, but the extraordinary verdict of the coroner's jury has provoked so much comment and criticism that perhaps a few words here may not be amiss. This jury, after proving that the person who had charge of the boilers was wholly inexperienced in such work; and was entirely ignorant of the duties pertaining to the care and management of steam boilers; and was, besides, an intemperate man, which fact alone would unfit him for a position of such responsibility, and render an explosion not only liable, but likely, and almost certain to occur sooner or later, proceeded to censure the Hartford Steam Boiler Inspection and Insurance Company in the following terms: "The inquest consider that the Hartford Steam Boiler Inspection and Insurance Company are especially censurable for the incompetence and negligence of its agents who inspected and certified to the safety of this boiler."

Did they prove in what respect the agents and inspectors were incompetent or negligent? Not at all; and we think it would be a hard matter for them to do so. The inspectors of this company are men of experience and common sense, and are selected with particular regard to practical knowledge and familiarity with everything relating to the care and management of steam boilers; and in this instance particularly there was no evidence whatever tending to show that the inspectors performed their duty in anything but the best known and most approved manner. Sufficient evidence that the inspectors of this company are properly qualified men, can be found in the comparative freedom from explosion of the boilers that are insured and inspected by the company. This is evidence that speaks for itself and cannot be impeached. The Hartford Steam Boiler Inspection and Insurance Company has some 13,000 boilers under its care, and it is rare that one explodes. Those which have exploded have done so from causes beyond the company's control. Overworking the boiler or carelessness of the engineer — no supervision can prevent such accidents. The spirit which seems to have actuated this jury has been called *malicious* towards the company, and although some members of the jury have hastened to explain that they were not actuated by unfriendly motives, the verdict itself is a strong and convincing argument against any such explanations or protestations. It is a lamentable fact that some of the men whose names are signed to that verdict have enjoyed the reputation of being men of scientific attainments and of ability in the line of mechanical engineering. Few of the mechanical engineers in this country or any other would have descended to so low and disreputable a piece of business. It was perfectly proper for them to criticise the flat cast-iron head if they were convinced by experience that it was unsafe, and it was further proper for them to recommend the city authorities of Philadelphia to prohibit its use in the city if they were convinced by experience that its use was especially dangerous. Not only the city but the country at large would have received their verdict as a valuable contribution to the science of steam engineering had it shown careful investigation of the subject, with results founded upon incontrovertible facts and experience. The best type of scientific men — men of genuine scientific attainments — are very cautious about giving hasty and ill-digested opinions. Malice and prejudice are eliminated from their investigations, and their effort is to weigh matters in the scale of exact truth. Such investigations are entitled to great respect, and they have weight. Although we may at times dissent, nevertheless we cannot fail to respect the man or men who through patient investigation have arrived at certain results. Now what are the facts in this case. The flat cast-iron head has been used in Philadelphia for some forty years. It is extensively used in the state of Pennsylvania and in other parts of the country, and so far as is known has not been any more dangerous than other types of boilers. The wise men who have suddenly arisen to condemn it have been silent on the subject until now, and some of them have not only recommended its use in days past, but it is said have manufactured boilers with flat cast-iron heads. We have never recommended cast-iron heads; always have advised people to use wrought-iron. All specifications which have been prepared for boilers by this company have called for well-braced wrought heads. If people will have cast-iron heads we advise convex or concave patterns. We would invariably advise the latter.

But we have no authority to oblige people to use this or that form or type of boiler, and in the absence of any facts going to show that cast-iron heads were especially dangerous except on theory, and inasmuch as they are and have been used extensively in Philadelphia, and manufactured by boiler-makers there, and are approved daily by the chief inspector of the city, we fail to see how this company is *censurable* for approving such a boiler 36 inches diameter, new, and well constructed of approved material, at a pressure of 70 lbs. The press, mechanical and secular, the country over, has risen up in protestation against such an unjust verdict. Coroner's juries are supposed to be for the public good, but this one is regarded as having used its high office to bitterly attack, with the intention to embarrass a corporation for which for some reason it seems to have a special dislike. Some members of this jury failing to suppress their hostility openly declared, it is said, "*Now we've got the Hartford Boiler Company; we will fix them this time.*" Think of such language as coming from a member of a jury selected with reference to its fitness for investigating so important a matter, and bear in mind that this was said before the verdict was rendered. It is to be hoped that all the members of the jury were not infused with this special venom, but the fact that their names are all signed to the verdict leads the public to infer — and justly so — that they were all actuated by the same spirit. It is a lamentable fact that some of these jurors should have placed themselves before the public in such a light. But further, the makers of the boiler, Messrs. Sidebotham & Powell, being dissatisfied with the sweeping condemnation of Flat Cast-heads by the jury, constructed a test boiler of the same diameter, made of the same material, with cast-iron of the same identical pattern as those of the exploded boiler, — the very counterpart of it, save in length, — and in the presence of a number of people, including many if not all of the jury, subjected it to hydrostatic pressure. Under this test the head gave away at 450 lbs. per square inch. Further comment is unnecessary. We leave the matter here for the public to make their own verdict as to the "incompetence and negligence" of this company. We shall continue to conduct our business on what we believe to be a safe basis. We shall always be gratified to our friends for any information which will aid us in making the use of steam power safer. We are not unwilling to be criticised, if it is done in a candid and intelligent manner. That our course in this case is right is shown by the universal support of the entire mechanical press of the country, for which gratifying evidence of confidence they have our heartiest thanks.

Resistance of Flues and Tubes to an External or Collapsing Pressure.

(Continued from page 93.)

In our last number we mentioned some of the principles relating to the strength of flues when subjected to uniform external fluid pressure; we will now speak of them more in detail and endeavor to present the most important part of what is known of the subject, in as plain and comprehensive a manner as possible. There is as yet no perfectly satisfactory theory of the manner in which a tube collapses when subjected to external pressure. The most that is known about it, is that it seems to be related to laws governing the resistance of long columns to a longitudinal compressive force or thrust. A long column under the action of a thrust in the direction of its axis, gives way, not by crushing, but by bending, and the stress at the section where failure occurs is a compound one, and depends upon the combined action of the thrust and the bending of the column at that point. The law governing the stability of such a column may be briefly stated as follows: let a thrust or compressive force be applied to a long bar in the direction of its axis, then if the thrust is just sufficient to balance the elasticity of the bar, it will retain its stability, but let the pressure be increased in the slightest degree and the elasticity of the bar is destroyed and it ultimately buckles and gives way. The mathematical expression for the greatest load consistent with the stability of the bar is as follows: where T = greatest safe load, I = moment of inertia of the section of the bar with respect to an axis passing through the center of gravity of the section, and at right angles to the plane in which it most easily bends, which in the case of a rectangular column would be $\frac{1}{12}$ of the length multiplied by the cube of the breadth, and E = modulus of direct elasticity of the material of which the bar is composed, which in the case of ordinary wrought iron may be taken equal to 28,500,000, and l = the length of one of the arcs into which the bar divides when it doubles up.

Then $T = \frac{I\,E}{l^2}\pi^2$ for which expression we are indebted to the theoretical investigations of Euler. The condition of stress which the metal of the column would be in, would of course be $T = b\ t\ p$, where b = breadth, t = thickness, and p = pressure per square inch.

Take now a piece of a flue of any length L. The resultant pressure on either side of any diametral section $T = L\ d\ p$, where d = diameter of the flue and p = pressure per square inch, hence we see that the material of the flue is in the same condition of stress as a straight column of length $\pi \times d$ subjected to a pressure of the same intensity. From the foregoing it would appear that a formula for collapse might be deduced in the case of long columns. The only obstacle to such a course would be the determination of the number and length of the arcs into which the flue divides at the moment of collapse. Such theoretical deductions have been made however, and by introducing values of l obtained from experiment they are very useful inasmuch as they indicate the limits within which the ordinary empirical formulæ can be used.

Some of best known and most reliable of the various empirical formulæ are as follows:

Fairbairn's, $p = 9{,}672{,}000 \frac{t^{2\cdot19}}{l\,d}$ - - - - - - - - - - (1)

Love's, $p = 5{,}358{,}000 \frac{t^2}{l\,d} + 41{,}906 \frac{t^2}{d} + 1{,}323 \frac{t}{d}$ - - - - - - - (2)

D. K. Clark's, $p = t^2 \left(\frac{50{,}000}{d} - 500\right)$ - - - - - - - - - (3)

Grashof's, $p = 1{,}057{,}180 \frac{t^{2\cdot081}}{l^{\cdot564}\ d^{\cdot889}}$ - - - - - - - - - (4)

In all the above, p denotes the collapsing pressure per square inch, t the thickness of flue, l the length, and d the diameter, all in inches.

Wilson's, $p = \frac{262.4\,t^2}{l\,d}$ - - - - - - - - - - - (5)

in which p = collapsing pressure in pounds per square inch, t = thickness in thirty-seconds of an inch, l = length in feet, and d = diameter in quarter feet.

Lloyds' — working pressure $= \dfrac{89,600\, t^2}{l\, d}$ - - - - - - - - (6)

where t = thickness in inches, l = length in feet, and d = diameter in inches.

Board of Trade (English) working pressure $= \dfrac{\text{constant} \times t^2}{(l + 1) \times d}$ - - - - (7)

in which t = thickness in inches, l = length in feet, and d = diameter in inches. The following are some of the values of the above constant.

Flues with butt joints and drilled rivet holes.

90,000 where the longitudinal seams are welded.
90,000 ″ ″ ″ ″ ″ double riveted, with single butt straps.
80,000 ″ ″ ″ ″ ″ single ″ ″ ″ ″ ″
90,000 ″ ″ ″ ″ ″ ″ ″ ″ double ″ ″

Flues with butt joints and punched rivet holes.

85,000 where the longitudinal seams are double riveted, with single butt straps.
85,000 ″ ″ ″ ″ ″ single ″ ″ double ″ ″
75,000 ″ ″ ″ ″ ″ ″ ″ ″ single ″ ″

Flues with lap joints and drilled rivet holes.

80,000 where the longitudinal seams are double riveted and beveled.
75,000 ″ ″ ″ ″ ″ ″ ″ ″ not beveled.
70,000 ″ ″ ″ ″ ″ single ″ ″ beveled.
65,000 ″ ″ ″ ″ ″ ″ ″ ″ not beveled.

Flues with lap joints and punched rivet holes.

75,000 where the longitudinal seams are double riveted and beveled.
70,000 ″ ″ ″ ″ ″ ″ ″ ″ not beveled.
65,000 ″ ″ ″ ″ ″ single ″ ″ beveled.
60,000 ″ ″ ″ ″ ″ ″ ″ ″ not beveled.

For the following rules we are indebted to Prof. W. C. Unwin:

For flues with longitudinal lap joints; $p = 7,363,000 \dfrac{t^{2 \cdot 1}}{l^{\cdot 9}\, d^{1 \cdot 16}}$ - - - - (8)

For flues with longitudinal butt joints; $p = 9,614,000 \dfrac{t^{2 \cdot 21}}{l^{\cdot 9}\, d^{1 \cdot 16}}$ - - - - (9)

For flues with longitudinal and girth seams like ordinary flues; —

$$p = 15,547,000 \frac{t^{2 \cdot 35}}{l^{\cdot 9}\, d^{1 \cdot 16}} \qquad (10)$$

where t = thickness, l = length, and d = diameter, all in inches, and p = the collapsing pressure. The above three rules were deduced from Sir Wm. Fairbairn's experiments by Prof. Unwin on the theory that the laws of collapse were related to the laws of the resistance of long columns to compression, and is the first attempt that has been made to deduce a rational formula for the strength of flues. Their agreement with experiment is remarkably close, much closer than is the case with any of the other formulas given to determine the collapsing pressure. In our next number we will endeavor to show which formulas are to be preferred for practical use, and the reasons for such preference.

H. F. S.

LARGE SCHOONER, PROBABLY LARGEST AFLOAT. — Four-masted schooner, George W. Adams, Buffalo, N. Y. Length over all, 234 feet. Breadth of beam, 40 feet 3 inches. Depth of hold, 20 feet. Draft loaded, 15 feet 3 inches. Load, 126,000 bushels oats and 87,000 bushels corn.

The following article, which appeared in the *American Machinist* of July 30th, 1881, is of interest, taken in connection with the articles on the same subject which appeared in the *Locomotive* for May and June.

Holding Power of Boiler Tubes.

Editor American Machinist:

Your number of July 9th, 1881, gives the results of some interesting experiments made by the Hartford Boiler Insurance Company on the holding power of boiler-tubes, a subject upon which very erroneous ideas prevail among engineers and boiler-makers. The absolute holding power of boiler-tubes and the relative value of various methods of securing boiler-tubes were first thoroughly investigated in the year 1877, by the present Engineer-in-chief of the Navy, Com. Wm. H. Shock, who made a series of tests with forty-eight brass tubes and eighteen iron tubes of different dimensions fixed in iron, steel, and copper tube plates, by the various methods employed in marine and locomotive engineering. An account of these experiments was first published in *Engineering*, September 14th, 1877, and they are fully described and illustrated in Com. Shock's book on "Steam Boilers," published by D. Van Nostrand, New York, 1880. I can give in the present article only a few of the highly interesting results of these experiments, and quote the following, viz.:

EXPERIMENTS ON HOLDING POWER OF BOILER TUBES, BY CHIEF ENGINEER WILLIAM H. SHOCK, U. S. N.—JANUARY, 1877.

Number of Experiment.	Outside diam. of end of tube where fracture took place.	Area o. cross section of body of tube.	Thickness of tube-plate.	Strain in pounds—Mean result.	Method of Fastening.
(*a*)	ins.	sq. ins.	ins.	lbs.	
IRON TUBES.					
1–3; 5–8	$2\frac{5}{8}$	.981	$\frac{7}{16}$	22,650	Expanded by Dudgeon tool, end riveted over.
9–10	$2\frac{5}{8}$	.981	$\frac{7}{16}$	22,150	Expanded by Dudgeon tool, end partly riveted over.
4	$2\frac{3}{8}$	.981	$\frac{3}{8}$	25,525	Expanded by Dudgeon tool, end riveted over.
11–12	$2\frac{3}{8}$	.981	$\frac{3}{8}$	29,675	Expanded by Dudgeon tool, feruled, *not* riveted over.
13–14	$2\frac{3}{8}$	.981	$\frac{3}{8}$	13,050	Simply expanded by Dudgeon tool.
(*b*)					
BRASS TUBES.					
5	$2\frac{1}{2}$	.9	$\frac{1}{2}$	21,150	Expanded by Dudgeon tool, end riveted over.
21–22	$2\frac{1}{2}$	.9	$\frac{3}{4}$	6,750	Expanded by Dudgeon tool, end *not* riveted over.
31–32	$2\frac{1}{2}$	.9	$\frac{3}{4}$	19,450	Expanded by Dudgeon tool, end riveted over.
43–44	$2\frac{1}{2}$	.9	$\frac{3}{8}$	23,070	Expanded by Dudgeon tool, end riveted over.
3–4	$2\frac{1}{2}$	.9	$\frac{3}{4}$	34,375	Expanded by Dudgeon tool, end feruled, and riveted over.
8	$2\frac{1}{2}$	.9	$\frac{1}{2}$	46,000	Expanded by Dudgeon tool, end feruled, and riveted over.
9–10	$2\frac{1}{2}$	.9	$\frac{3}{8}$	37,650	Expanded by Dudgeon tool, end feruled, and riveted over.
23–24	$2\frac{1}{2}$	.9	$\frac{3}{4}$	28,310	Expanded by Dudgeon tool, end feruled, *not* riveted over.
1–2	$2\frac{1}{2}$	.9	$\frac{3}{4}$	29,125	Expanded by Prosser tool, feruled.
6	$2\frac{1}{2}$	.9	$\frac{1}{2}$	12,000	Expanded by Prosser tool, *not* feruled.
7	$2\frac{1}{2}$	.9	$\frac{1}{2}$	27,800	Expanded by Prosser tool, feruled.
11–12	$2\frac{1}{2}$	.9	$\frac{3}{8}$	25,850	Expanded by Prosser tool, feruled.

"The tubes secured by nuts only screwed on the outside of the plates, gave way by drawing the ends through the nuts without stripping or otherwise injuring the thread. When iron ferules were used in connection with the nuts, the holding power of the tubes was greatly increased."

"The lowest results were obtained in experiments No. 21 and 22 [with brass tubes], when the tubes were simply expanded by the Dudgeon tool in a $\frac{3}{4}''$ plate without being beaded over or secured by ferules, the resistance being 7,650 pounds and 5,850 pounds respectively. It will be seen that even in this most unfavorable case, the holding power of the tube was greatly in excess of any strain which would be occasioned by the pressure of steam upon the portion of the tube plate, which any one tube would have to support in a boiler."

These results agree very closely with those obtained by the Hartford Boiler Insurance Company.

The following are some of the general conclusions drawn from the results of Mr. Shock's tests of brass tubes, viz.:

"(1) That the tubes fixed by the Dudgeon expander, and beaded over, have a considerably stronger hold of the tube plates than those fixed by the Prosser expander, particularly with thin tube plates. (2) That if the tubes are not beaded over, the hold afforded by the Dudgeon is less than that afforded by the Prosser system of fixing. (3) That with both expanders, the introduction of ferules adds very materially to the holding power of tubes. . . . (6) That the employment of nuts screwed on the tubes outside the tube plates is not of any service in increasing the holding power unless the tubes are feruled."

In the case of iron tubes, fracture took place almost invariably by breaking off, or cracking the ends which were riveted over; and as fracture took place in this manner with greatly different strains, it appears that iron tubes are apt to be injured by the process of riveting over their ends. The iron tubes simply expanded by the Dudgeon tool bore a considerably greater strain than the brass tubes secured by the same process.

In consequence of these experiments, the use of stay tubes secured by nuts has been abandoned in boilers for United States naval vessels carrying 80 pounds of steam. All tubes are simply expanded by the Dudgeon or Prosser tool, except some few tubes in the neighborhood of man-hole plates and trussed flat surfaces, which have their ends riveted over.

C. R. Roelker.

Washington, D. C.

The Monthly Report of the Chief Engineer of the *Manchester Steam-Users' Association*, for the months of January, February, March, April, and May, is just received, and contains much that is interesting. From it we learn that there have been since the first of January, 9 explosions of steam boilers, by which 23 persons have been killed, and 23 injured, the most disastrous one occurring at Batley, by which 16 persons were killed, and 11 others injured; 9 of those killed were women and girls. It was proved at the inquest that the boiler was 25 years old, and had been purchased second-hand 10 years ago by its present owner, and set on damp brick flues, and had never been inspected, and also that a large stone had been hung on the safety-valve lever, so that the pressure was frequently seen as high as 70 pounds per square inch, although the working pressure was only 35 pounds. The plates at the back end, which were originally $\frac{5}{8}$ inch thick, were corroded to the thinness of a sixpence. The owner, when remonstrated with for overloading the safety-valve, had replied that "The stone was where it was going to stay." He has been committed for trial for manslaughter.

Van Nostrand's *Engineering Magazine* for August, contains a very interesting paper by Professor Robert H. Thurston on a new alloy discovered by him, which is claimed to be the strongest bronze yet made. Its composition is copper 55 parts, zinc $44\frac{1}{2}$ parts, and tin $\frac{1}{2}$ part. This alloy when tested showed a tensile strength of 68,900 pounds per square inch, and elongated 47 to 51 per cent., with a reduction of from .69 to .73 of its original diameter. It is also claimed to be remarkably homogeneous, two different tests giving exactly the same figures. A very interesting comparison of it is also made with ordinary gun metal.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. II. HARTFORD, CONN., AUGUST, 1881. No. 8.

Flanging Boiler Heads.

The study of the causes and nature of the defect known as grooving, as well as the character and appearance of the fractures which frequently occur in the flanges of heads or tube sheets, and other parts of boilers where flanging is done, leads to the conclusion that flanges, as ordinarily turned, are very much too sharp, or turned to too short a radius. The evil effect upon iron of bending it too sharply is shown in Fig. 1, which represents

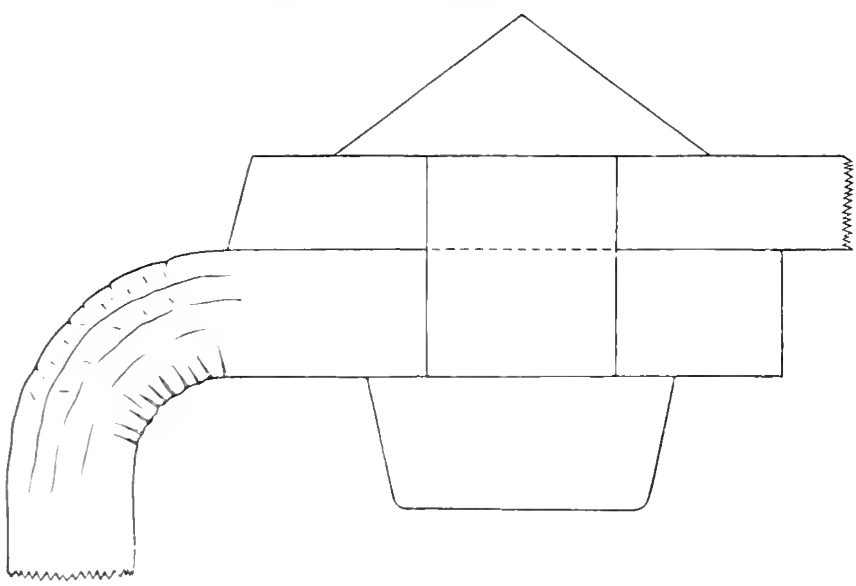

FIG. 1.

a full sized section of a tube sheet, at the angle or flange, bent to a radius equal to about the thickness of the plate, as they are frequently found in practice. Indeed they are frequently found with a still shorter bend, sometimes almost a sharp corner on the inside. The effect of this is to unduly strain the iron, both on the outside and inside of the flange, the outside being under a combined tensile and bending strain generally to such an extent that a section of the flange shows a laminated appearance as seen in Fig. 1, caused by the layers of the plate being separated, and sliding upon each other, while the outside of the plate, unless of extra fine iron worked with more skill than is usual, if examined closely, will be found to be filled with small cracks having the appearance of season checks, as seen in timber. The inside of the flange, on the contrary, is in a state of undue compression, the fibers being crushed and buckled up as shown in Fig. 1. The effect of too sharp flanging may easily be shown; by taking a narrow strip of boiler plate and bending it sharply, the effect will be very marked.

This disturbance of the fibers and laminae of the iron, renders it peculiarly susceptible to the corrosive action of the acids present to a greater or less extent in all waters, the result being manifested by grooving or channeling, and fracture along the angle of the flange caused by the combined action of grooving, and the "working" caused by variations of pressure and contraction and expansion. This is well illustrated by a recent case where the head of a boiler blew out. The fracture followed the angle of the flange entirely around, and in addition the piece blown out showed upon careful inspection to be full of cracks or checks in the immediate neighborhood of the flange and main fracture, which were evidently caused by the "working" due to great and sudden variations of pressure, which effect in this case was heightened by the injury done to the iron by too sharp flanging originally, and the total absence of the necessary bracing.

From close observation and long experience with such cases, we are led to recommend as proper for flanging, an internal radius of about four times the thickness of the plate flanged; or, for all ordinary boiler heads or tube sheets, flue plates, etc., of a thickness of from $\frac{3}{8}$ to $\frac{1}{2}$ inch, the internal radius may be 2 inches. Experience has shown that with this radius, and ordinarily good plates and careful working, there is no danger of injuring the plate during the operation of flanging. The flange will then have the proportions shown in Fig. 2, which is drawn one-half full size. This gives a very free, easy

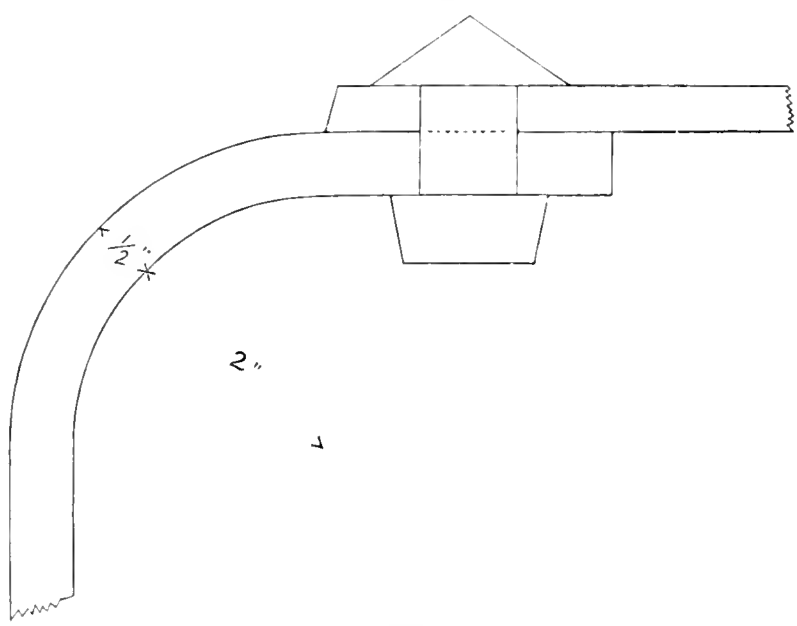

FIG. 2.

bend by which the liability to groove is entirely obviated; at the same time the head will be considerably stiffer in consequence of the diminished area of the flat surface, while the bend will not interfere with placing the tubes, as no tube should be at a less distance than 3" from the shell of the boiler.

As regards the best method of turning the flange itself, there is no doubt that it can be done with proper machinery far better than by any other method. The usual method of performing the operation, which requires several heats, and bending down a portion at a time, is objectionable for several reasons, but will probably continue to be used to a very great extent on account of the small first cost of the requisite plant. It would seem, however, that proper machinery might be constructed for a very moderate sum, for so small a sum at most that it would be a matter of economy in shops of any considerable size, to do their flanging by machinery.

That the system of flanging by machinery is both practical and economical is proved by the following, which is taken from *Engineering*:

"Boiler plates have been successfully flanged by hydraulic pressure for many years past, and we have frequently referred to hydraulic flanging machines in these columns. Their construction has hitherto rendered it necessary to make dies and blocks capable of flanging the plate in one operation, or squeeze, this entailing a considerable outlay in blocks and matrices; consequently up to the present time these machines are chiefly used either by railway companies or leading firms of locomotive builders. * * * *

"In agricultural locomotives, although the work is not so heavy, there is a very large output and a great repetition of parts, consequently we find that engineers making this class of machinery are extensive users of hydraulic flanging presses. * * * *

"All the riveting at Wallsend is done on Tweddell's system, and the flanging and straightening machine we now illustrate is another application of the system to shop tools. The first object being to reduce the cost of the dies and blocks, it was decided to flange the plate gradually, or step by step, following as nearly as possible the process of hand flanging. Fig. 3 shows a side elevation of the machine arranged to flange a common head or tube sheet.

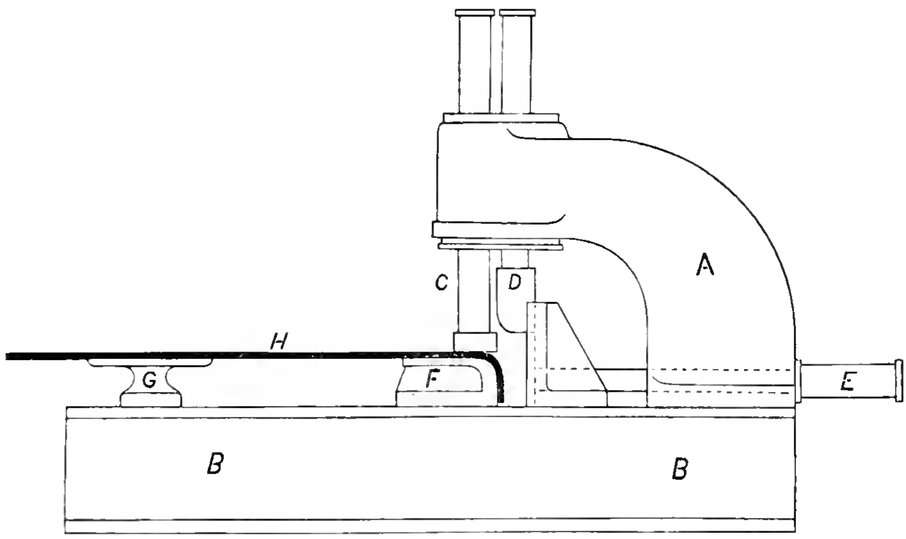

Fig. 3.

"In Fig. 3 A is a standard attached to the bed-plate. B B; the former carries three hydraulic cylinders, C, D, and E, and to the latter is fixed the small block F, and center-pin G. The plate having been heating for a length of 5 or 6 feet along its edge is placed on the block F, which is merely a segment of a circle with a radius equal to that of the boiler-head for which it is intended. On the plate being placed on this anvil or block, the hydraulic ram C is lowered down upon it; this acts as a vice and prevents the plate being dragged forward when it is turned over as shown in Fig. 3 by the descent of the ram D. This ram carries a specially shaped tool for turning the edge of the plate over the end of the block or anvil. This operation being finished the ram D is again raised to the position shown in Fig. 3, and the vice ram being released the whole plate H is turned round on the center pin G, thus presenting a further length to be turned over, and the above operation is repeated until the whole length heated is flanged. As soon as the whole length is turned over the plate is again turned round on its center G, and the ram D being raised out of the way, the horizontal ram E fitted with a hammer head, then advances and straightens and squares up the flange against the anvil F, thus completing the operation.

"It is evident from this description that the block or anvil may be made to fit any irregular shape of plate, and when the flanges are straight of course the center pin G is not used. * * * *

"It will be observed that this system not only effects an immense saving in the cost of the blocks and dies for very large or irregular work but for this class it avoids the outlay for a large heating furnace. The machine itself is also much cheaper, the cylinders of course being much smaller owing to the work being done by several efforts instead of by one. The actual results, so far as the quality of the work is concerned, are excellent and the economical results are also most satisfactory. To a certain extent the machine at present is not favorably placed for economical working, but the results up to now show that it can do a given quantity of work in less than half the time and at half the cost of the same work when done by hand. The quality of the work, moreover, is much superior to hand work and there is a great saving in fitting and putting the boilers together."

Where the usual method, however, is followed, care should be exercised that in the first place a good smooth former of the proper radius is used, then only the best flange iron should be put into heads, make the heats even, or of the same temperature each time as nearly as it is possible to make them, as much of the head should be heated at once as it is possible to work before cooling, and no more; the work should proceed as rapidly as is consistent with careful workmanship, and the iron should not be hammered after it is so cold that it would be likely to be injured thereby. All of these conditions can easily be attained by the exercise of proper care and oversight, and the employment of good workmen, and then cases of grooved and broken flanges, in boilers of proper design, would become exceedingly rare.

Inspectors' Reports.

JUNE, 1881.

Below will be found the summary of the work done by the inspectors of this company during the month of June. The number of visits of inspection made was 1,916, by which 3,820 boilers were examined, of which number 1,294 were annual internal inspections. The hydrostatic test was applied to 352 boilers, principally new ones. The complete summary of defects is as follows: Whole number of defects 1,518 — 420 dangerous; furnaces out of shape, 100 — 23 dangerous; fractures, 124 — 79 dangerous; burned plates, 88 — 27 dangerous; blistered plates, 224 — 52 dangerous; cases of deposit of sediment, 207 — 28 dangerous; cases of incrustation and scale, 262 — 33 dangerous; cases of external corrosion, 112 — 29 dangerous; cases of internal corrosion, 81 — 19 dangerous; cases of internal grooving, 22 — 9 dangerous; water-gauges defective, 31 — 10 dangerous; blow-out defective, 20 — 9 dangerous; safety-valve overloaded, 12 — 6 dangerous; pressure-gauges defective, 123 — 31 dangerous; boilers without gauges, 50 — 1 dangerous; cases of deficiency of water, 5 — 5 dangerous; broken braces and stays, 45 — 30 dangerous; heads defective, 5; boilers condemned, 15.

In the course of the investigation into the cause of a recent boiler explosion which happened in England, some facts were developed regarding pressure gauges which are a more convincing argument in favor of the necessity of periodical inspection than a whole volume of ordinary reasoning, however sound. There were two gauges which had been in use on the exploded boilers and they were afterwards tested with the following result: With the first one when the mercury column showed a pressure of 5 lbs., the gauge indicated 7½ lbs., and the succeeding figures were 10 lbs. — 12½ lbs.; 15 lbs. — 17½ lbs.; 20 lbs. — 22½ lbs.; 30 lbs. — 32 lbs.; 35 lbs. — 36 lbs.; 40 lbs. — 41½ lbs.; 50 lbs. — 51½ lbs.; 60 lbs. — 61½ lbs. The second gauge registered as follows: When the mercury showed 5 lbs., the gauge indicated 6 lbs.; 10 lbs. — 10½ lbs.; 15 lbs. — 15 lbs.; 20 lbs. — 18½ lbs.; 30 lbs. — 25 lbs.; 40 lbs. — 29 lbs.; 50 lbs. — 34 lbs.; 60 lbs. — 40½ lbs.; 70 lbs. — 51 lbs.; 80 lbs. — 58 lbs.; 90 lbs. — 67 lbs.; 100 lbs. — 76 lbs.; 120 lbs. — 100 lbs.

The case is one of the greatest importance in view of the fact that implicit reliance is generally placed on the reading of the gauge. Steam users should remember that gauges are just as likely to get out of order as other machines, and that when they show from 25 to 50 pounds less than the actual pressure it *may* become a very serious matter.

Boiler Explosions.

Saw-Mill (88).— The steam saw-mill of F. A. Gleason & Co., of Bennington, Vt., located at Woodford, was burned Tuesday evening, July 5th. Loss $10,000; insured. The fire was caused by the explosion of a boiler.

Locomotive (89).— On the morning of the 8th of July, the engine of a freight train on the New York Central & Hudson River road exploded its boiler when near Chili, N. Y., tearing the engine to pieces and injuring the engineer very badly.

—— Mill (90).— The boiler in Patterson's mill, near Vestaburg, Mich., exploded, July 9th, severely scalding the engineer and badly shattering the mill.

Dye-Works (91).— An explosion occurred about 3.30 p. m., July 11th, at Barrett & Nephew's dye-works at Cherry Lane, Port Richmond, Staten Island. Five men badly hurt; not expected to recover.

Saw-Mill (92). —The boiler of a portable saw-mill at Watertown, O., blew to atoms July 19th, from lack of water. Casualties: Hiram Brockway and Eugene Barclay, instantly killed; Isaac Johnson, since died; Robert Alexander and William Corner, fatally injured.

Threshing-Machine (93).— July 28, on the farm of W. T. Sneed, about six miles north of Napa, Cal., the engine of a threshing-machine exploded, and instantly killed Willis Crowe, Geo. Platt, and Rob't Davis. Harry Gillam was slightly injured.

Distillery (94).— At six o'clock, July 30th, a terrible explosion occurred at Woolner's distillery, in Lower Peoria, in which Max Woolner, son of Abraham Woolner, was instantly killed, and sixteen others scalded. The following are the names of the wounded: Ignatius Woolner was badly burned, and will probably die, John Kirkland, Henry Williams, William Rice and two sons, Henry Goetz, Charles Hoffner, August Stettler, Tom Lawless, Sinclair of New York, Freeman, Henry Cushing, William Fehl and two sons, August Reifnider, all of whom are badly burned, and some will no doubt die.

Locomotive (95).— On the afternoon of the 31st of July, the engine of a freight train on the Chicago & Northwestern road exploded its boiler near Peshtigo, Wis. The engine was completely wrecked, five cars damaged, a brakeman killed, the engineer and fireman hurt.

A curious thing occurred lately in the works of M. Fleury, at Cette, France. The feed-water of the boilers giving much incrustation, M. Fleury was advised to put into the boiler some fragments of zinc as a deincrustant, and did so. In a few days, in spite of oiling, the steam-engine began to work very badly, the piston catching a great deal, and it soon became necessary to stop and make an examination. The piston was found to be covered with a thick adherent layer of copper. It was put into a lathe, and at certain ovalized points the metallic layers were so thick that the tool worked in copper alone. The explanation given by M. Fleury is this: The boiler was connected with the engine by copper pipes. Particles of zinc carried off by the steam would form with the copper numberless small galvanic couples; hence the transport of copper to the piston, which would principally attract them by reason of its motion and the heating produced. It is remarked in *Les Mondes* that the eminently electric properties of expanding steam may have helped in development of the phenomenon.— *Railroad Gazette.*

The Locomotive.

HARTFORD, AUGUST, 1881.

WE call attention to the article on flanging boiler-plates which appears in this issue of the LOCOMOTIVE. Experience has shown us in too many cases that the work of flanging is not properly done. The turn is too sharp, and the strength of the fiber of the material is often greatly weakened. It is not uncommon to find the flanges on boiler heads turned at a sharp angle, with little or no curve. By this method the outer stratum or fiber is put under great strain, while the inner stratum is crushed and "crumpled." If a true curve is given to the metal in bending, its strength is not impaired. This will be evident to any one who carefully studies the subject. Formers for flanging should be so made as to give the turn or bend on a radius of 2½ inches. It will give more strength and be less liable to deterioration from corrosion and grooving. We ask the attention of boiler-makers particularly to this matter.

There are many points in boiler construction which can and should be improved. Of course this remark is not applicable to all boiler-makers; for there are many who are progressive, and who are not so wedded to the practices of their fathers that they are unwilling to adopt valuable suggestions when the proof of their value is before them. But then, again, there are those who plod along in the same old rut that their fathers did before them, and set themselves solidly against any innovations. Methods of bracing, size and pitch of rivets, strength of riveted joints, and "chipping and caulking" have very little special attention. Everything must be done as it has been for the past half century.

It was formerly regarded as good and economical practice to "cram" a boiler with tubes, place them close together and very near the shell. There was little space for the water to circulate, and if the water carried impurities it found very convenient places to deposit them, on and around the tubes.

The argument was and is to-day with many, "the more heating surface the greater efficiency." It has been most completely demonstrated that many of the lower tubes in a boiler overcrowded with tubes are of little service for heating purposes, and are very detrimental in impeding good circulation; but it is very difficult to make some boiler-makers believe that such is the case.

Resistance of Flues and Tubes to an External or Collapsing Pressure.

[Concluded from Page 113.]

On pages 112 and 113, we gave examples of some of the best known formulæ which have been advanced at different times to determine the strength of boiler flues and tubes.

For the purpose of comparing the different formulæ with each other, and also with the actual results obtained in practice, the following table is appended. The first three columns give the dimensions of the flue experimented upon, the fourth column gives the observed pressure which produced failure, and the remaining columns, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 give values of p calculated by the formulæ on pages 112 and 113. The number at the head of each column refers to the formula having the same number on pages 112 and 113.

Dimensions.			Observed Collapsing Pressure.	P Computed by Formula No.									
Diameter.	Length.	Thickness.		(1.)	(2.)	(3.)	(4.)	(5.)	(6.)	(7.)	(8.)	(9.)	(10.)
54″	$71\frac{1}{4}$″	.25″	105	119	140	27	153	155	17	14	...	94	...
54″	36″	.25″	132	241	226	27	225	311	35	25	...	...	125
$18\frac{3}{4}$″	61″	.25″	420	406	449	135	429	529	59	...	...	370	...
20″	360″	.25″	65	54	163	106	125	72	9	...	...	...	76
42″	300″	.375″	127	90	273	138	198	105	12	...	...	...	120
42″	420″	.375″	97	64	195	138	163	75	9	...	...	...	88
$14\frac{5}{8}$″	60″	.125″	125	116	149	46	127	172	19	...	...	...	131
$33\frac{1}{2}$″	360″	.34″	99	75	211	116	176	78	10	...	...	...	105
$7\frac{4}{5}$″	276″	.157″	110	77	215	148	150	109	12	...	...	...	116

An examination of the above table shows at a glance that formulæ (2.), (3.), (4.), and (5.), are wholly unreliable, and should never, under any circumstances, be used to determine the dimensions of boiler flues. This is so evident that we do not think they deserve further notice.

Formula (1.), or Fairbairn's, gives closer results but the table shows that it cannot be implicitly relied upon. It is, in fact, nothing more than an empirical formula, deduced from a limited set of experiments made upon flues and tubes much thinner, smaller, and shorter than are generally used in boilers at the present time. It is interesting, however, from the fact that it was the first attempt that was ever made to formulate the strength of flues on an experimental basis, and has been very generally used for the last twenty years. In it, it is assumed that the strength is inversely proportional to the length, and that, if rigid rings be attached to the flue, dividing it into any number of equal parts, the strength is increased in the ratio which the whole length of the flue bears to the length of each division. Later experiments have shown this is not strictly true for flues of ordinary dimensions, though practically true for very thin ones. In using this formula therefore, if a flue is furnished with "collapse rings," it is customary to take the length equal to the distance from center to center of the rings. Another very grave defect in Fairbairn's formula arises from the fact that no allowance is made for differences of strength arising from different forms of joint, as single or double riveted, lap or butt joints, or whether the flues are built up in courses as they ordinarily are, or formed of a single plate with a longitudinal lap, or butt joint. Taking all these points into consideration, we would not advise the use of formula (1.) with a factor of safety less than eight.

Formula (6.) is evidently nothing more than a slight modification of (1.), with a factor of safety of 7; the real factor, as the record of observed collapsing pressure shows, varying from $3\frac{3}{4}$ to $10\frac{8}{10}$. This formula would, generally, be safe to use in fixing the working pressure of a boiler, if the materials and workmanship were of approved quality. We would not however advise its general use, for the same reasons which apply to Fairbairn's formula.

Formula (7.) is used by the Board of Trade, in England, for fixing the working pressure in boilers having large circular furnaces. The data in our possession specifies the kind of joint used with sufficient exactitude to enable us to apply this formula, in but two cases. From this it appears that the factor of safety is not less than 5 in the best kind of joints, hence this rule may be safely used in all cases. The form of this rule is very similar to Lloyd's, but, as it will be seen, the constants must be varied to suit each particular kind of joint. This variation of the constant for each particular case seems to be very judiciously done, as we might well expect, coming from the high source it does, and the rule might profitably be adopted by all steamboat inspectors in this country. From experience we can recommend it as eminently safe.

Professor Unwin's formulæ, (8.), (9.), and (10.), are, however, the most rational and accurate of any yet published for determining the collapsing pressure. It seems to be the only one founded on correct principles, and deduced from reasoning on general principles. Its agreement with the result of experiment is very close, the difference between the actual collapsing pressure and that indicated by the formula, being no greater than we would naturally expect would arise from variations in the quality of the materials and workmanship. It is easily used with the assistance of logarithms. By the application of logarithms the formulæ take the following form:

$$\text{Log } p = 6.8671 + 2.1 \times \log. t - (0.9 \times \log l + 1.16 \times \log. d) \quad (8)$$
$$\text{Log } p = 6.9829 + 2.21 \times \log. t - (0.9 \times \log. l + 1.16 \times \log. d) \quad (9)$$
$$\text{Log } p = 7.1916 + 2.35 \times \log. t - (0.9 \times \log. l + 1.16 \times \log. d) \quad (10)$$

For the sake of illustration take the fifth example in the preceding table.

$t =$ .375, log. $t = 1.5740$, $\times 2.35 = 2.9989$, $7.1916 + 2.9989 = 6.1905$.
$l = 300$, log. $l = 2.4771$, $\times 0.9 = 2.2294$.
$d = 42$, log. $d = 1.6232$, $\times 1.16 = 1.8829$.
Then log. $p = 6.1905 - (2.2294 + 1.8829) = 2.0782$, hence $p = 119.7$.

Should, however, the use of logarithms be attended with inconvenience, the following modification of formula (10) may be used:

$$P = 15{,}547{,}000. \frac{t^2}{l\,d} \cdot \frac{a}{b\,c} \quad (11)$$

Then if the following values are given to the variable co-efficients, a, b, and c, the use of logarithms may be dispensed with.

When t lies between	0.061 and 0.087	0.087 and 0.119	0.119 and 0.159	0.159 and 0.206	0.206 and 0.261	0.261 and 0.325	0.325 and 0.399	0.399 and 0.483	0.483 and 0.577	0.577 and 0.682	0.682 and 0.80	0.80 and 0.931	0.931 and 1.07
$a =$	0.40	0.45	0.50	0.55	0.60	0.65	0.70	0.75	0.80	0.85	0.90	0.95	1.00
When l lies between	13 and 25	25 and 51	51 and 110	110 and 253	253 and 628								
$b =$	0.75	0.70	0.65	0.60	0.55								
When d lies between	2.4 and 4.	4. and 6.5	6.5 and 10.2	10.2 and 15.5	15.5 and 22.9	22.9 and 33.0	33.0 and 47.	47 and 65					
$c =$	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9					

Take the same example as before.

$$p = 15547000 \times \frac{.140625}{300 \times 42} \times \frac{0.7}{0.55 \times 1.8} = 120.9.$$

From a consideration of the way in which a flue breaks up in collapsing, Prof. Unwin concluded that a tube reached its minimum strength when the length was about $6.7d^2$. If the length is increased the strength remains the same, and in computing the collapsing pressure l should be taken $= 6.7d^2$. Conversely, the formula will cease to apply if the length is less than $4468 \frac{t^{2 \cdot 22}}{d^{0 \cdot 13}}$ . . . . . . (12)

The following table gives the maximum limit of length for ordinary cases:—

Diameter of flue =	4″	8″	12″	18″	24″	36″
Maximum limit of length =	107″	429″	965″	2170″	3860″	8680″

And the next table the minimum length:—

Thickness of Flue.	Diameter of Flue.					
	4″	8″	12″	18″	24″	36″
$\frac{1}{8}$″	34″	30″	28″	26″	25″	23″
$\frac{1}{4}$		142	131	122	116	108
$\frac{3}{8}$		348	324	301	286	265
$\frac{1}{2}$			614	570	542	504
$\frac{5}{8}$			1007	935	889	826
$\frac{3}{4}$				1403	1334	1239

If the flues are shorter than those in the above table, the following rule may be used to fix the working pressure:

$$\text{working pressure} = \frac{2ft}{d} \quad \ldots\ldots (13)$$

Where f may be taken equal to 4,000 pounds per square inch for boiler flues. This rule should be used in all cases where the thickness is greater than $\frac{1}{19}$ of the diameter. When formulas (8), (9), (10), are used the factor of safety should be at least 6.

For further and more extended information on this subject, Fairbairn's "Useful Information for Engineers," Unwin on the "Resistance of Boiler Flues to Collapse," and Board of Trade's "Instructions to Surveyors of Ships," may profitably be consulted.

H. F. S.

Welding Cobalt and Nickel.

At the exhibition in Düsseldorf in 1880, some exhibits of special interest were shown by Dr. Theodor Fleitmann, of Iserlohn, these comprising a whole series of samples, illustrating the manufacture of nickel and cobalt, from the crude ore down to the purified metal. Among the specimens illustrating the application of these metals were particularly remarkable iron sheets, and articles of iron, such as plates, salvers, cups, teakettles, and other domestic utensils, which were covered on both sides with a thin plating of nickel or cobalt. This plating, however, was not combined with the iron by any process of galvano-plating, but solely by welding both metals firmly together. The welding process was made conspicuous by sections of welded metals, amongst others by an eight millimetre iron plate with a skin of nickel upon each side of only $\frac{1}{2}$ millimetre in thickness. The welding operation had been carried out when both metals were still much thicker, and core and covering were then rolled out hot to the required thickness. It appears that since these samples were exhibited at Düsseldorf, Dr. Fleitmann has succeeded in further improving his process of welding nickel and cobalt with iron. He has proved that nickel may be alloyed with an equal quantity of iron by melting in a crucible, and that the alloy, which is thus obtained, will still weld very well, the same being the case with those alloys of nickel and copper which, when heated, remain soft enough to be rolled out in sheets without breaking. Both alloys, as well as alloys of nickel and cobalt containing zinc, will firmly unite with iron or steel when welded upon clean metallic surfaces, provided that during the welding operation under the hammer or the rolls, the atmospheric air is carefully excluded, so that any oxidation of the welding surfaces is prevented. When the metals are thus firmly united, they can be rolled down to any required thickness, or they may even be drawn out to very thin wire, when the coating of the pure metals of nickel and cobalt, or their respective alloys with iron, copper, and zinc, will protect the core against oxidation. The exclusion of air during the welding operation can be obtained in various ways; for instance, by wrapping the metals before welding in a cover of thin sheet iron, which is afterwards separated by dissolving in a weak acid, which will not attack nickel and cobalt nor their alloys. The same result may be obtained by heating the metals in closed vessels until they have attained a welding heat, or, finally, by heating them in an atmosphere of gases such as carbonic oxide or carburetted hydrogen, which prevent any intrusion of atmospheric air. In a similar manner an alloy of nickel and copper may be employed as a core and pure metal welded upon the surfaces, as the pure metal will adhere just as well as upon iron or steel. It is indeed a great progress in plating metals, that Dr. Fleitmann should succeed in welding firmly upon iron, steel, copper, or copper alloys, any thickness of nickel and cobalt or their alloys, supposed that free oxygen is carefully kept out under the operation. The articles which are thus plated with nickel preserve a bright surface even in a damp atmosphere, and can be easily kept clean with soap, and they have thus a great advantage over polished steel, iron, or brass; and they will be found very useful for a great many domestic uses, such as kitchen utensils and ranges, pots, pans, kettles, etc.—*Engineering.*

In reply to a correspondent who asks for information about boilers foaming, the *Mechanical Engineer* says: Foaming is a common trouble with steam-boilers, and arises from several causes, chiefly however, from the nature of the water and condition of the boiler itself. A new boiler foams from the oil, grease, and dirt that get into it in the process of construction. A small boiler is easily cleaned out, but a large one like a marine boiler takes time to clean thoroughly. All sorts of rubbish collect in them; old rivet-kegs that the men take in to sit on and don't always take out again; jacket-lamps that tumble down full of oil into the water-legs, old shoes, and other things unnameable. The only thing to be done with this rubbish is to blow the boiler out under pressure, taking out by hand what will not pass the blow-cock. Blown down as far as it is safe to, then pump up and blow again before firing up, and previous to putting on the man-hole plate the engineer in charge should send a man into new boilers to collect all the sticks that float. If this is not done, some of them may get carried over into the steam-pipe and under the valves, doing great damage. This thing has happened before now. Some new boilers never foam at all, and others will for a long time. In case the boiler is clean and in good order, this may arise from hard firing; thin water-spaces will also make trouble for an engineer. When this is the cause, the obvious remedy is to stop firing hard, and open the doors for a moment or two, so that the water will drop to its natural level. There is not only danger of burning the boilers when foaming occurs, but also, liability of knocking out a cylinder-head by water carried over, and an engineer should take prompt measures by slowing down as soon as it occurs.

The probable identity of wave velocity in light and electricity has been established in various ways. Weber and Kohlrausch measured the quantity; Sir William Thomson and J. Clerk Maxwell experimented upon the electro-motive force; Ayrton and Perry operated upon the electro static capacity. The extreme range of velocity in the various results was about 10 per cent.; the mean of all the results appears to correspond precisely with the velocity of light. The meaning of this accordance may be explained as follows: Suppose two parallel plane surfaces, each charged with a unit of positive electricity and placed at unit of distance: they will repel each other with a unit of force. Now suppose that they are both set in motion in the same direction, but remaining parallel and at the same distance; they will produce the effects of two parallel currents of the same kind, and will exert a mutual attraction which will increase with the velocity of motion. It is possible to conceive of a velocity, such that the attraction resulting from the motion will exactly counterbalance the repulsion which arises from the similitude of electricity; this velocity is precisely that of light.—*La Lumiere Electrique.*

A Peculiar Property of Matter.—A good deal has been written concerning the physical properties of matter, and it would seem, that so far as our knowledge extends, the subject was well nigh exhausted. Strange as it may appear, there is one property of the most common substance with which the machinist has to do, that has never been accounted for, or in any way alluded to, in works on this subject. We refer to that peculiar property of cast iron, by virtue of which, when in the condition of old cylinders, pieces of pipe, safety valves, and a multitude of other forms, it manages to get exactly in the way of every man in a good sized machine shop, and at about the same time. Practical men know this to be a fact, and are looking to science for an explanation. It has long been reasonably well established, that in a shop where the custom is to preserve such things, notwithstanding they may be relegated to some particular corner devoted to their preservation, they will find a way to get themselves distributed all over the shop without any very serious delay. It would be a valuable acquisition to our present knowledge, to know why this is so. While carrying on the investigation necessary to determine what particular property enables inert matter to get away with the best intentions of proprietors, foremen, and workmen, it might be well to conduct it with a view to finding out what property could be added to cast iron, so that it would be possible to get useless scrap from the machine shop into the cupola.

There is a broad field here for scientific investigation, and in a direction where there can be no possible clashing of theory and practice; the latter having virtually withdrawn from the contest.—*American Machinist.*

Care of Steel Boilers.—Steel has been tried in numerous cases for locomotive boilers, and abandoned by some, because of the cracking of the sheets that form the fire box.

If a boiler having a steel fire box is blown off and washed with cold water before allowing it to cool, the sheets will generally crack. But if the boiler be washed out with hot water the sheets will not crack. We know of an important railroad where they were constantly troubled by cracked steel boilers while pursuing the former plan, but since adopting the latter, not a single sheet has cracked. It is also an excellent method to bank the fires and not let them go out, unless it is necessary to do work upon the boilers.

The boilers are thus kept free from the damaging and dangerous results occasioned by great and frequent changes of temperature.—*American Machinist.*

An apparatus for steering a ship by electricity has lately been patented in England and is now being tried on a steamer between London and Glasgow, the principle of which is as follows:—The compass card is fitted with an index which can be set to the required course, two metallic contact pins are adjusted one on each side of the index and distant from it about one degree. Each pin is connected to a single Daniell cell, and the apparatus is arranged in such a manner that when the vessel deviates more than one degree from her course, the index comes in contact with the pins and the current is established, thus actuating an hydraulic apparatus which works the helm, the positive current moving the helm one way, and the negative moving it the other, and thus the required course is maintained.

Professor O. N. Rood of Columbia College, describes in a recent number of the *American Journal of Science*, a modification of the Sprengel pump, by which he has been able to obtain a vacuum of $\frac{1}{390000000}$ without finding that the limit of its action had been reached.

The Locomotive.

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Lap-Riveted Joints for Steam Boilers.

The subject of riveting boiler plates, although theoretically one of comparative simplicity, would seem, judging from the very great diversity of opinion and practice which prevails among engineers and boiler-makers regarding it, to be one of the most difficult with which the iron worker, and more especially the manufacturer of steam boilers, has to contend.

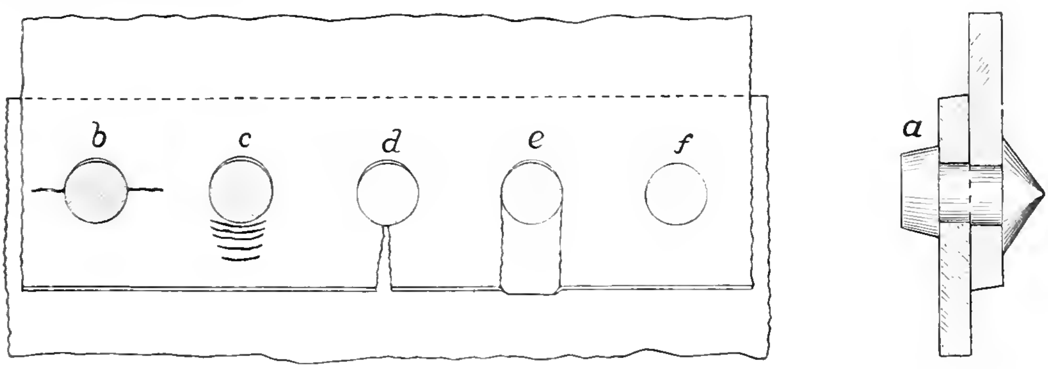

FIG. 1.

If, however, we investigate the cause of this diversity of practice which prevails in different shops and localities, we shall in most instances find that it arises from the fact that the size and pitch of rivets, and some other matters which greatly influence the strength of joints, are always established by somebody's "guess so," and it is a well-known fact that no two men ever guess alike on any given problem, and we think we may go still further and safely say that no *one* man ever guesses twice alike on the same thing. That this last assertion holds good, especially with reference to boilers, is, we think, abundantly proved by the fact that one day any given boiler-maker will deliver a boiler with a certain diameter, thickness, and length of shell, with rivets of a certain size and pitch, and some day the next week, or perhaps sooner, he will deliver another boiler, the exact duplicate of the first one, so far as the diameter, thickness, and length of shell are concerned, but the second boiler will be riveted up with rivets of a very *un*-certain diameter and pitch; probably, though, the rivets will be a sixteenth or an eighth of an inch larger or smaller, and the pitch anywhere from a quarter to a half of an inch less or greater. Having demonstrated as a curious physiological fact that the size of a man's "guess" varies from day to day, it would be interesting to continue the study further and determine just how much the different elements of the weather, such as force and direction of wind, temperature, storms, etc., affect the magnitude of the "guess," and thus, indirectly, the proportions of riveted joints. Such, however, is not the purpose of the present article; we only hope to throw some light on what we know from experience to be *good* proportions for rivet diameter and pitch.

Riveted joints are of various kinds; those we are more particularly concerned with in this article are known as lap joints, and are almost exclusively used for steam boilers in this country. They may be either single or double-riveted; a single riveted joint is shown in Fig. 1, and a double-riveted joint is shown in Fig. 2. The lap joint is not the strongest form of joint that can be made, on the contrary it is one of the weakest, as the material, both of the plate and the rivets, is very disadvantageously placed to resist the strain it is subjected to. Its advantages are its ease of construction and consequent cheapness for plates of ordinary thickness, and for these reasons it is used for steam boilers.

In investigating the strength of a lap joint, with the view of obtaining correct proportions, it is first of all necessary to inquire in what manner it may break under the influence of the strains to which it may be subjected. The principal strain to which it is subjected in a boiler shell is the resultant of the uniform internal steam pressure, which tends to pull the plates apart in a direction parallel to their length. The effect of this strain may break the joint in either one of the several different ways which are shown at Fig. 1. The manner in which the joint fails will depend upon the proportion of its different elements. These elements may be considered to be:

The tensile strength of the plates.

The crushing strength of the plates.

The shearing strength of the rivets and plates.

The thickness of the plates.

The diameter of the rivets.

The pitch of the rivets.

The joint may fail in either one of the following different ways, shown in Fig. 1.

The plate may tear between the holes as shown at *b*. This method of fracture occurs when the strength of the rivets is in excess of that of the plate, which may be because the rivets are too large, while the pitch is correct, or more frequently because the pitch is too small, while the rivets are of the proper diameter. It may also occur from the pitch being too *great*, in which the stretching of the plate allows all the strain to be concentrated on the fibres of the plates at the sides of the rivet-hole.

If the rivets are too small they will shear across as shown at *a*.

When the rivets are too large for the thickness of the plate, the plate may be crushed in front of the rivet, as shown at *c*.

When the line of rivets is too near the edge of the plate, a piece of the plate of a width equal to the diameter of the rivet may be sheared out as shown at *e*, or the plate may crack between the rivet-hole and the side of the plate as shown at *d*. It is also said that the fractures shown at *b* and *d*, which are frequently found in new boilers before they have left the maker's shops, *may* be caused by the reckless use of the *drift-pin*, but we believe this is generally denied by all except *first-class* boiler-makers.

Now, it is evident that the strength of a joint cannot be greater than the strength of the weakest part of it, and that we shall have the strongest joint when it is so proportioned that the strength of all its elements is equal.

In determining the proportions of riveted joints, the first thing to be done is to ascertain the proper diameter of rivet for any given thickness of plate. When the resistance of the plate to crushing is just equal to the resistance of the rivet to shearing, the proper conditions of strength are fulfilled.

Let us consider a strip of plate at the joint of a width equal to the pitch, or distance between two contiguous rivets, and suppose the joint to be single-riveted.

Then, the resistance of the rivet to shearing can be proved to be equal to the area of its cross section, multiplied by the shearing strength per square inch of the rivet iron; and the resistance of the side of the rivet-hole to crushing can be proved to be equal to the thickness of the plate, multiplied by the diameter of the rivet, and this product multiplied again by the resistance per square inch of the plate to crushing.

The direct crushing strength of wrought iron is generally about equal to its tensile strength, in the case of short isolated bars, but the metal around the rivet-hole in a boiler plate is in a different condition, being supported by the surrounding unstrained metal of the plate. Direct experiments which have been made on plates, with the object of ascertaining the crushing strength under these circumstances, show on an average the crushing resistance may be taken at twice the shearing resistance, consequently, in order that the shearing resistance of the rivet and the crushing resistance of the plate may be equal, the area of the rivet-shank should be equal to twice the product of the thickness of the plate multiplied by the diameter of the rivet. Deducing from this the value of the diameter of the rivet in terms of the thickness of the plate, we find that it should be $2\frac{1}{2}$ times the thickness of the plate.

This is the theoretically correct size of the rivet, but practically it is found necessary to make the rivet somewhat smaller for the following reasons; first, if the rivet is given the above size, when we reach thicknesses of plate above seven-sixteenths of an inch, the rivet becomes too large to be properly closed by hand riveting; second, the material of the plate is somewhat injured by the punching and cannot *always* be relied upon to bear twice the shearing strength; third, it would be necessary to space the rivets so far apart, to retain equal strength of plate and rivet, that it would be impossible to make a steam and water-tight joint; fourth, the plate is more apt to be reduced in thickness by corrosion than the diameter of the rivet is, so it is found better to give it an excess of strength at the start to allow for wear. For these reasons the diameter of the rivet is made as small as twice the thickness of the plate, and even smaller for the thicker plates.

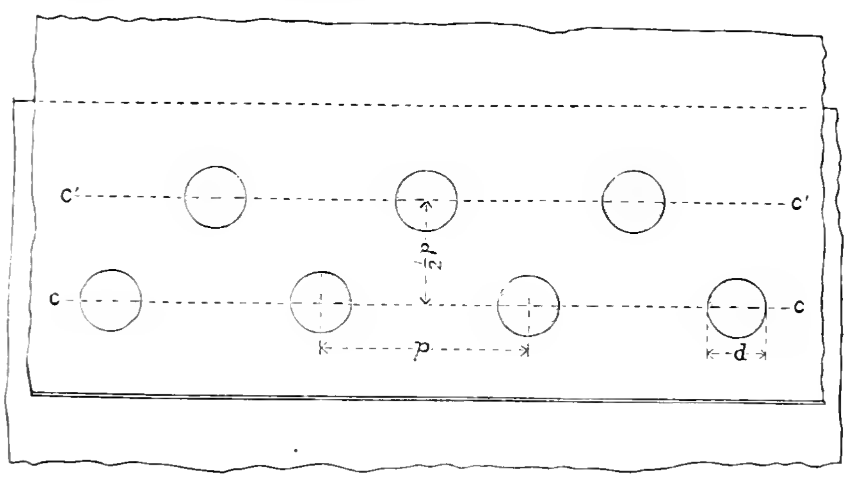

Fig. 2.

Having determined the proper diameter of the rivet, the next thing is to calculate the pitch. This is very easily done. The proper conditions for maximum strength will be fulfilled when we have the resistance of the plate to tearing between the rivets equal to the resistance to shearing of the rivets.

The shearing strength of iron is about four-fifths of the tensile strength. But rivet iron is generally of somewhat better quality than plate iron, and the plate is somewhat injured by punching the holes, sometimes to the extent of twenty per cent., so it is found better practically to make the shearing and tensile strength equal to each other. This proportion is generally adopted by engineers both in this country and in Europe, and experiments show that it is right on an average. Consequently, we have only to make the section of plate between the holes equal to the area of the cross section of the rivet, to obtain equal tensile and shearing resistances. This gives the strongest form of joint with the least material, but practically it will be found better to give some excess of material to the plate when the boiler is new, as under the conditions of actual use the plate is more liable to be fractured than the rivet is to be sheared, and some allowance should be made for reduction of thickness of plate by corrosion, which does not affect the shank of the rivet. An excess of plate area of about 10 per cent. is generally considered about right by the best authorities.

The amount of over-lap of the plates should only be just sufficient to give security against the plate breaking through from the rivet-hole to the outer edge of the plate. The iron in front of the rivet may be considered to be in the condition of a beam fixed at the ends and loaded at the center. If we calculate the dimensions on this hypothesis we shall find that the usual practice of making the distance from the side of the hole to the edge of the plate equal to the diameter of the rivet to be about right; it certainly gives a margin of strength to the plate. As the amount of this over-lap does not influence any of the other proportions of the joint it is unnecessary to further consider it. For double-riveted joints, the same size rivets should be used as for single riveting, but the pitch should be greater. This is so evident that it would seem superfluous to make the statement, and we would not do so did we not find boiler shells every day with the ring seams single riveted and the longitudinal seams double riveted, both however having the same sized rivets and the same pitch. We confess our inability to see any material advantage in this plan. Nearly every joint as ordinarily made and single riveted has an excess of strength in the rivets, and how the section of plate between the rivet holes, which is the weakest part of the joint, can be materially strengthened by adding another row of rivets is not very clear. It is true that the increased width of lap required, with the extra row of rivets, tends to neutralize the oblique strain, which from the very form of the lap joint is unavoidable, but that it does so to the extent generally believed we very much doubt. Certainly the joint cannot have *more* strength than that due to the portion of plate between rivet holes, and experiments show that with drilled holes and thicknesses of plate less than seven-sixteenths inch the single-riveted joint possesses practically the full amount of strength due to the net section of plate between holes.

It will be evident if we stop to think a moment that with rivets of the same size the pitch in double riveting should be increased just enough to still keep the rivet and plate sections equal as in single riveting. It is also plain that it will require simply that the section of plate between the holes should be doubled, hence the pitch for double riveting for any thickness of plate may be found by the following simple rule: *Double the pitch for single riveting, and subtract from the result the diameter of the rivet used; the remainder will give the proper pitch.*

With regard to the distance between the centers of the rows of rivets in a double-riveted joint, it is only necessary to say that they should be placed so that the distance from the center of one rivet to the center of the next rivet, in the other row, should be about equal to the pitch in single riveting. This condition is fulfilled when the perpendicular distance between the centers of the two rows is equal to one-half of the pitch. By placing the rivets in this manner a much tighter and stauncher joint can be obtained than is possible when they are placed in the form of an equilateral triangle, as they generally are, which necessitates a reduction of the pitch to obtain a tight joint.

In accordance with the above principles the following table has been prepared for determining the diameter and pitch of rivets for the different thicknesses of plates for both single and double-riveted joints, when the plates and rivets are both iron. For steel plates iron rivets are generally used, but the pitch should be somewhat less.

TABLE OF PROPORTIONS FOR LAP JOINTS IN IRON PLATES.

Thickness of Plates,	$\frac{1}{4}''$	$\frac{5}{16}''$	$\frac{3}{8}''$	$\frac{7}{16}''$	$\frac{1}{2}''$
Diameter of Rivet,	$\frac{7}{16}''$	$\frac{9}{16}''$	$\frac{11}{16}''$	$\frac{13}{16}''$	$\frac{15}{16}''$
Diameter of Rivet Holes,	$\frac{1}{2}''$	$\frac{5}{8}''$	$\frac{3}{4}''$	$\frac{7}{8}''$	$1''$
Pitch in Single Riveting,	$1\frac{5}{16}''$	$1\frac{11}{16}''$	$2''$	$2\frac{5}{16}''$	$2\frac{9}{16}''$
Efficiency of Joint,	.62	.62	.62	.62	.62
Pitch in Double Riveting,	$2''$	$2\frac{5}{8}''$	$3\frac{1}{4}''$	$3\frac{5}{8}''$	$3\frac{11}{16}''$
Distance apart of Pitch Lines in Double Riveting,	$1''$	$1\frac{5}{16}''$	$1\frac{5}{8}''$	$1\frac{13}{16}''$	$1\frac{27}{32}''$
Distance from Pitch Line to edge of Plate,	$\frac{3}{4}''$	$\frac{15}{16}''$	$1\frac{1}{8}''$	$1\frac{5}{16}''$	$1\frac{1}{2}''$
Efficiency of Double Riveted Joint,	.75	.75	.75	.75	.75

We are well aware that the above table gives somewhat larger pitches, especially for the double riveted joints, than are usually practiced by boiler-makers, but still we are satisfied that it is right when the workmanship is good. That tight joints can be made with the above pitches we are certain, for it is regularly done in many shops at the present time, and, indeed, in some places still greater pitches are used with still smaller rivets than are given above. For proof of this we refer to D. K. Clark's *Manual of Rules, Tables and Data for Mechanical Engineers*, and Shock's new work on *Steam Boilers, their Construction and Management*, both of which can be relied upon as embodying the results of the best practice of modern engineers.

Inspectors' Reports.

JULY, 1881.

The summary of the work done by the Inspectors of this Company for the month of July shows a very gratifying state of affairs. The number of visits of inspection made was 1,665, and the number of boilers examined externally was 3,926, of which number 2,144 were inspected both externally and internally, and 339 were subjected to hydrostatic pressure.

The whole number of defects found was 2,222, of which number 519 were considered dangerous. The detailed statement of defects is as follows:

	Whole Number.	Dangerous.
Furnaces out of shape,	128	37
Fractures,	301	155
Burned plates,	127	41
Blistered plates,	390	52
Cases of deposit of sediment,	285	36
Cases of incrustation and scale,	467	33
Cases of external corrosion,	147	46
Cases of internal corrosion,	71	24
Cases of internal grooving,	24	5
Water gauges defective,	29	9
Blow-out defective,	34	18
Safety-valves overloaded,	19	11
Pressure gauges defective,	162	28
Boilers without gauges,	46	3
Cases of deficiency of water,	5	4
Broken braces and stays,	26	14
Heads defective,	3	3
Boilers condemned,	19	

Boiler Explosions.

COAL YARD (96).—The boiler in Smith, Grant & Co.'s coal and lumber yard, at Pawtucket, R. I., exploded Aug. 1. Bernard McCudden, the engineer, was blown a distance of 40 feet, and instantly killed. He was 40 years old and unmarried.

PAPER-MILL (97).—At nine o'clock in the evening of Aug. 1, the boiler of French & Son's paper-mill, at Carrolton, O., exploded, demolishing the boiler-house and the bleaching-house. The explosion was terrific and threw fragments to a great distance in every direction. The loss is about $3,000. No person was injured.

STEAM-THRESHER (98).— The boiler of a steam threshing-machine, on the farm of Henry Young, near Columbia, Ill., on the St. Louis and Cairo Narrow-gauge Railroad, exploded Aug. 9, killing five persons and seriously injuring five others. The killed are Joshua Morgan, Christian Diehl, Frederick Batcheldor, Nathan Brown, Alfred Arnold, (colored) and a man known only as "Charley." Conrad Linderman, the engineer, George Storm, and Henry Diehl are mortally wounded, and two or three others slightly injured. The boiler was carrying about 130 pounds of steam, and was nine years old.

WOOLEN-MILL (99).—The boiler in the East Falmouth woolen-mill exploded Aug. 15, doing considerable damage. It was the result of over-pressure.

WOOLEN-MILL (100).— At four o'clock on the morning of Aug. 19, one of the battery of two boilers in engine-room No. 4 of the New Albany Woolen-mills exploded, injuring three persons, one fatally, and blowing the engine-room to fragments. At a point one foot below the water line on the side a weak place was shown where the boiler had been burned.

TUG-BOAT (101).— The boiler of the tug A. B. Ward exploded Aug. 20, at Chicago. The force of the explosion was so great that the boiler was fired like a bullet into the boat-house at the end of Clark street bridge. The Captain, Frank Butler, was hurled into the air and fell, fatally mangled but still alive, upon the deck of a barge that the tug had in tow. William McDonald, a deck hand, and Ole Oleson are missing. They are supposed to have been killed and entangled in the wreck. Michael McDonald, the fireman, and Frederick Whitaker, the cook, were slightly injured. The tug was valued at $6,000 and is not insured. The boiler was built in 1877, and was inspected April 29 last, and was found to be in excellent condition. The coroner's jury found that the explosion of the boiler was due to low water.

PLANING-MILL (102).— On the afternoon of August 22, the boiler in How's planing-mill, Bay City, Mich., exploded with terrific force, completely demolishing both engine and boiler, the pieces landing one hundred feet distant. The body of James Kealey, contractor, was found lying on his back, and almost unrecognizable. W. Abrams was literally blown in pieces, his arms and legs being fifty feet apart. There were several other casualties, but none fatal.

ROLLING-MILL (103).— A boiler at the Joliet Steel Works, Joliet, Ill., exploded Aug. 22, caused by carelessness of engineer who allowed the water to get low. Damage slight.

HOISTING-ENGINE (104).— On the morning of Aug. 26, a boiler on the hoisting sloop Gazelle exploded at Haverhill, Mass., wrecking the bow of the sloop and badly scalding the captain, John Tull, and a diver, Frank Blaisdell, slightly. The boiler was old and unsafe, and there were eighty pounds of steam on.

SAW-MILL (105).— A portable engine attached to a circular saw-mill owned by John Ferris and brother, on the farm of James Belanga, at Metamora, Ind., exploded Aug. 25. Sylvester Vale, engineer, was thrown 100 feet, striking a log, and killed.

SAW-MILL (106).— The boiler at Henry Moody's saw-mill at Campbellsville, Ky., exploded Aug. 29. Henry Gaines was killed instantly, and John Fletcher and Samuel Cook were fatally injured. Benjamin Allen was badly scalded, but will probably recover. Two other employees were injured, but neither seriously. The mill shed was reduced to a total wreck. The explosion was caused by the use of sulphur water in the boiler.

ACCIDENTS OTHER THAN BOILER EXPLOSIONS.

The steamer Plymouth Rock on her morning trip to Long Branch, Aug. 17, with some 1,000 or 1,100 passengers, at 2.30 o'clock, when about twenty miles from the iron pier, she burst a steam pipe, knocking open the doors of the engine-room from which an immense volume of steam escaped. A scene of terrible confusion and terror ensued, the passengers being panic-stricken. During the panic there were a number of women and children knocked down and trampled upon, some being severely injured.

At 5 o'clock P. M., Aug. 17, the lid of a fat-trying tank in the pork-packing establishment of Hirtler & Sons, at 68 Washington street, Jersey City, was blown off by the heavy pressure of steam. The lid, which was of solid iron, was driven through the roof of the building and the fat was scattered over the roof to the sidewalk. Jules Mesmer, the engineer, who was standing near the tank, was badly scalded by boiling fat. The damage amounts to $700.

Railway Accidents and Brakes.—At the usual monthly meeting of the Foremen Engineers' and Draughtsmen's Association, held in London, Eng., Mr. John Batey read a paper on "Continuous Brakes." He stated that it was of the highest importance for the safety of the public that an efficient brake should be used for the purpose of stopping a moving train and preventing disasters. It has been clearly shown that the recent railway accident at Blackburn would have been mitigated if the Westinghouse brake could have been properly applied, and therefore he considered that the subject was one which demanded public attention. The Board of Trade had drawn up certain conditions which were considered necessary to make up a good brake. Those conditions were based on the experiments carried out from time to time by Captain Galton and others, and nothing short of them, he urged, should be adopted by railroad companies. He believed that the reason why railway directors did not carry out the request of the Board of Trade with regard to continuous brakes was because so many failures had been recorded in the blue-book. Although none of those failures were productive of serious results, still they had a tendency to weaken the faith of the strongest believer in their efficacy, and that fact was doubtless a clue to the want of unanimity of opinion amongst directors as to the best brake for universal adoption. He contended that a brake to be efficient should have a power equal to the weight of the train, for the purpose of balancing the coefficient of friction between wheel and rail sufficiently to hold the wheel, but beyond that it was necessary that a certain power should exist for the purpose of checking the ultimate velocity of the wheel. Therefore, the absolute power applied was represented by time, multiplied by the power applied. He disagreed with Captain Galton, who contended that the power applied, just short of that which was necessary to stop the rotation of the wheels, was a better means of stopping the train than skidding, which Mr. Batey considered opposed to theory and practice. He believed it was utterly impossible to bring an unskidded train, traveling at the same rate, to a stand-still in the same time and at the same distance as a skidded one. That point appeared to have been finally settled by the trials on the Midland railway, carried on by the authority of the Railway Commission, under Mr. E. Woods and Colonel Isglis; and he concluded that it was necessary that a brake should be applied, equal in power, to each vehicle in order to stop it, and thus avoid the unpleasant bumpings. A brake, to be efficient, should be capable of being applied instantaneously. He then alluded to the proposals to stop a train by applying the power on the locomotive, which he thought insufficient for the purpose, and would cause the carriages to "telescope."—*The Railway Review.*

The Locomotive.

HARTFORD, SEPTEMBER, 1881.

Strength of Riveted Joints.

One of the most important points in boiler construction is the making of a strong joint where the plates are riveted together. Upon the strength of such joints depends mainly the strength of the boiler. It is well known, that in making a riveted joint a portion of the sheet must be cut away for the rivet holes, and the original strength of the plate is thereby greatly reduced. Just how much of the plate should be cut away for the rivet holes is an important problem, and one that should be well considered by every boiler-maker. The distance between the centers of the rivets, on a line running through their centers, is called the pitch of the rivets, and this pitch, as well as the diameter of the rivet, must be calculated for every thickness of plate. If the rivets are too near together, too much metal will be cut away from the plate, and the joint will consequently be unnecessarily weak; and again, if the rivets are too far apart there will be danger of a leaky joint, besides weakness arising from too few rivets. It is assumed in practice, that the tensile strength of the iron, and the resistance of the rivets to shearing, are the same in equal sectional areas. Hence the problem to be wrought out is, at what pitch must the rivets be driven in order that their shearing strength and the strength of the plate shall be approximately the same? In order to obtain this result, the size of rivet must be determined by the thickness of the plate, and the pitch of the rivet by its diameter. These rules are very rarely followed by the boiler-makers generally. Some rule that has been used in the shop for perhaps 25 or 30 years is continued in use. And from some specimens of work which we have seen, it would appear as though the maker considered that the more rivets he used the stronger was the joint. In another column of this paper will be found an article on this subject which, we believe, will be found to be in accordance with the best practice.

THE series of articles now appearing in the *Boston Journal of Commerce* on the Steam Engine Indicators are of very great interest to engineers and steam users generally, and we cannot too strongly recommend their perusal to all interested in such matters.

PHOSPHOR LEAD BRONZE.—Mr. Moss of Cheapside, London, is introducing a new alloy into the market which is said to possess great strength and resistance to the effects of friction. The advantages claimed for phosphor lead bronze are—self-lubricating properties, tenfold wearing capacity of any other metal or alloy, great tensile strength combined with extreme hardness, non-liability to fracture, keeps perfectly cool under continuous and excessive friction. These qualities, it need hardly be said, are those most necessary for bearings and bushes of every description, guide blocks, slide valves and faces, piston rings, pinions, valves, etc.—*Boston Journal of Commerce.*

Second-Hand Boilers.

F. B. ALLEN.

It will, of course, be conceded that occasionally great bargains may be obtained in buying second-hand material. Such cases sometimes occur through the bankruptcy of large manufacturing companies, or from other business causes. In cases of this kind it is easy to find out who furnished the plant, the length of time it has been in service, and the manner in which it has been used, with perhaps satisfactory assurances of its present condition. Opportunities of this kind are few and far between.

Ordinarily, he who buys second-hand goods, realizes when it is too late, he has made a bad investment, but consoles himself in the thought of having obtained a valuable experience, in some cases dearly bought. The purchaser of a second-hand boiler is peculiarly liable to be victimized, and is not only in danger of losing his money— but in most cases runs an additional risk of losing his life.

Engaged in the business of buying and selling second-hand machinery are many honorable men, who, understanding their business, are careful to buy only fit and salable articles, and thus they avoid the necessity for misrepresentation in selling again. The dealer is not alone to blame for the gross misrepresentation sometimes made. The average buyer of second-hand machinery is not content to buy the article for what it really is, and his evident desire to be humbugged stimulates unscrupulous men, who in the trade are largely in the majority, to make a shrewd calculation as to the manner of man with whom they are dealing, and cook up a story most likely to serve their purpose. Many tricks are resorted to by the latter class of dealers to sell their second-hand boilers. It is doubtful if they ever handled anything that had been used over a year, and was not built by days' work, if we may believe their story. One of these worthies sold from his stock for several years, each customer being assured that particular boiler was one of a number made by him for a large and well-known manufacturing company in a distant part of the State, who when the boilers were nearly finished changed their plans, had him build larger boilers, and retain those first ordered. Tubular, flue, upright, and locomotive boilers were alike sold from that order, and for aught I know to the contrary, he may be filling orders yet from the same mythical stock.

One of our assured who had just bought a *new boiler* under some such representation, notified us to make an inspection before he began using it. In the report of inspection, after describing the location of certain defects, there was a further recommendation from the inspector as to the best means to be employed in cleaning the boiler of scale. Our friend did not understand how a new boiler could have so many defects, and his astonishment and indignation were further increased when he read that part of the report concerning the removal of scale. He returned the report to our office with what was meant to be some very caustic comments, ironically suggesting that he must have, by some mistake, received somebody else's report. It could not refer to his boiler, for it had never been used before. He was sure of that. It had to be finished after he bought it.

On investigation it transpired the *alleged* new boiler had not only been used for a number of years, but it had been grossly abused by firing up on it without any water, and burned so badly it was thought unprofitable to repair it by the boiler-maker, who sold a new boiler in its stead. The burned boiler next passed into the hands of a second-hand dealer for about the price of old iron. He had it repaired, shortening it up by cutting off the worst ring of plates. In setting it up again in the brick work, it was thought advisable to turn the boiler end for end. This, of course, left new holes to be drilled and tapped in the boiler head for gauge cocks, water gauge, &c. This was the proof relied upon by our friend to convince us, as it did him, that the boiler was a new and unfinished one at the time he purchased it. He now realizes the truth of the old adage which teaches "appearances are sometimes deceptive," and feels it has a special application to that class of boilers.

In second-hand boilers the accumulation of sediment and scale on some inaccessible part during a period of years, greatly reduces the value of its heating surface. Therefore such boilers are necessarily more expensive in fuel than the new ones. In some localities where fuel is abundant and cheap, the matter of economy is of little importance. As a rule, boilers are only removed for some sufficient cause affecting their safety or economy, and they will be found on examination, when this is the case, fatally defective in some important particular. It may not be an easy job to make a careful examination of a boiler after it has been scraped and heavily painted. The most careful, painstaking examination under such circumstances, may be very unsatisfactory in failing to detect incipient fractures in the sheets, the first external evidences of crystalization. The paint pot imparts a freshness and bloom of youth to the jaded boiler of twenty years' service, that is well calculated to stagger one's belief in "wear and tear," and doubt if there is any such thing as "fatigue in metals."

The poorest (?) specimens of second-hand boilers in this market are bought up and shipped to Mexico and Cuba; at least, the buyers report that as their destination. In view of recent disclosures it's not beyond the range of possibilities that the patriots who disburse (if they ever do) the "Irish Skirmishing Fund," may be surreptitiously buying these deadly instruments for shipment to England, Canada, or Australia. The attention of the proper authorities is most respectfully called to this view of the case. In conclusion we cannot, perhaps, do better than to advise readers of "The Locomotive," who contemplate buying second-hand boilers, to have them first examined by some competent authority. When this necessary precaution cannot be exercised, we commend to them the admirable advice of "Punch" to those who were about being married — "Don't."

A peculiar case of "Bagging."

INDIANAPOLIS, IND., August 31, 1881.

To the Editor of The Locomotive:

On the 26th of last November I was hurriedly called upon to inspect a steam boiler at the above place. The circumstances were these: A new grain elevator had been built, and everything was ready to start it up. About 150 cars of grain were on the track, awaiting their turn to be taken in and stored. A fire was made under the boiler, and when the gauge registered 60 lbs. the engine was put in motion; as soon, however, as a brisk fire was called for, an unusual circumstance took place, a violent leakage started over the fire. The engineer had the fire drawn, and discovered that the first two plates over the fire space had sagged downward. Boilermakers were fetched, and were puzzled, as the plate did not show any signs of unfair treatment. They caulked the leaky places, and made her tight, the fire was started again, the engine put in motion, with precisely the same result. After due consultation with experienced boiler-makers and engineers, it was thought that there was something in the quality of the iron of which the boilers were made which caused the trouble, together with the fact that the slide valves of the engine had so little lap that practically there was no cut off. It was, therefore, decided to alter the slide valves and give them some lap, and take out the two defective plates over the fire, and patch with new plates of C. H. No. 1 iron. This was accordingly done; the fire was made a third time with fear and trembling; the engine started under manifest alarm, for all had lost their confidence, and feared, they knew not what, possibly an explosion. Well, strange to say, as soon as the engine was started and the fire urged, the very same phenomena occurred, the plate hung down like a bag, but did not tear away from the boiler, the seams becoming loose and leaking over the area of the fire space. Now, it will be observed that the trouble did not occur until the engine was started; and that as soon as the steam began to go down and the fireman urged the fires to keep it up, that then the boiler failed them. It was, therefore, decided that the trouble lay in the engine, and wise heads looked grave and learned; and after an ominous shake declared that his satanic majesty was in the engine. I ought to have said, that before the last trial it was deemed advisable to procure a portable boiler and connect it with the offending one to help it. But if the d—l was in the engine, he spent his infernal wrath on the same boiler as before, and took no notice of the auxiliary boiler. The whole of the above experience covered the space of two or three weeks, when all concerned gave up the contest. The writer was then called, and after surveying this remarkable case in all its bearings, came to this summing up: that the trouble arose from a combination of unfavorable circumstances, any one of which, alone, would not have caused the mischief.

1. The engine, owing to the disproportionate construction of its valves and valve-gearing, was prodigal in its consumption of steam, and justly charged with being a fire eater.

2. The boiler was rather small for the work it had to do, and

3. To make up for this the fire area was large, and

4. To make the fire intense the draft was excellent.

5. The steam dome was small for the want of a greedy engine, and unwisely placed: plumb over the fire.—this combined with a rapid exit of steam, caused unusual priming, this in turn interfered slightly with the specific gravity of water.

6. But worse than all, the tubes were crowded in so close together, that the "circulation" of the water was impeded, and did not reach the plate over the fire in time to keep it from injury, and would undoubtedly have caused a bad explosion, had not the engine been promptly stopped, and the fire as promptly drawn, thereby stopping the generation of steam, and allowing the water to fill the chamber below the tubes, which were also too small. I ordered two new boilers, with a capacious drum over them, and in a month had one of them at work, and since that time have worked them alternately with the same engine with the best results.

Yours truly,
HENRY COKER.

It has apparently remained for electricity to disturb the traditions of that peculiarly English institution, the treadmill. The latest move is to utilize the wasted energy of English prisoners — energy that has hitherto had for its ultimate object "making the wheels go around." With this purpose in view, E. B. G. Jenkins, F. R. A. S., proposes that a Gramme machine be geared to the treadmill, and the energy stored up in the form of electricity by means of a Faure accumulator. In the event of the success of this enterprise, our own genial countryman may feel called upon to give us a new version of the "Song," a proceeding to which there will probably be no objection.—*American Machinist.*

A daily paper thus proceeds to cast reflections on one of the prime mechanical powers: Many a bad man rests the lever of hypocrisy upon the fulcrum of religion to help him raise the devil.—*American Machinist.*

The Collapsing of Marine Boiler Furnaces.

The following report by Mr. William Parker, the chief engineer surveyor to Lloyd's Committee, is of much interest and deserves careful attention. We shall shortly have something more to say on the subject with which it deals.

LLOYD'S REGISTER OF BRITISH AND FOREIGN SHIPPING,
2, WHITE LION-COURT, CORNHILL, E.C.
January 3, 1880.

Sir. — In accordance with your instructions, I attended at Hartlepool, on the 29th of December, for the purpose of investigating the cause of the apparently mysterious collapsing of the furnaces of the boiler of the screw steamer Roumania, which had arrived at that port a few days previously.

This vessel, which was launched only a few months ago, is the property of Mr. W. Gray, of West Hartlepool, and has been employed chiefly in the Mediterranean and Black Sea trades. She is fitted with a double-ended boiler made by Messrs. Thomas Richardson and Sons, of Hartlepool, who are also builders of the engines. The boiler is 11 feet 4 inches in diameter, and 14 feet long, with four furnaces, two at each end, of 39 inches outside diameter, and 4 feet 9 inches in length, the thickness being $\frac{7}{16}$ inch. The furnaces are made in two plates having lap joints about 9 inches below the top of the firebars, and were made perfectly cylindrical. The two combustion chambers are common to both the forward and after furnaces without any division between them. The relative proportions of grate surface, heating surface, steam space, etc., are such as to render it an excellent steaming boiler, and no fault whatever could be found with its design, which is in accordance with the requirements of the Society's rules to work at a pressure of 85 lbs. per square inch, for which pressure all the parts are amply strong. It appears that during the vessel's last voyage from Cardiff to Odessa the whole of the furnaces collapsed in succession, the first one came down after about five days' steaming when the pressure was about 83 lbs. per square inch, and was repaired at Lisbon, and the vessel proceeded on her voyage. On returning from Odessa this same furnace and another one gave out after 14 days' steaming under a pressure of 75 lbs., while the two remaining furnaces collapsed about five days afterwards when the steam pressure was only about 50 lbs. per square inch. The engineer stated that after each collapse the water in the boiler was changed, and the boiler run up with salt water. It is to be regretted that samples of the water that was in the boiler when the collapse occurred, and of that which was in use when the vessel arrived were not preserved, as an analysis of the same would have cleared up an important point in the case.

A careful examination of the furnaces showed that the damage to one furnace varied from another, only in the amount of depression of the indented parts, and the appearance of the plates being similar, it was evident that the collapse was caused neither by shortness of water nor accumulation of salt or scale. And any suggestion of structural weakness having caused the accident was entirely out of the question, as a furnace of the dimensions of those in this instance should be capable of standing in its cold state an ultimate collapsing pressure of about 550 lbs. per square inch without showing any signs of weakness. So long, therefore, as the temperature of the plate did not far exceed the temperature of the water inside the boiler, the furnaces should have remained perfectly cylindrical under the approved working pressure of 85 lbs. per square inch. But it was observed that the furnaces, tubes, shell-plates, and all the inside of the boiler were covered with a black gluey coating of what appeared to be the refuse of the oil used in the lubrication of the cylinders. From the statement of the engineer, it appeared that at least half a gallon of Crane's mineral oil mixed with olive oil had been used each day for this purpose, and that neither the scum-cock nor the blow-off had been opened while steaming. With the view of ascertaining how the deposit would affect water boiling when placed in direct contact with the surface of a plate, I suggested that an experiment should be made at the works of Thomas Richardson and Sons. Two dishes were made from boiler plate of the same thickness as the furnace plating of the boiler of the vessel; the inside of one was coated with a portion of the deposit, whilst the other was left clean; half a pint of fresh water was placed in each, and they were placed on the same fire, and the blast applied. The water in the clean dish commenced to boil in 25 seconds but the water in the dish with the coating did not begin to boil until one minute and 25 seconds had elapsed, by which time the contents of the first dish had entirely evaporated. This experiment was repeated with the bottom of one dish covered with sand instead of the deposit, but no appreciable difference was observed between the sand-covered and the clean dish as regards time taken in boiling. A subsequent experiment showed that when the density of the water in the pan became greater, the deposit which had been placed on the bottom gradually mixed with the water, and eventually rose to the surface. The results of these simple experiments would seem to indicate that the deposit found in this boiler is a great non-conductor of heat when placed in direct contact with the surface of iron plates, and might be sufficient to account for the plates becoming heated and softened to such an extent as to be unable to resist the external pressure, and so collapse ensue, either shortly after steam has been raised or when the vessel has been steaming for some days. In the latter case, it would appear that in a boiler having large quantities of the refuse, this latter, which when steam was lowered would fall to the bottom of the boiler, remains there undisturbed, until by frequent extra supplies from the sea, the density of the water in the boiler is increased, when the sediment gradually ascends and mixes with the water, imparting to it, especially in the narrow water spaces between the furnaces, a consistency so great as to be incapable of absorbing the heat, the ultimate collapse being then only a question of time.

In order to avoid such accidents in future I would recommend that:

(*a*) More care be taken in cleaning the boiler.

(*b*) Much less oil than half a gallon daily be used for lubricating the cylinders of an engine of this power, and

(*c*) Nothing but pure mineral oil be used.

I would also suggest the desirability of occasionally scumming, which has for some time been greatly abandoned in high-pressure boilers.

I may further add that this is not the first case that has come under my notice of furnaces collapsing in a somewhat mysterious manner.

The particulars of each case as far as obtainable are being carefully noted as they occur, and it is to be hoped that we may eventually be enabled to arrive at a conclusion which will satisfactorily account for the varying circumstances under which collapses have occurred.

The principal difficulty is to secure perfectly accurate and reliable information of the surroundings of each case.

I am, Sir, your obedient servant,

WILLIAM PARKER,

Chief Engineer Surveyor.

— *Engineering.*

The British war vessel "Imperieuse," to be built at Portsmouth, it is said "will not resemble any vessel afloat." The cost of her hull alone is to be £325,000. Her length is to be 315 feet, with a beam of 61 feet. The guns will be 18-ton breech loaders, with a "disappearance arrangement." Engines are to be 8,000 H. P. If she ever comes into action, and encounters one of Capt. Ericsson's torpedo vessels, of the kind we illustrated and described in issue of Sept. 24, the "disappearance arrangement" will be suddenly and alarmingly facilitated. — *American Machinist.*

The Secret of Boiler Explosions.

And now somebody else has found out the grand secret. It isn't a "wedge of steam" this time, but simply "gas," and nothing else. We have all along suspected that there was more or less "gas" generated in *accounting* for explosions, but never dreamed that it was the cause of "nine-tenths" of all explosions which take place, but such it seems is the case if we are to believe the statements made by an "old engineer" (?) of Louisville, Ky., who claims to "know all about it." We will give a few extracts from his theory as published in one of our contemporaries. He says: "My boiler was a single flue boiler, 38 inches diameter, 16 feet long, made in 1818, of $\frac{3}{16}$ inch iron, and placed on the steamboat Tennessee, which sunk in the Mississippi river, in 1824. It lay slumbering in said river 15 years, and was then resurrected and brought to Louisville, and I traded a new cylinder boiler for it, weighted it to carry 120 pounds of steam, and worked from 70 to 100 pounds pressure on piston to do my work." Let us see about this. If his judgment was at fault in fixing his pressure at 120 pounds per square inch on such a boiler as this, he *may* be at fault in some of his other statements. Let us assume in the absence of correct data, 45,000 pounds per square inch as the tensile strength of the iron of which his shell was composed. Then we have $(45{,}000 \times \frac{3}{16} \times .56) \div 19 = 248$ pounds per sq. in. for the bursting pressure of the shell, supposing it to be in as good condition as it was when it was new, which would hardly be the case after it had been running six years on a western river boat, and "slumbering" 15 years more at the bottom of the Mississippi. The reckless use of the boiler would seem to indicate that his statements should be taken with the same caution which we should exercise if we were compelled to approach within a thousand feet of his boiler, when he had on 120 pounds pressure. He continues: "About 10 o'clock I noticed my engine working with increased speed — the governor did not have any control of the engine. I supposed the fly-valve was loose, and throttled the engine, but found upon examination that the valve and governor were all right. I then looked at the safety-valve; raised the valve and *gas of a grey color escaped from one side of the valve and steam from the other.* In about five minutes my engine commenced to run away with its work."

We don't blame the engine. If we had an engine that wouldn't run away from such a boiler with 120 pounds of steam on, with "steam escaping from one side of the safety valve and gas of a grey color from the other," we would never give it another cylinder-full of steam as long as we lived, but we shouldn't expect to live a great while in the vicinity of *that* boiler under such circumstances. He then says: "I throttled down to 90 revolutions per minute, and then tried my safety-valve; found no steam in the boiler. (The "gas of a grey color" had evidently got the start of the steam.) Next opened the flue-cap; all right in flue. Next opened fire doors; found a moderate fire, boiler all right, no appearance of any extra heat. I then tried my gauge cocks and found no steam, but gas of a dull brick-red color escaped, which had a sweet sickish smell. The boiler seemed to have a fine tremble and gas was spitting out all over the boiler, between the rivets." Here was where the boiler was level-headed. We should think that any boiler with any sense whatever would "spit out" all over if it was filled almost to bursting pressure with "gas" "which had a sweet sickish smell." This seemed to be a pretty good day for gas. It must have been very embarrassing for the boiler, however, to be discharging grey gas from one side of the safety-valve, steam from the other, and brick-red gas from the gauge-cock and through the shell "*between the rivets.*" We don't wonder it had a "fine tremble." We would have had one ourselves undoubtedly if we had "been there," at any rate we would have trembled for our safety, and naturally suppose the boiler did the same: more especially as it had just been aroused from its 15 years' "slumber." And right here we would respectfully suggest that *perhaps* the gas which escaped through the gauge-cocks would not have had a dull brick-red color if the boiler had not been "slumbering" (or *corroding*) so long on the bottom of the "said river," etc.

Further: "I let on a full head of water to the force-pump, which was throwing twenty gallons per minute. I detached the mill from the engine and run the pump by the gas in the boiler. The engine after a few minutes showed signs of getting tired." Poor engine! What terrific exertions it must have put forth to run "on gas." We don't wonder it got "tired." He continues: "I raised the throttle and let the engine have all the gas in the boiler, and after running about three minutes it slowed down to about 55 per minute (notice how exact he is regarding the speed), stopped short and made half revolution back. . . . . The gas had disappeared from the boiler suddenly, leaving a partial vacuum. Had there been any steam or vapor arising from the hot water in the boiler, there could have been no vacuum formed in the boiler." How strange that the gas should "disappear suddenly" after he had "raised the throttle and let the engine have it all," thereby running several minutes. And what conclusive evidence of the presence of "gas" is contained in the fact that there was "no steam" in the boiler after he had wet down the fire, opened the throttle-valve wide open, and thrown cold water into the boiler for several minutes at the rate of twenty gallons per minute.

But we have no space to comment further, and we presume most of our readers have seen the article in question, and laughed at its absurdity. It certainly is interesting as showing the incompetence and ignorance of men, who, in many instances are put in charge of steam boilers, and fairly illustrates the style of ideas current regarding boiler explosions generally.

A New Submarine Vessel.—A young Roumanian engineer, Trajan Theodoresco, has succeeded in constructing a submarine vessel which puts everything that has gone before in submarine navigation completely in the shade. This boat, up to a certain maximum size and corresponding tonnage, it is said, may be navigated under water for twelve hours at a stretch, at a depth of 100 feet; she may, however, according to the inventor, be lowered to over 300 feet below the surface of the water, and without coming into contact with the atmosphere. On the surface of the water the vessel may be manœuvred under the same conditions as an ordinary steamboat. Her speed, however, is not so great as that of steamers, but greater than that of sailing vessels. The submersion is effected by screws and vertically, either suddenly or successively, and the vessel is raised in the same way. If once under water, sufficient light is supplied enabling those on board to see all obstacles at all distances up to 130 feet, and the movements of the boat may be so regulated as to avoid them. The air supplied for the crew is said to last for from twelve to fourteen hours. In case of need, the reservoir containing the air may be refilled, while under water, for another twelve hours, pipes telescoping into each other being directed to the surface for that purpose. The propulsion of the vessel and its submersion are stated to cause no noise. Should all these particulars prove correct, the novel boat will be the most formidable vessel for torpedo warfare. But she may also be turned to more useful purposes. In the Matchin Canal, near Braila, there lies, since May, 1877, the "Lutfi Djelit," which had on board the war-chest of the Turkish Danube flotilla, amounting, so report says, to several million piasters. It might be possible to recover that sum by means of the new submarine boat, and if the experiment should prove successful, it would at the same time be profitable.—*Van Nostrand's.*

The Locomotive.

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NEW SERIES — VOL. II. HARTFORD, CONN., OCTOBER, 1881. No. 10.

The Explosion of a Badly Corroded Flue Boiler.

The accompanying cut represents the appearance of a boiler which exploded at the Pendleton Fire Brick Works, at Rochester, Pa., on the 28th day of August last.* The

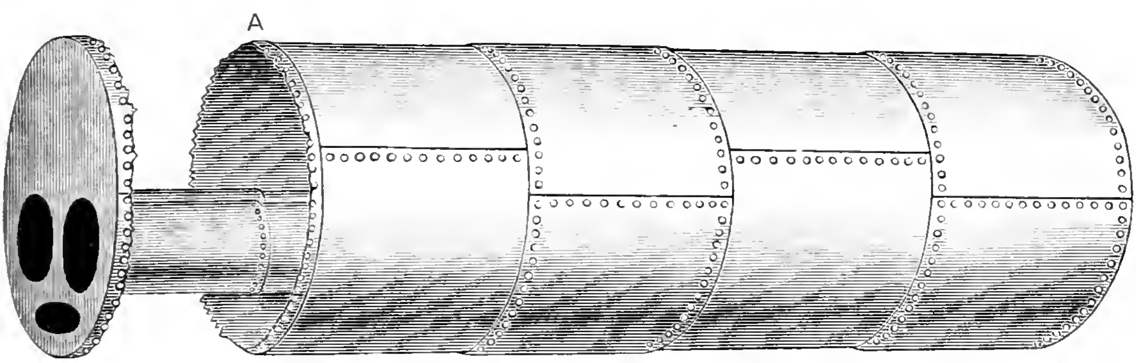

FIG. 1.

immediate cause of the explosion was the badly corroded condition of the sheets on top of the shell. The initial rupture occurred at the point marked A, Fig. 1, and extended circumferentially entirely around the shell, the portion blown out having the appearance shown at Fig. 2.

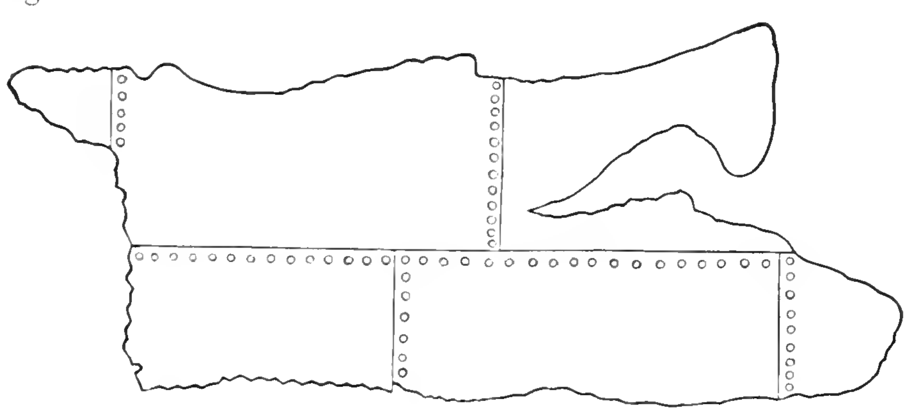

FIG. 2.

Fortunately no one was injured, but the occurrence is a good illustration of the dangers which arise from neglecting the general condition of boilers, and allowing corrosion to go on unchecked until the strength of the shell is destroyed.

The primary causes of corrosion are various. It may attack the exterior surface of boilers and eventually destroy them if it is not arrested. It may arise from contact with lime, contained in the setting, or from dampness, especially when the shell is supported directly on a brick wall which is liable to be wet from any cause whatever. This is particularly apt to be the case when boilers are supported on a "mid-feather" as it is called, which is a wall extending nearly the whole length of the shell underneath, and on which the boiler rests.

* These facts and sketches were furnished us by Chief Inspector A. C. Getchell, of the Cleveland, Ohio, department.

Boilers set in this manner almost invariably corrode on the bottom where it rests on the supporting wall, and as that portion cannot be seen without removing the bricks, it is almost certain, unless the brickwork is periodically removed, to go on undetected until the shell becomes dangerously weak.

In a recent case where a boiler exploded killing 16 persons and severely injuring 11 others, the report of the inspector, who viewed the wreck, says: "The plates at the back end of the boiler, which were originally three-eighths of an inch in thickness, were wasted away by external corrosion for upwards of four feet in length, where resting on the right hand seating wall till only one-eighth of an inch remained, while in some places they were as thin as a sixpence." It further appeared that the external brickwork flues were damp, and the boiler was twenty-five years old, and had never been inspected by a competent person.

External corrosion may also be caused by wet ashes or soot remaining in contact with the shell when the boilers are cold, therefore it is of very great importance that boilers that ever remain idle for any length of time, which, for instance, is the case with most boilers used for heating purposes, should be thoroughly cleaned externally when they are stopped, and not left, as most of them are, half smothered in ashes and dirt of all kinds. In a case which recently came under our notice of three boilers in a large manufacturing establishment, which were used for heating the shops in the winter, it appeared that the usual cleaning-out of the flues had been neglected longer than usual the preceding spring, "because the boilers were going to be stopped when the weather got warm." It is needless to add that they were not cleaned *then*, and they presented a very sorry appearance indeed, being almost entirely filled with ashes, and a damp coating of the same, about an eighth of an inch thick, adhered to the shell, underneath which corrosion was going on very rapidly. We were not surprised to be told by the superintendent that "the boilers were very poor steamers, it being impossible to get more than 20 pounds of steam with hard firing." The only surprising thing about the whole matter was that with the flues choked up as they were, he could get even that pressure.

External corrosion also occurs wherever there is leakage of water, whether at a seam or around manhole or handhole openings, which occurs very frequently indeed, and is the result of carelessness in replacing the coverings of the above-named openings. This is particularly apt to be the case with the back handhole in horizontal boilers, and we know of many places where it is quite the usual thing to have severe leakage around the plate until corrosion has gone on long enough to "take up" the leakage.

Corrosion arising from any of the above-mentioned causes, is entirely inexcusable, and can always be prevented if ordinary care is exercised. Boilers should never be seated directly on brickwork. If it is necessary to support them on walls directly, as in the case, for instance, of drop-flue boilers, which rest on the end walls of the setting, some non-corrosive substance should always be introduced between the brickwork and shell. Putty, or red lead, is an excellent substance for this purpose, and can always be obtained easily and cheaply; a good coating should be applied to the seating-wall, and a much better bearing can thus be obtained than by placing the shell directly upon the bricks.

Where corrosion is caused by contact of the shell with damp ashes, there is obviously but one remedy, and that is a very simple one, namely: keep the shell clean. In some cases, where boilers lie idle for a season, and the flues are damp from any cause, it may be necessary after cleaning the shells to give them a coating of red lead and oil; this will be found to be very effectual in preventing corrosion.

Leaky seams should always be caulked up tightly, as this is one of the most dangerous forms of corrosion, inasmuch as it attacks a part of the shell already greatly weakened by cutting away the metal for the rivet holes, and consequently any further deterioration cannot be afforded, especially if it attacks the longitudinal seams. This is an important matter, and no boiler-owner or user can afford to neglect it under any circumstances.

Corrosion from leakage around man or hand holes can always be prevented by using due care in replacing the plates after they have been removed. We would especially call attention to the importance of removing every portion of the old gasket whenever these plates are removed, as, unless it is done, there is always danger of leakage unless they are screwed up so tightly as to endanger the frame around the opening, if it be of cast iron, as is generally the case with manholes. One of the most destructive explosions that has occurred lately was caused in this manner. The manhole plate was removed for the purpose of making some repairs, the old gasket was not more than half removed, and when steam was raised after replacing it there was considerable leakage, and two men applied a wrench to the nut and screwed it up. Failing to stop the leak in this manner they increased the length of the wrench by putting a piece of gas-pipe several feet long on the handle, and again exerted their strength. They succeeded in stopping the leak in this manner but fractured the manhole frame, and the boiler soon afterwards exploded, killing several persons and doing much damage.

The causes of internal corrosion are generally more obscure and more difficult to combat. It is usually due to the chemical action of the feed water, combined with the mechanical action resulting from the strains produced by the steam pressure, and expansion and contraction due to heating and cooling.

Internal corrosion may show itself in several distinctive ways. It may appear in the form of general or uniform corrosion, pitting, and grooving. By uniform corrosion is meant that form of wasting of the plates and tubes, where the action of the feed water corrodes them in a comparatively even or uniform manner, in large patches, and generally has somewhat the appearance of ordinary rusting, although seldom quite so uniform in its effects. It can generally be discovered easily by inspection, where there is no incrustation, and in some cases where there is incrustation its presence is revealed by red streaks where the scale is cracked. But in some cases where the patch of corrosion has no sharply defined limit it requires an experienced inspector to discover it, and even then its depth can often be discovered only by drilling a small hole through the plates or tube, and accurately measuring the thickness of metal which remains.

The only way to prevent this kind of corrosion is to change the feed water, or introduce some substance into it which will neutralize the injurious effect of the acids contained in it.

Grooving or channeling as it is sometimes called is generally the result of combined mechanical and chemical action. It attacks the angles of flanges, and is frequently found running along parallel with, and close to, the edges of the plates in lap joints. It is caused in the first instance by the buckling action at the angle of the flange which injures the grain or fibres of the iron, and allows the acids, always present to a greater or less extent in fresh waters, to readily attack it. This action is often induced and aggravated by too sharp flanging, by which the metal of the flange is permanently and seriously injured.

Obviously the best way to guard against this form is to have flanges made with as large a radius as possible, so that the iron may not be unduly strained in bending. This, however, is a matter generally left to the judgment of the boiler-maker, and the only way the steam user can guard against it, is to have proper specifications made and see that they are carried out faithfully.

Grooving is also very liable to attack the shells and furnaces of internally fired boilers, in the water space around the furnace, when the latter and the shell are riveted to a thick ring, as is generally the case with small upright portable boilers. Such boilers should never be made without a sufficient number of hand holes in the shell to allow every part of the joint inside to be reached, so that the fault may be detected if it exists. Even then in many cases it can only be discovered by examination with a blade of a penknife or some similar sharp pointed instrument.

There can be little doubt that internal grooving is, in many cases, induced by reckless caulking, by which the outside skin of the iron is destroyed, and the interior exposed to the action of the corrosive agents in the feed water. That this is so can be seen by examining the shells of new boilers, where, in many instances, a groove may be found running along the edges of the plates, where they have been caulked, anywhere from a sixty-fourth to a thirty-second of an inch in depth.

As a general rule, external corrosion may be regarded as more dangerous than any kind of internal corrosion, because it is often impossible to discover it from the inaccessibility of the plates where it occurs. Boilers should always be set, if possible, so that every part of the shell may readily be seen without removing a great mass of masonry, or even stopping the boiler.

Inspectors' Reports.

AUGUST, 1881.

Below will be found the one hundred and seventy-ninth monthly summary of the work done by the inspectors of this company. The total number of visits of inspection made during the month of August last was 1,815, and the whole number of boilers inspected was 3,539. Of this number 1,289 were thoroughly examined both externally and internally, and 419 others were subjected to the hydrostatic test.

The whole number of defects found was 1,414, of which number 388, or nearly 28 per cent., were dangerous. The detailed statement of defects is as follows:

	Whole Number.	Dangerous.
Furnaces out of shape,	116	46
Fractures,	140	88
Burned plates,	91	16
Blistered plates,	186	17
Cases of deposit of sediment,	161	31
Cases of incrustation and scale,	275	26
Cases of external corrosion,	107	30
Cases of internal corrosion,	64	15
Cases of internal grooving,	4	3
Water gauges defective,	33	12
Blow outs defective,	35	22
Safety-valves overloaded,	18	8
Pressure-gauges defective,	121	33
Boilers without pressure-gauges,	40	
Cases of deficiency of water,	21	20
Broken braces and stays,	32	19
Heads defective,	1	1
Mud drums defective,	1	1
Boilers condemned,	19	19

The monthly statements of work done by the company's inspectors will probably be passed over without any very serious consideration by most people, but to any one interested in the use of steam (and who is not, either directly or indirectly?), they must prove of more than ordinary interest.

To most non-mechanical people, the word *inspection* will probably convey a very vague idea of what competent boiler inspection really is, or the amount and kind of labor involved in it, and judging in the light of our experience, we venture to say that many professedly mechanical people have very limited ideas of the nature and importance of the work involved.

The use of steam boilers has now become so general, and they are so often seen working with every appearance of safety, on railroads, on steamboats, in manufacturing establishments, and many other places, that people generally are apt to forget the dangers attendant upon their use, if they are faulty, either through improper design or bad workmanship, or have become so through long or improper use.

The destruction wrought by the explosion of a steam boiler is generally so great that people unacquainted with the nature and extent of the forces involved, are easily impressed with the idea that some mysterious and unknown force has been suddenly brought into play, and thus have arisen numberless theories regarding the influence of electricity, the generation of mysterious explosive gases, the spheroidal condition of water, and so on, ad nauseam.

A very little consideration will enable any one to realize that there is plenty of force stored up in a steam boiler, working under ordinary circumstances, to account for all the violence of an explosion, if it be liberated suddenly, and that it is wholly unnecessary to have recourse to any theory of mysterious forces to account for it.

"A boiler of average size contains, when at work, sufficient accumulated 'force' in the shape of steam and heated water, to work a 30-horse-power engine for about 10 minutes without additional firing, and if this should be liberated *in one second*, by the rupture of the boiler, the power to cause explosion would be equal to the united effort of 18,000 horses."

"It has been calculated that the explosive effect of each cubic foot of water in a boiler at 60 pounds pressure, is equal to that of one pound of gunpowder; so that in the above case there would be the same effect as from the explosion of about 500 pounds of gunpowder."—*Mr. E. B. Marten.*

An examination of the record of some thousands of explosions which have occurred during the last twenty years, shows that in nearly every instance the explosions have occurred from some fault, either of the boiler itself, or the management of it, and could easily have been prevented by inspection.

It is evident that the value of boiler inspection depends, the same as all professional work does, upon the intelligence and experience of the person who makes it.

The inspection of a boiler consists first of a careful examination of every detail of boiler, setting, connections, and fittings. The general arrangement of everything should be noted and well considered, and sufficient sketches and measurements should be taken to enable a complete detailed drawing to be made if necessary, and all defects should be carefully noted, whether of design or workmanship, as well as those that have arisen from use.

The boiler should also be entered through the manhole, and the interior thoroughly examined and sketches made and dimensions taken in detail, sufficient to enable drawings to be made.

The measurements and sketches could be made by any good mechanic, but the discovery of defects, with their cause, and suggestions for remedying them can only be made by an experienced inspector; one who is familiar with all kinds of boilers, their working and management, and the defects which they are most liable to from any peculiarities in design or setting.

Internal inspection is generally prevented by too small a manhole, or when it is so placed that it is impossible to get into it. Boilers are frequently set so that the manhole is but a few inches from the under side of a floor, and in some cases pipes are run over it so closely that it is impossible to twist into it in any way. It would seem that pecuniary considerations, if nothing else, would cause boiler owners to see that their boilers are not set in any such way, but such does not seem always to be the case.

But we have no space to comment further. Much might be written on the subject, but we will close by citing a short paragraph from an eminent authority on the subject of boilers and explosions:

"I submit that periodical inspection is the surest means of securing the safety of steam boilers. Also, that this inspection is a very good and useful safeguard, if only done by the man in charge; but that it is a still greater safeguard if done by independent inspectors, who have the experience of seeing many boilers, and are not influenced by the exigencies of the manufacturers for whom the boiler is used."

Boiler Explosions.

SEPTEMBER, 1881.

FIRE-BRICK WORKS (107).—A boiler at the Pendleton Fire-Brick Works, Rochester, Pa., exploded August 28th. Caused by a badly corroded shell. No one injured.

SAW-MILL (108).—The boiler of Captain Evington's steam mill at Oak Chia exploded Aug. 12th, with terrible results, killing the fireman and wounding several others. The cause of the explosion is attributed to the unfortunate man who was killed, who was drunk at the time. He had let all the water out of the boiler and then raised a hot fire in the furnace, when the over-tasked iron of the boiler gave way. It is said by some negroes that they heard the fireman make the remark just before the accident that "he was going to send that mill to hell." The fireman, Sheppard Walker, was torn completely in two parts; his head and upper part of his body were thrown about seventy-five yards, and his legs and lower part of his body about twenty yards further.

THRESHING MACHINE (109).—The boiler of a threshing machine exploded near Patoka, Ill., Sept. 3d. Six men were killed and some of them horribly mangled. Several others were seriously scalded.

STEAM TUG (110).—By the explosion of the boiler of the engine at Brown's dry dock, Jersey City, Sept. 13, Captain Decker and James Tammany, of the tug Glenwith, were instantly killed, and three others seriously injured. The pilot house of the tug was torn to pieces by the flying pieces of iron. A horse and car were cut to pieces, two large trees cut down, a lamp-post and hydrant smashed, and two wagons torn to splinters. John Smith had his sight destroyed, and was probably fatally injured. Engineer M. Quinn was badly injured and Engineer Eveson was also seriously hurt.

LOCOMOTIVE (111).—An engine on the Lehigh Railroad exploded near Packerton, Sept. 12th, throwing fifteen freight cars off the track, and slightly injuring the engineer.

SAW-MILL (112).—A boiler exploded in Card & Co.'s mill, near Monroe, Jasper county, Iowa, Sept. —, instantly killing E. N. Garnant, and fatally injuring M. L. Card.

MINE (113).—A fatal boiler explosion occurred near Dunbar, Pa., on what is known as the Hill farm, shortly after eight o'clock, Sept. 16. James McDonough was killed outright, and George McNally was frightfully scalded and thrown by the force of the explosion nearly 40 feet, lighting on a post, which made a severe wound on his chest. He will probably die. A number of others were burned and bruised, Charles Lynch and Wm. Nieman most seriously. The heavy iron support of the smokestack was blown off and cast over a hundred feet by the explosion. The true cause of the explosion is unknown.

LOCOMOTIVE (114).—A locomotive hauling a freight train between Chetopa and Parsons, on the Missouri Pacific road, exploded, Sept. 21, with great force, killing four men, and wrecking the engine and ten or a dozen cars. The killed were George G. Adams, engineer; Simon Bailey, fireman; John Denny, and a stranger named O'Neil. All were in the cab at the time, and were blown from one to two hundred yards distant, and terribly mangled. Bailey's head was blown completely off, and could not be found.

FURNACE (115).—A terrific boiler explosion occurred at the Keel Ridge furnace of Kimberly, Carnes & Co., at five o'clock Sept. 22. A thirty-foot cylinder boiler of a battery of four, tore apart in the middle and the two ends were thrown asunder with great force. One end struck the furnace stack and the other was thrown about one hundred and fifty feet, cutting through the bed of a stock car and snapping off the heavy timbers, finally bringing up against a railroad bridge abutment. But one man, Com. Watson, who was almost in front of the boiler when it exploded, was hurt. His left arm was broken by a flying missile. The mud drum giving away was the probable cause of the explosion. Loss several hundred dollars.

STEAM THRESHER (116).—By the explosion of a steam thresher on a farm at Thurlow, near Ottawa, Ontario, Sept. 23, four persons were killed, including a little daughter of the owner of the farm.

SAW MILL (117).—A boiler in Hoff & Holdman's saw mill, near South Traskwood, Ark., exploded Sept. 24. Hoff and two employés were killed and several others were wounded.

LOCOMOTIVE (118).—A boiler of a train on the Hastings & Dakota Division of the Milwaukee & St. Paul Railway exploded Sept. 26, near Prior Lake, while running 15 miles an hour. The engine was thrown 150 feet forward, and off the track, two cars being derailed. Engineer Grove Bradbury was thrown a considerable distance and died soon after. The fireman and Conductor Jones were slightly injured.

ENGINE (119).—A boiler used on the farm of Mr. George Taylor, at ——, N. C., exploded Sept. —. The engine was blown to atoms, and at a distance of two and one-half miles the jar was distinctly felt. Loss, $1,000. Cause unknown.

LOCOMOTIVE (120).—A locomotive on the New Jersey Central Railroad burst a flue Sept.—. No one was injured, and damage slight.

LUCIFERS BY THE MILLION.—Edward Prince, splint manufacturer, of Horseshoe Bay, Buckingham township, is authority for the statement that there are about twenty-two match factories in the United States and Canada, and that the daily production—and consequently daily consumption—is about twenty-two thousand gross per day. It may seem a queer statement to make, that one hundred thousand hours of each successive day are spent by the people of the two countries in striking a light, but such is undoubtedly the case. In each gross of matches manufactured, there are 144 boxes, so that the 25,000 gross produces 3,600,000 boxes. Each box, at least those made in the States, where a duty of one cent upon every box of matches is levied—contains 100 matches, so that the number of matches produced and used daily amounts to 360,000,000. Counting that it takes a second to light each match—and it is questionable whether it can be done in less time than that, while some men occupy several minutes sometimes in trying to strike a light, particularly when boozy—to light the 360,000,000 would take just that number of seconds. This gives 6,000,000 minutes or 100,000 hours. In days of twenty-four hours each it figures up to 4,166⅔, and gives eleven years and five months, with a couple of days extra, as the time occupied during every twenty-four hours by the people of North America—not figuring on the Mexicans—in striking matches. Figuring a little further, it gives 4,159 years' time in each year. The fact may seem amazing, but is undoubtedly correct.—*Ottawa Press.*

The Locomotive.

HARTFORD, OCTOBER, 1881.

Useless Tubes in Boilers.

In the early history of the horizontal tubular boiler the opinion prevailed that the more tubes that were crowded into a boiler the greater the efficiency. It was not uncommon to find the lower half of the boiler literally packed with 2½-inch tubes. They were put down as near the bottom and shell on the sides as the flanging of the tube sheet would allow. They were arranged in the boiler on what is known as the "staggered" plan; that is, instead of being placed vertically one over the other, they were so arranged that the tubes of one row were placed over the spaces of the row next below, and there was consequently no unobstructed spaces through which the water could circulate. But this was not the greatest difficulty. It is well known that most of the waters used in boilers carry more or less impurities in suspension, mechanical or chemical, and which are deposited in the process of evaporation. This may consist of

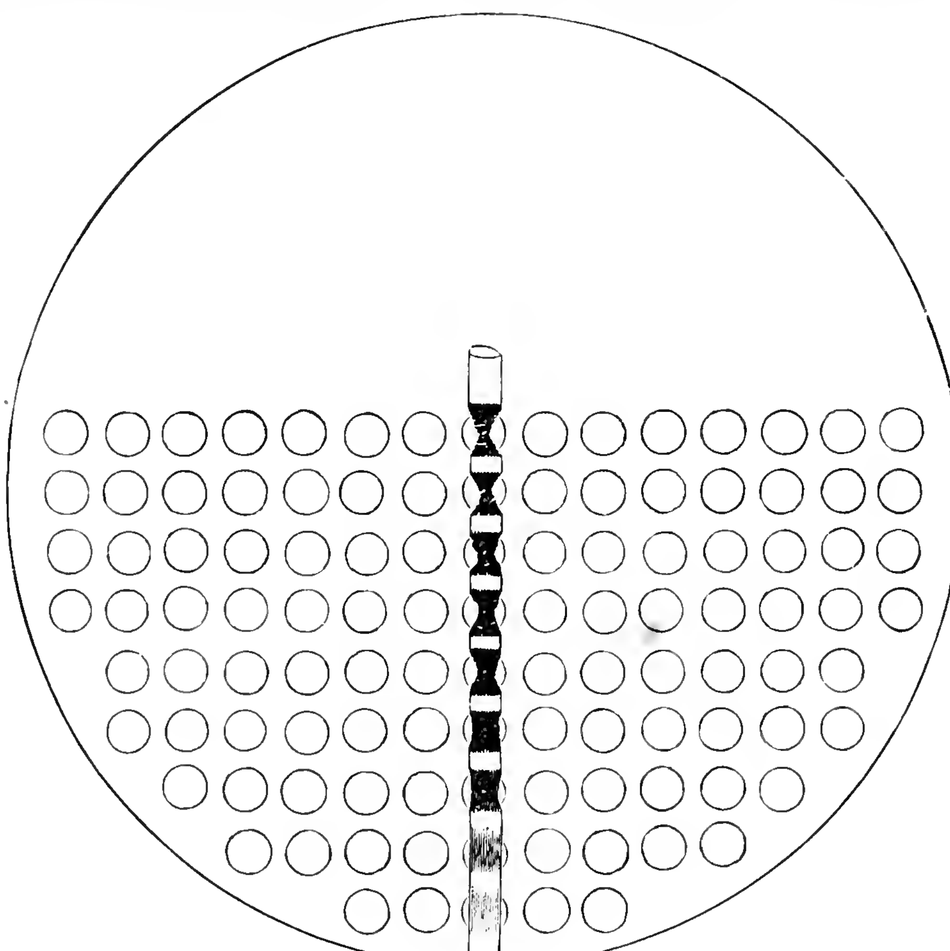

FIG. 1.

the carbonates or sulphates of lime or magnesia, or of argillaceous matter, or the deposit of mud arising from impure water in times of floods. All these deposits settle upon the bottom and tubes of boilers, and if frequent cleaning and very careful cleaning is neglected there will be formed on the bottom and among the tubes a very hard scale, which cannot be removed without removing the tubes. From this condition of things the efficiency of the boiler is very greatly reduced. The heating surface being covered more or less by a substance which is a non-conductor of heat, the heat, in passing over it, is not taken up, and so passes on and is lost. This condition of things was, in time, somewhat remedied by the introduction of tubes of larger diameter (3 inches), arranged in vertical and horizontal rows, but they were carried very near the bottom and sides of the shell, and the difficulty was only partially remedied. A great many boilers are made in this manner to-day, and it is a difficult matter to convince some boiler-makers that it is erroneous. Their argument is, "the more tubes, the more heating surface," and it must be said that manufacturers, in many instances, have the same views, and in ordering boilers require the excessive number of tubes. One object in view in preparing this article is to show that too great a number of tubes makes the boiler neither more efficient nor safe. It has been found by experiment that if the two lower rows of

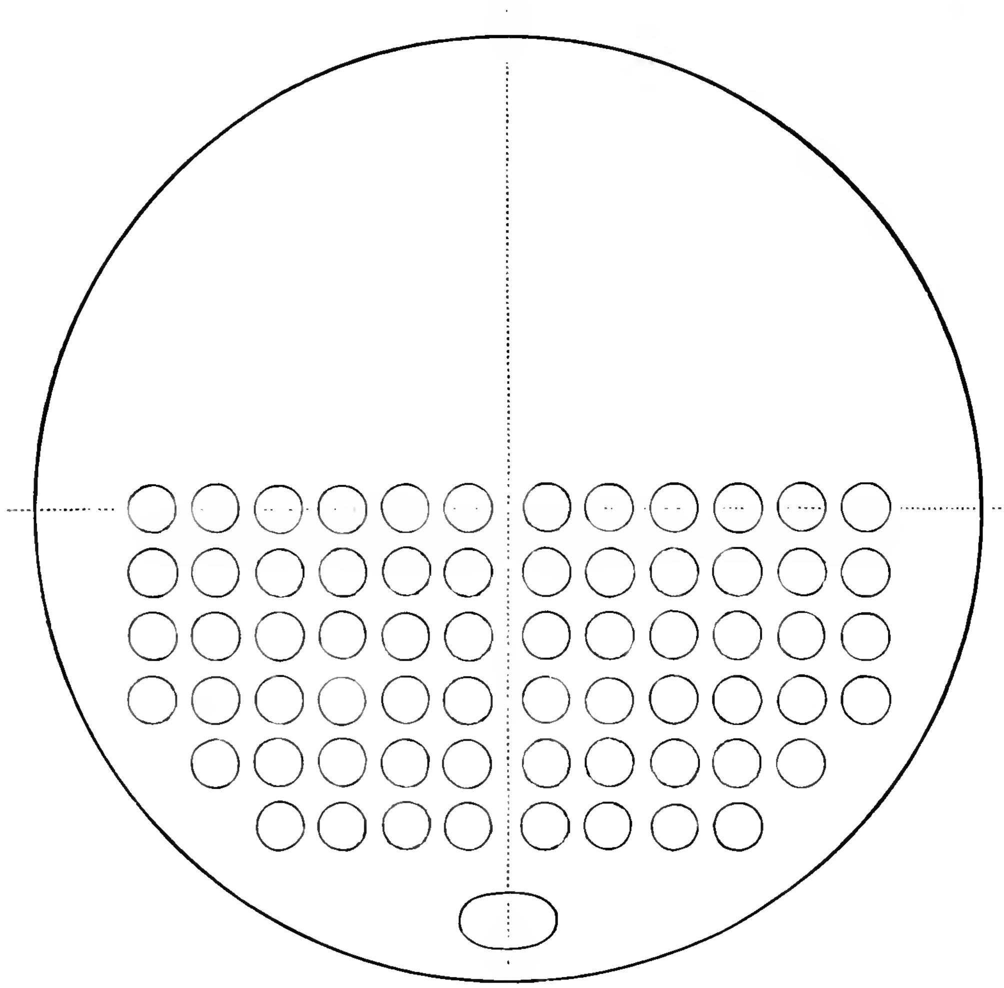

Fig. 2.

tubes in a boiler (where the tubes extend down close to the shell) are plugged up the efficiency is not impaired,—we are speaking now of externally fired boilers. By studying the progress of the heated gases as they leave the furnace, it will be seen that they pass over the bridge wall, and "lick" the bottom of the boiler its entire length, then turn upward at the rear end and enter the tubes. The levity of these heated gases carries them mainly to the upper rows of tubes, and only a very small portion enters the lower tubes. To demonstrate this in a way that will be understood by all, though it may not be regarded as occult enough for some of the mystic experts, a clean piece of soft white pine was placed at the front end of a boiler, nearly in contact with the ends of the center (vertical) row of tubes, as shown in Fig. 1. It was fastened so as to maintain its position, and left for several days. When examined it was found that the end of the stick in contact with the upper tube was burned to a coal, and barely held together: at the tube next below it was a little less charred, and the effects of the heat decreased towards the bottom, as shown in Fig. 1. Against the two lower tubes the wood was only a little discolored, showing that the upper tubes were most effective, while the very lowest were of little account.* But another fault in this arrangement of tubes is that, besides the trouble from deposit of sediment, there is no body of solid water for the heat to act upon as it leaves the furnace. In our experience we have found great difficulty with this arrangement of tubes, particularly when used with bad water. It gives a greater area of tube surface, but a considerable portion of it is useless and worse than useless, from the fact that the water space is unduly taken up by the superfluous tubes. Fig. 2 shows an arrangement of tubes which is far better. The lower row is well up from the bottom of the boiler, leaving a good solid body of water for the heat from the furnace to act upon. The tubes are kept well away from the shell of the boiler on the sides, no tube being nearer than three inches to the shell, and a space of double width is provided for between the center (vertical) rows of tubes. Good circulation is obtained, and the boiler is much easier cleaned and its maximum efficiency maintained. Other arrangements of tubes of larger diameter, and carried even higher up from the bottom, so that a manhole can be placed underneath, will be discussed in some future number.

Determination of the Efficiency of Large Cylindrical Iron Tanks.

BY JOHN D. CREHORE.

From Van Nostrand's Engineering Magazine.

Sometime in the spring of 1868, in Cleveland, Ohio, a new wrought-iron tank 60 feet in diameter, and filled with water to the height of 18 feet, burst and fell asunder. The thickness of the single riveted sheets composing this tank did not exceed three-sixteenths of an inch.

On the 29th of June, 1881, at Cincinnati, Ohio, a new iron water tank, 48 feet in height and 100 feet in diameter, burst at a point 12 feet or more from the bottom and fell asunder, when filled to the estimated depth of about 40 feet. The riveted plates of which this tank was made, ranged in thickness from half an inch at bottom to a quarter of an inch at top, as stated in *Engineering News* of July 9, 1881.

It would seem from the continued recurrence of such failures, that there is need of reiterating the teachings of the standard treatises on applied mechanics, or of emphasizing to parties interested, the necessity of having the right specifications made before constructing; and of insisting upon carrying out such specifications strictly in honest execution.

Not having the actual complete data required for determining the strength of these two particular tanks, I give the ordinary mode of finding the requisite thickness of both single-riveted and double riveted plates used in the construction of cylindrical tanks with vertical axes; and then apply the general expression to two cases where the diameters are 60 feet and 100 feet respectively.

Take 62.425 lbs. = weight of one cubic foot of water.
" .0361256 lbs. = weight of one cubic inch of water.
r = radius of cylinder base.
x = depth of water measured from surface.

Then the divellent force, due to water pressure, upon any elementary portion, or ring, of the height dx, is

$$dP = .0361256 \times 2rxdx.$$

* Our attention was first called to this experiment by the Honorable H. B. Bigelow, Governor of Connecticut, an extensive manufacturer of machinery and boilers.

Therefore, after integrating between limits 0 and P, 0 and x, we have

$$P = .0361256rx^2, \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)$$

which is the total force for the depth x, tending to send the sheets along any two diametrically opposite elements of the cylindrical surface.

But since this divellent force, for a given diameter, at a given point, varies with the height of water above that point, we have the simple formula

$$p = .0361256 \times 2rx, \text{ lbs.} \quad . \quad . \quad . \quad . \quad (2)$$

which is the intensity of bursting force at any depth x, if r and x are in inches.

For the inch of depth, next above the point x, we find from equation (1)

$$\Delta P = .0361256r[x^2-(x-1)^2] = .0361256r(2x-1) \quad . \quad . \quad . \quad . \quad (3)$$

as the total divellent force for that inch. Now, since equation (2) gives the intensity at the bottom of this inch, it should be used instead of equation (3).

To resist the force p, of the water, we have for each inch of the depth, two plates of the thickness t inches each, and able to sustain with safety a tension of T pounds to the square inch of cross section. Therefore,

$$p = .0361256 \times 2rx = 2tT, \text{ lbs.} \quad . \quad . \quad . \quad . \quad . \quad (4)$$

$$t = \frac{.0361256rx}{T}, \text{ inches,} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (5)$$

It is plain that the safe allowed inch-strain, T, depends upon the quality of iron, the mode of riveting, and the workmanship thereof. Following, with Rankine, the ordinary rules for riveted work to resist steam or water, we take :

"Diameter of a rivet for plates less than half an inch thick, about double the thickness of the plate."

"For plates half an inch thick and upwards, about once and a half the thickness of the plates."

Calling the ultimate resistance of good iron plates, to tension, equal to the ultimate resistance of rivet-iron to shearing, we ought to have for single-riveted sheets

$$ct - 2r_1t = \pi r_1^2$$

$$c = 2r_1 + \frac{\pi r_1^2}{t}, \quad . \quad . \quad . \quad . \quad . \quad (6)$$

where c=distance between centers of consecutive rivets in a row,

r_1=semi-diameter of a rivet,

t=thickness of a plate,

all in inches.

For double-riveted sheets,

$$c = 2r_1 + \frac{2\pi r_1^2}{t}, \quad . \quad . \quad . \quad . \quad . \quad (7)$$

When the sheets are less than half an inch thick, we have $r_1 = t$, and equation (6) becomes

$$c = t(2+3.1416) = 5.1416t, \quad . \quad . \quad . \quad . \quad . \quad (8)$$

for single-riveted joints ; and

$$c = t(2+6.2832) = 8.2832t, \quad . \quad . \quad . \quad . \quad . \quad (9)$$

for double-riveted joints.

When the sheets are half an inch thick and upwards,

$$2r_1 = \tfrac{3}{2}t, \ r_1 = \tfrac{3}{4}t,$$

$$c = t(1.5 + \tfrac{9}{16}\pi) = 3.2671t, \quad . \quad . \quad . \quad . \quad . \quad . \quad (10)$$

for single-riveted joints ; and

$$c = t(1.5 + \tfrac{9}{8}\pi) = 5.0343t, \quad . \quad . \quad . \quad . \quad . \quad . \quad (11)$$

for double-riveted joints.

The plates are weakened by the simple removal of iron from the rivet holes in the ratio,

$$\frac{c-2r_1}{c}=\frac{\pi r_1{}^2}{2r_1t+\pi r_1{}^2}=\frac{3.1416}{5.1416}, \quad . \quad . \quad . \quad . \quad (12)$$

$$\therefore\ T_1=15,000\times\frac{3.1416}{5.1416}=9,165$$

for single-riveted sheets less than half an inch thick. And

$$\frac{c-2r_1}{c}=\frac{3.1416}{5.8082}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (13)$$

$$\therefore\ T_1=15,000\times\frac{3.1416}{5.8082}=8,113,$$

thickness one-half inch or more.

Similarly for double-riveted plates, the value of T is virtually reduced in the ratio

$$\frac{c-2r_1}{c}=\frac{2\pi r_1{}^2}{2r_1t+2\pi r_1{}^2}=\frac{3.1416}{4.1416} \quad . \quad . \quad . \quad . \quad . \quad (14)$$

$$\therefore\ T_1=15,000\times\frac{3.1416}{4.1416}=11,379,$$

when $r_1=t$, and $t<\frac{1}{2}$ an inch.

But when $r_1=\frac{2}{3}t$, and t is not less than half an inch, T is virtually reduced in the ratio

$$\frac{c-2r_1}{c}=\frac{3.1416}{4.4749}, \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

$$\therefore\ T_1=15,000\times\frac{3.1416}{4.4749}=10,532.$$

The value of T, here taken for perfect unpunched plates, is one-fourth of 60,000 lbs., the assumed ultimate resistance of the iron as specified, thus rendering the so-called "factor of safety" equal to 4; whereas, in fact, 15,000 lbs. is doubtless a strain beyond one-half of that at the elastic limit, so that the real factor of safety here does not exceed 2.

From the *Cincinnati Commercial* of July 1, 1881, I quote the following extracts from the specifications for the large tank:

"The tank to be composed of twelve (12) rings of the best quality of fibrous boiler-iron plates of a tensile strength of 60,000 pounds to the square inch. The annexed tables give the required thickness and weight of iron in pounds per square foot and also the number, length, width, and area for all the plates for the bottom of tank and for each ring in the circumference of the tank."

"All the vertical joints in the first six (6) rings of plates from the bottom upwards, to be double riveted, known as "staggered" riveting: the remainder of the six (6) vertical joints as well as the horizontal joints in the bottom of the tank, to be riveted with a single row of rivets. The diameter, length, and pitch of rivets corresponding to the thickness of plates, and width of laps for joints, are given in the annexed Table, No. 3."

As no tables are given, I am unable to assign the actual thickness of the plates, except as above stated in *Engineering News*.

I have therefore assumed, in case of the Cincinnati tank, that the thickness of plates varied uniformly from $\frac{1}{2}$ an inch at bottom to $\frac{1}{4}$ inch at top; and for the Cleveland tank have given the greatest, and probably uniform, thickness of $\frac{3}{16}$ of an inch.

Some local reporters of the disaster at Cincinnati call the burst reservoir a "steel" tank; but as the specifications call for iron, I presume the contractors did not substitute steel.

Computing the required thickness, t, of the plates, by equation (5) the following table results:

Depth of water in feet. x	Radius of tank in feet. r	Kind of Riveting.	T=15,000 lbs., and within elastic limit.		T=30,000 lbs., and beyond elastic limit.		Supposed actual thickness.
			T_1	Thickness of iron. t.	T_1	Thickness of iron. t.	
0	50	Single.	9,165	0. inches.	18,330	0. inches.	.25 inches.
4	"	"	"	0.114 "	"	0.0570 "	.2708 "
8	"	"	"	0.227 "	"	0.1135 "	.2917 "
12	"	"	"	0.341 "	"	0.1705 "	3125 "
16	"	"	"	0.454 "	"	0.2270 "	.3333 "
20	"	"	8,133	0.640 "	"	0.3200 "	.3541 "
24	"	"	"	0.768 "	"	0.3840 "	.3750 "
28	"	Double.	10,532	0.691 "	22,758	0.3200 "	.3958 "
32	"	"	"	0.790 "	"	0.3657 "	.4167 "
36	"	"	"	0.889 "	"	0.4114 "	.4375 "
40	"	"	"	0.988 "	"	0.4572 "	.4583 "
44	"	"	"	1.087 "	"	0.5029 "	.4792 "
48	"	"	"	1.185 "	"	0.5486 "	.5000 "
0	30	Single.	9,165	0. "	18,330	0. "	.1875 "
4	"	"	"	0.0681 "	"	0.0341 "	" "
8	"	"	"	0.1362 "	"	0.0681 "	" "
12	"	"	"	0.2043 "	"	0.1022 "	" "
16	"	"	"	0.2724 "	"	0.1362 "	" "
20	"	"	"	0.3406 "	"	0.1703 "	" "

It is apparent from my table, above given, that neither of these tanks gave a margin of safety so large as I have assumed. For having taken T=15,000, and the so-called factor of safety=4, the Cincinnati tank would fail to give this factor, with 20 feet of water, and the Cleveland tank would fail to give this factor with 12 feet of water.

Again calling T=30,000, that is, the nominal factor of safety =2, but really taxing the iron beyond its elastic limit, the Cincinnati tank would fail to yield this factor at the center before being entirely filled; and the Cleveland tank would cease to give the factor 2 at the depth of 24 feet.

Now, all this assumes what is probably never completely realized in practice, viz.:

1. That the tensile strength of the plates, before punching, is 60,000 lbs. to the square inch of section.

2. That the remaining cross section of a plate, after the rivet holes have been punched, is equal to the cross section of the rivets.

3. That the rivets under their initial longitudinal strain are still capable of sustaining shearing stress equal to the tensile strength of the plates.

4. That punching does not unfavorably affect the strength of the iron between the rivet holes.

5. That the distribution of strain is uniform on the remainder of plate, between two consecutive rivets.

6. That all rivets fill their holes, and are perfect.

7. That the rivet holes are exactly opposite in the two plates, so that no "drifting" is required.

Taking into consideration all these things, it is easy to see how a so-called factor of safety of two, straining the iron past its elastic limit, would be used up with consequent disaster.

Of course the thickness of plates near the top should be greater than the values of t found by the formula, and not less than the supposed actual values in the table. Although the pressure is greatest on the lowest rings, yet, owing to its connection with the bottom, failure occurs above this ring. Large, high tanks should be properly braced and stiffened to resist the action of wind.

Facts and Figures.

The following "Useful Facts and Figures" are condensed from a small pamphlet issued by Mr. Robert Grimshaw of Philadelphia:

The INDICATOR shows the performance, condition, power, and economy of the steam engine; the power wasted by want of lubrication, improper alignment of shafting, badly designed gearing, slip, or excessive tightening of belts. It can be used to register the amount of power consumed by each tenant or machine; detects carelessness or incapacity of the engine-runner; points out leaks, chokes, bad packing, condensation, uneven or badly-timed valve motion, etc.

ENGINES rated by their builders at 100 H.P., with 22½ lbs. of steam per hour per H.P., are sometimes found by indicator or brake to develop but 75 H.P., consuming 30 pounds of steam hourly. In each case, 2,250 pounds of steam is used, and probably 250 pounds of coal burned; but, in the second instance, both power and economy are too low, and might sometimes be brought to proper capacity and duty simply by re-setting the valves. Engines having irregular motion, causing great loss in cotton factories, paper and flour mills, etc., can always be brought to proper performance by intelligent treatment after using the indicator to reveal the cause. Regularity is especially important to those using the electric light.

Some descriptions of ELECTRIC LIGHT MACHINES sold to produce a given candle-power with a stated number of horse-power, consume from two to ten times the stipulated motive force. BOILERS sold to produce, say, 100 H.P., with an evaporation per pound of coal of 9 pounds of water from and at 212° Fahr., yield but 70 H.P., each pound of coal making only 6.3 pounds of dry steam. Many boilers can be made to steam better, or use less coal, or both, by merely altering the height of grade or bridge wall, or making some equally simple change. Drier steam may be got by very slight alterations. Some BOILER AND PIPE COVERINGS effect a saving of 10 per cent. in fuel; others, less durable, yet more costly, not 3 per cent.

COAL, bought as equal to some well known standard, often turns out to have but three-quarters the steaming power, although at nine-tenths the price per ton.

One cubic foot of pure water, at 62° Fahr., weighs 62.355 pounds; at 212° Fahr., only 59.640 pounds. A cylindrical foot of water, at 62° Fahr., weighs 48.973 pounds. One ton of water is 35.90 cubic feet.

A column of water 2.3093 feet (or 27.71 inches) high, at 62° Fahr., will exert a pressure of one pound per square inch. A column of water 33.947 feet high, at 62° Fahr., will exert a pressure of one atmosphere (14.7 pounds per square inch). 1,728 cubic inches, 2,200.15 cylindrical inches, 3,300.23 spherical inches, or 6,600.45 conical inches, make one cubic foot.

One metre equals 39.37043 inches, 3.28087 feet, 1.09362 yards. One inch equals 2.53995 centimeters. One foot equals 0.3048 metre. One square inch equals 6.45148 square centimeters. One square foot equals 0.09201 square metres. One square yard equals 0.836112 square metres. One litre equals 61.02524 cubic inches, or 0.8804 quarts. One gramme equals 15.4323 grains. One kilogramme equals 2.2046 pounds av. One pound per foot equals 1.488 kilogrammes per metre. One pound per square inch equals .0703077 kilogrammes per square centimetre. One pound per square foot equals 4.883 kilogrammes per square metre. One kilogrammetre equals 7.233 foot pounds. One foot pound equals .138 kilogrammetre. One cubic foot of cast steel weighs 489.3 pounds; of wrought-iron, 480 pounds; cast-iron, 450 pounds.

To reduce pounds per square inch to net tons per square foot, multiply by .072; to gross tons per square foot, by .0598. Thus, 8,000 pounds per square inch equals 576 net tons, or 478.4 gross tons, per square foot.

Dark red color indicates about 700° Cent., equals 1,292° Fahr.; cherry red, 1,652°

Fahr.: white heat, 2,372 Fahr. Air at constant pressure expands 1.461 of its volume for each degree Fahr. above zero. Average comparative specific heat of ice, 0.504; of water, 1; of gaseous steam, 0.622.

The temperature of steam rises more slowly than its pressure. To make one pound of steam at 212° Fahr., it takes, to raise the water from 32° to 212° Fahr., 180.9 heat units (sensible heat); to form the steam, 892.9 units (latent); to resist the pressure of the air (14.7 pounds per square inch), 72.3 units; total, 965.2 units latent; grand total, 1146.1. Average coal, in burning thoroughly, takes 2.46 pounds of oxygen per pound, or 10.7 pounds of air (equals 141 cubic feet) at 32° Fahr. Re-heating and rolling down or forging down wrought-iron bars reduces their elongation and increases their tensile strength. The skin of wrought-iron is *not* the strongest portion. Cold rolling increases the strength of wrought-iron. Tensile strength of wrought iron averages 10 per cent. more with the fibre than across it. Compressing melted steel with a pressure of about six tons per square inch increases its strength. The shearing strength of steel averages 72 per cent. of its tensile strength. Steam expanded from the initial volume, 1, to 2, 4, 8, 16 volumes, will give out work in the proportions of 1, 1.693, 2.386, 3.079, 3.772.

A good rivet, cold, should bend double without breaking. The head should flatten out, when hammered hot, to $\frac{1}{8}$ inch thick without fraying at the edge or breaking. Boiler plates should be calked with a convex tool.

Lubrication. For general purposes, sperm answers best; next, winter-strained lard oil. For high speed and heavy pressure, add finest air-floated plumbago (graphite, black lead). For cooling heated journals, use flour of sulphur and olive oil. For curing badly-scored journals, use lead filings.

Distance between parallel sides of bolt head and nut, for rough bolt, $1\frac{1}{2}$ bolt diameter, plus $\frac{1}{8}$ inch. Thickness of heads, rough bolt, half distance between parallel sides. Nut thickness equals bolt diameter. Thickness of head, finished bolt, equals thickness of nut. Distance between parallel sides of finished bolt head and nut, and thickness of nut, $\frac{1}{16}$ inch less than for rough.

Horse Power of steam engine $(HP)=\frac{PLAN}{33,000}$; (HP) being indicated horse power; P= mean steam pressure on piston, in pounds per sq. inch; L, stroke in feet; A, piston area in sq. inches; N, number of strokes (or double the number of crank revolutions) per minute. Equal piston diameter and stroke, in inches, of cylinder of any assumed HP, mean pressure, and number of strokes per minute of piston rod,

$$d=79.59\sqrt[3]{\frac{(HP)}{PN}}.$$

An Engineer on the Lehigh Valley road broke the valve of his whistle-pipe the other day, and, to save his life, couldn't stop the shrill screaming that followed. The prolonged whistle caused much commotion among the people living along the line of the road, and many ran from their homes to ascertain what was the matter. The engineer pointed to the whistle, which the fireman was vainly endeavoring to fix, but his gestures were not understood. Stationmen, flagmen, trackmen, and others had an idea that the engineer was crazy, and began to predict all sorts of disasters. The engine was run to Sugar Notch and housed, and there the fire was drawn. All this time, and until the steam was exhausted, that insatiable whistle tooted away like mad. It was a funny sort of an accident, and created quite an excitement.—*Cincinnati Artisan.*

A Recent English invention is a device for cutting four-inch wrought-iron pipes by hand with a stock. The idea is not easily described without engravings. We may say that the thread is cut by a single tool, as in a lathe, the pitch being governed by a hub somewhat like a box lathe for brass work. It is very compact.—*Cincinnati Artisan.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES — VOL. II. HARTFORD, CONN., NOVEMBER, 1881. No. 11.

The Jersey City Explosion.

F. B. ALLEN.

At about 7.45 A.M., September 13, 1881, a stationary boiler, of the locomotive type, upon the floating dock of Messrs. Bulman & Brown, foot of Essex St., Jersey City, N. J., exploded with terrific violence, killing two men and injuring five others, also destroying property to the amount of some $2,000, besides damaging surrounding property to perhaps an equal amount.

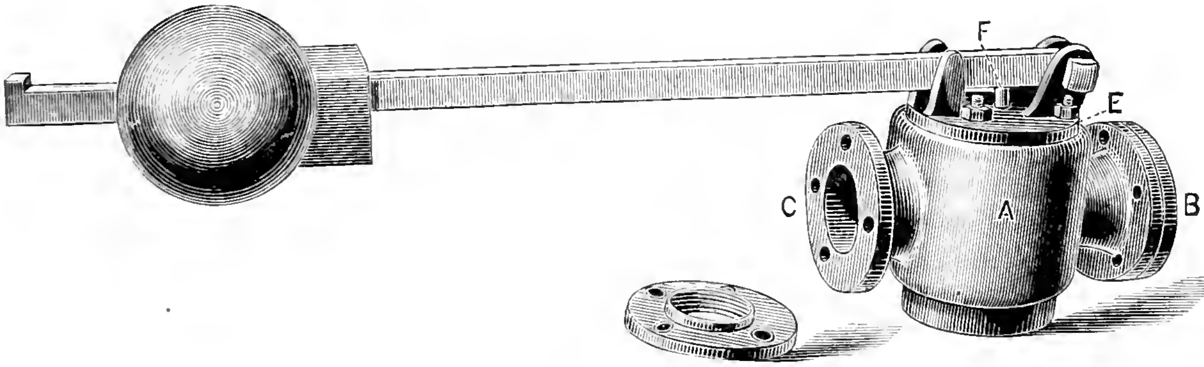

FIG. 1, SAFETY-VALVE.

A.— Valve chamber.

B.— Flange to which escape-pipe was attached.

C.— Flange to which steam-pipe was attached.

E.— Bonnet.

F.— Wrought-iron valve-stem.

The boiler that exploded was but little over three years old. The iron used in its construction was of good quality, if the mill stamp could be relied upon, and there appeared no reason to doubt it. It was stamped in a number of places, "Best Flange," and C. H. No. 1 shell, 50,000 lbs., Glasgow Iron Works, Pa.

Its principal dimensions were as follows: Length, 16 ft. 4 in.; diameter, 40 in.; fire box part, 54 in. long, 60 in. high. The shell was made up of three courses of $\frac{3}{8}$-inch iron plates, single riveted, $\frac{3}{4}$-inch rivets, heads $\frac{7}{16}$ in. Crown sheet and side sheets of fire-box in one piece, as commonly used in the smaller sizes of this class of boilers. It was $\frac{5}{16}$ in. thick, braced to the wagon-top on areas of thirty-nine square inches, side sheets stayed to the shell by screw stay-bolts $\frac{7}{8}$-in. diameter, pitched $5\frac{3}{4}$x$6\frac{1}{2}$ inches between centers, screwed into both sheets and headed up.

The front tube-head was braced to the shell by three braces, the back head by eight braces, three of which extended well back and attached to intermediate course of shell. In speaking of the front and back heads of locomotive boilers there is a possibility of confusion. In this description the front head is the one nearest the front or fire-box end of the boiler, while the back head is at the opposite or smoke-box end. Dome 24x30 in., $\frac{5}{16}$-inch iron, double riveted on flange, wrought-iron dome-head securely braced, substantial manhole frame on intermediate course of shell.

There were thirty-eight 3-inch tubes, 10 feet long, rolled into both heads by a "Dudgeon Expander," and slightly flared on their ends. Beading over iron tubes is practically abandoned in this part of the country. It is not recommended by our boiler-makers, and only done where required by specification. The fittings, in addition to valves, pipes, and usual attachments, were a $2\frac{1}{2}$-inch safety-valve, a steam gauge, three gauge-cocks, and a glass water-gauge. The safety-valve was *supposed* to have been set to blow off at about 75 lbs.

The construction of the boiler was workmanlike. Its builder bore a high reputation as a designer and practical boiler-maker of both land and marine work, and many evidences of his skill may be found ashore or afloat. The owners, aware of this fact, probably gave little thought concerning the management of it, no doubt priding themselves on having a first-class boiler, in the use of which there would be no risk or damage for many years. The history of this case will be a profitable study to thousands of steam-users in the land who entertain a similar delusion. Let us hope their dream may not have so rude an awakening as the gentlemen of whom I write, who are now under bonds awaiting the action of the Grand Jury for their participation in the negligence of their engineer, besides being threatened by suits at law for the collection of claims arising from loss of life, injuries to limb, and damage inflicted on the property of others.

The testimony before the coroner's inquest established the fact that the boiler was a good one, and equipped with the necessary safety appliances relied upon to guard against explosion, in the hands of a competent, attentive engineer. As to the qualifications of the engineer and his attention to duty our readers can judge from his testimony, in part as follows: "He had been licensed as an engineer in Brooklyn, N. Y.; had charge of the exploded boiler since March, 1880. In addition to his duties as an engineer, he was a fireman, attended to certain lines, and arranged the blocks for the reception and discharge of vessels; sometimes did calking or keel work. The boiler was never inspected or tested to his knowledge. He never was inside the boiler. Had no occasion to go there. Steam gauge was in perfect order; a steam gauge will run six years without testing or repairs. The highest steam pressure he ever saw on the boiler was 78 lbs. Blew off steam from the safety-valve on Saturday before the explosion (three days). It was then all right. Started fire in the furnace the morning of the explosion, so as to have steam at 7 o'clock to lower a boat that had been docked for repairs. Had permission to go home from one of the firm, having received a telegram announcing the sickness of a member of his family, and requesting his presence. Recommended the employment of another engineer to look after the boiler in his absence."

Some time before 7 o'clock, a young man who sometimes assisted as fireman about the boiler and engine came on duty. Learning of the engineer's absence, and fearing they would be behind time in getting up steam, he added fresh fuel to the fire, and closed the furnace door, that had been left ajar by the engineer. At this time he was ordered away to assist in moving a barge. He admits being absent about forty-five minutes. Seems to have forgotten all about the boiler, when, hearing an unusual noise from escaping steam, he climbed up to the boiler, found the fire-room full of steam, which he says seemed to blow out around the seams about the front. While attempting to reach and open the furnace door with a long pole, the boiler exploded, and he was dangerously injured.

The force of the explosion projected the cylinder part of the boiler, weighing approximately two tons, some 650 feet, while the fire-box part was blown in the opposite direction, and part of it fell into the river. The attending circumstances indicated an explosion by over-pressure of steam. This theory was fully confirmed by an examination of the safety valve, Figs. 1 and 2, the stem of which, *F*, was corroded fast in the bonnet, *E*, so much so that a pressure of 3,200 lbs. was required to lift it $\frac{1}{32}$ inch, the pressure being gradually increased with a slight upward movement of the valve, until 4,000 lbs. was applied, when it raised $\frac{1}{4}$ inch from its original position — 4,000 lbs. being equivalent to 816 lbs. per square inch upon the boiler. From that point the valve was driven out of the chamber by a hammer. Its stem was found perfectly straight,

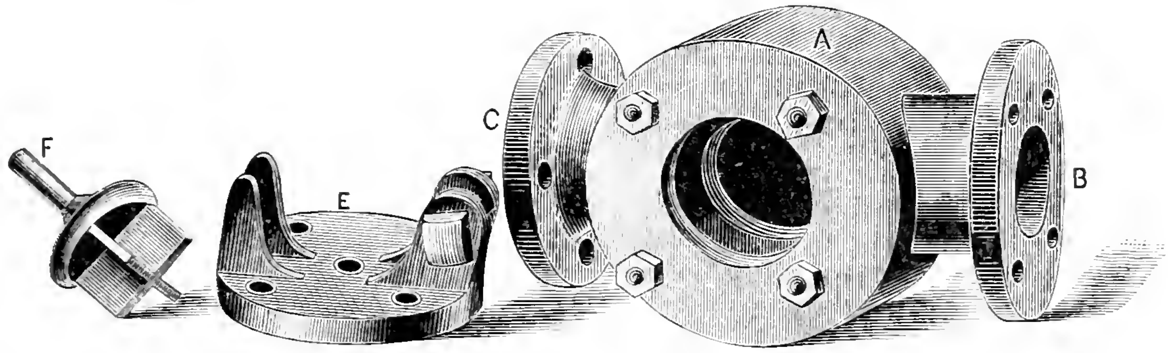

Fig. 2. Parts of Valve.

A.—Valve-chamber.

E.—Bonnet showing aperture where corrosion occurred.

F.—Valve and stem—Iron stem rigidly attached.

Like letters refer to the same parts in both cuts.

but when the scales of rust were removed it was found to have been reduced $\frac{1}{16}$ inch in diameter in that part of the stem where corrosion occurred. It was the opinion of the expert who made the examination and test that corrosion had been going on for a long time, part of which time it had not progressed sufficiently to affect the workings of the valve. He certainly did not — nor did any one else having any knowledge of the subject — credit the engineer's story that the valve had been in good working order less than three days before the explosion.

The safety-valve, Figs. 1 and 2, had the appearance of an old design. The valve-stem, *F*, being made of wrought iron instead of composition, there was a constant danger of its corroding fast in the cast iron bonnet, *E*, through which it passed to connect with the valve lever. The aperture in the bonnet was probably too close a fit in the first instance. This dangerous defect, as might naturally have been expected, escaped the attention of every one about the boiler, but was detected by an expert engineer, who examined the valve immediately after the explosion. Though the use of the iron valve-stem was attended with danger, and might have been expected to end in disaster in the hands of the average boiler attendant, it would not have occurred under the care of a competent engineer, who attended to the raising of a safety-valve daily, not by hurriedly raising the valve lever, but by assuring himself that the valve lifted from its seat and steam escaped. This operation of raising the safety-valve and letting it blow for the minute may be performed at the noon hour, if convenient, as likely to excite alarm at other times.

Many steam-users have what appears to me a very foolish objection to steam from the safety-valve escaping into the fire-room, and, in ridding themselves of what they may regard as an annoyance, they expose themselves to dangers they little dream of, making a pipe connection to the exit side of the safety-valve to carry off the escaping steam. With this connection, at times it is very difficult to tell whether the safety-valve is blowing off freely or not, particularly if more than one boiler is blowing off at the same time, without going out of doors where the open end of the pipe may be seen, and that is not always agreeable, especially in bad weather. At such a time a man is more likely to stay in doors and guess.

The accuracy of the guess in some cases determines the fate of the boiler.

There are at least two other objections that may be urged against such an arrangement of escape-pipe. *(a)* Tendency of the weight of the attached piping to produce distortion of the valve-chamber. *(b)* And the increased danger from corrosion due to the condensation of the steam and descent of the water to its lowest point, where it remains until evaporated or displaced by the next blowing out. The safety-valve, Fig. 1, had a pipe so connected, which retarded the free escape of steam. It will be recollected the valve was $2\frac{1}{2}$ inches in diameter, having an area of $2.5^2 \times .7854 = 4.90$ sq. in., which was rather small for the work. The effect of the $1\frac{1}{2}$-inch escape-pipe was to reduce its effective area to $1.5^2 \times .7854 = 1.76$ sq. in., making it dangerously small, the increased friction of the pipe and elbow not being considered.

There were well-defined evidences of pitting in several places on the interior of the boiler. It was particularly noticeable upon the crown-sheet, around the tube-holes in front head, and, to some extent, on the back head also, as well as on the upper row of tubes. The boiler was supplied by city water from the Passaic River, not remarkable for its wholesomeness or purity.

The most rational explanation of this pitting, perhaps, is the fact of the boilers being out of service about half the time.

From the preceding detailed statement as to the material and construction of the boiler, its use, and the manner in which it was cared for, for all practical determinations, it will, I am sure, be apparent to the reader there exists not the slightest necessity for invoking a mysterious agency to account for this explosion. A brief

SUMMARY

of events just preceding the explosion may not be uninteresting: That fire was started in the furnace at about 5.45 A. M., presumably with warm water in the boiler, according to orders of the night before, "to have steam at 7 A. M., to operate the dock while discharging one vessel and docking another"; that from the time fire was started until the departure of the engineer, soon after, with the exception of the addition of fresh fuel and an increased effort to hurry the fire by the man who sometimes acted as fireman, until warned by the shrill noise of the escaping steam from around the seams, immediately preceding and at the moment of explosion, 7.45 A. M., the boiler was neglected by the other employees, who, it is true, were each intent on performing their own duties; that with all the steam outlets from the boiler closed and an inoperative safety-valve, there was a steady accumulated pressure of steam, until it reached a pressure greater than the strength of the weakest point of the boiler — in this case the crown-sheet, which collapsed, the great strain upon it having bulged the plate around the rivet-holes. The distended holes allowed the brace rivets to draw through, shearing off part of their heads, not a brace remaining attached to the crown-sheet.

When the crown collapsed, bending over the upper part of the front head, to which it was attached, it yielded in the line of its weakest section — between the tube-holes on the top row — that fragment of the head being afterward found attached to the crown-sheet, the fracture an angular one, and the broken fiber indicating the direction in which the force had been exerted. With the collapse of the crown-sheet and accompanying fracture of the head as described, occurred a general destruction of the surrounding parts, the projection of the shell part in one direction and the fire-box part in another and opposite direction.

The following verdict was rendered by the coroner's jury:

"That the effective cause of the explosion on the morning of Sept. 13, 1881, of the boiler on the dry-dock of Bulman & Brown, located at the foot of Essex street, Jersey City, N. J., causing the death of Lionel D. Decker, was from an imperfect safety-valve, in the hands of a careless, incompetent engineer, in the person of George Everson; and we further censure Messrs. Bulman & Brown for leaving the boiler without an engineer from 7 to 8 o'clock in the morning; and we would recommend that the legislature of this State enact some law requiring the licensing of engineers and the inspection of all boilers once a year."

Coroner Wiggins held the engineer, Everson, and the firm, Messrs. Bulman &

Brown, each in the sum of two thousand dollars bail, to await the action of the Grand Jury.

Our daily papers in reviewing the testimony and the verdict of the inquest considered it their duty to direct public attention to the ignorance of the engineer who failed to detect the defective construction of his safety-valve and fittings, and to condemn in the most emphatic terms his negligence in permitting it to become so dangerously corroded as to be inoperative. I can say amen to the latter, but consider it a rank injustice to hold him responsible for his ignorance of safety-valve construction and proportion, a knowledge possessed by but a limited number of those who operate steam boilers. A knowledge of that subject and others equally important but few employers are willing to pay for, and they are not often the stock in trade of an engineer who can be employed at eighteen dollars per week, which is about the sum paid by the majority of employers who run a single boiler.

In paying higher wages they do not necessarily obtain increased knowledge, or experience. Everson, the engineer, was an experienced man. He had been examined and a certificate as to his qualifications to act as an engineer issued to him in Brooklyn, N. Y., some years previous. Yet he displayed a lamentable ignorance of his duties. The advantage of an additional certificate issued by some authority designated by the Legislature of the State of New Jersey is not apparent in this instance.

PREVENTION OF BOILER EXPLOSIONS.

The tendency of thé day, and with good reason, is toward specialties. Immunity from the danger of boiler explosions can be secured with the least expense to the steam user by obtaining a policy of insurance against explosion in some reputable company organized to make guaranteed inspections of steam boilers, who will send a carefully trained inspector to make periodical examinations of the boilers, setting, and connections. A man who is accustomed to look for weaknesses, or defects, whether of construction or incidental to service, and whose advice in matters affecting the safety and economy in management could not otherwise be obtained, nor could it be duplicated from any other source, except at a much greater expense.

There were other matters of interest developed by the investigation of this explosion, which I hope to discuss for the benefit of whom it may concern, at some future time, the present article being a more extended one than was contemplated at its commencement.

Inspectors' Reports.

SEPTEMBER, 1881.

The summary of the inspectors' work for the month of September is given below. From it we learn that the whole number of visits of inspection made was 1,818, the number of boilers examined 3,866, of which number 1,410 were internal inspections. The hydrostatic test was applied in 425 cases. The total number of defects found was 1,690, of which 543 were considered dangerous. The detailed statement of defects is appended. The figures are suggestive and speak for themselves.

	Whole Number.	Dangerous.
Furnaces out of shape,	84	26
Fractures,	254	182
Burned plates,	83	30
Blistered plates,	272	27
Cases of deposit of sediment,	194	42
Cases of incrustation and scale,	309	41
Cases of external corrosion,	98	42
Cases of internal corrosion,	70	19
Cases of internal grooving,	17	11
Water gauges defective,	26	7
Blow-outs defective,	12	4
Safety-valves overloaded,	28	19
Pressure gauges defective,	126	24
Boilers without pressure gauges,	35	3
Cases of deficiency of water,	16	13
Broken braces and stays,	66	53
Boilers condemned,		30

Boiler Explosions.

OCTOBER, 1881.

OAR FACTORY (121).— By a boiler explosion at Laduc & Phinney's oar factory at Carrolton, Mich., Sunday night, Oct. 2d, two brothers, John and James Ricard, were killed. The damage to the factory was about $7,000.

CANNING ESTABLISHMENT (122).— One of the boilers of Judson Farr's fish canning establishment, at Pemaquid, Me., burst Oct. 3d, and nearly destroyed the building. Most of the employés were temporarily discharged the week before, and a few remaining happened to be out, or many lives would have been lost.

MACHINE SHOP (123).— At two o'clock on the afternoon of Oct. 4th, one of the boilers at B. S. Nichols's machine shop, Burlington, Vt., exploded, cause unknown. The capacity of the exploded boiler was 55 horse-power. The explosion was of great violence, débris being thrown one hundred feet in the air, and the report being heard for miles around. Two-story brick buildings are a mass of ruins. No person was injured, though the engineer and fireman were in the engine room at the time. Loss, several thousand dollars.

SAW-MILL (124).—A saw-mill boiler at Richmondville, Sanilac Co., Mich., built since the fires, and owned by John Cornish, blew up Oct. 6th, and instantly killed the fireman, named Fred Bennett, who leaves a very large family. The accident was caused by pumping cold water into the boiler.

— MILL (125).— A boiler explosion occurred near Ripley, Mississippi, Oct. 10th, by which Dr. Charles Rucker and Mr. Jesse Stubbs were instantly killed and Mr. A. B. Simpson, who was badly injured, died the same day. Others were severely injured.

— MILL (126).— Fulford Fielde, son of ex-Assistant Commissary-General Fielde, of Prescott, Manitoba, while running a mill, forty-five miles west of Fort McLeod, was killed by the explosion of a boiler, Oct. —.

DYE-WORKS (127).— A terrific explosion occurred on the afternoon of Oct. 10th, at the Clifton Dye Works, Clifton, Pa. Two boilers used in the works exploded demolishing the boiler house and setting fire to the remaining buildings, which were burned. Robert McClure was instantly killed, and six other workmen were dangerously injured. The boilers were "old and rusty," and were placed in the mill four years ago at which time they were purchased as second hand. The loss was about $20,000.

— MILL (128).— The boiler in Major's mill, Collinville, Ont., exploded on October 11th, wrecking the engine house and mill, and seriously scalding William and Headley Major, sons of the proprietor, and William Bickel.

LOCOMOTIVE (129).— The boiler of a yard engine on the Wabash, St. Louis & Pacific road exploded in Keokuk, Ia., Oct. 14th. The engine was crossing the bridge over the Mississippi at the time, and the engineer says there was 120 lbs. pressure and three gauges of water. The forward part of the boiler was torn to pieces and the bridge damaged; three men in the cab were only slightly hurt. The boiler is said to have been over 20 years old.

PULLMAN CAR (130).— The Pullman palace car Bermuda was the scene of a singular accident Oct.—. It had been lying in the Union Depot yard, St. Louis, and was backed up near the Twelfth street bridge, where one of the yardmen made a fire up in the steam-heater with wood, banking it with fine coal dust, which he declares created a sufficient amount of coal gas to blow the boiler, furnace, and its immediate surroundings through the top of the car into space. In view of the fact that part of the furnace was found more than a block away from where the explosion occurred, this story is disbelieved, and it is believed that the boiler was worn out and exploded. The boiler in use is known as the "Baker," and generates steam, which heats the car in which it is situated. This is the system of heating in vogue in nearly all of the Pullman sleeping cars, and several of the conductors who were interviewed by a reporter at the Union Depot, stated that, unless managed by an expert, these boilers are sure to burst.

Dye Works (131).— A boiler at the Worcester dye and bleach works, Worcester, Mass., exploded Oct. 24th. Wm. Ronayne was scalded badly, and had his leg broken. Wm. Dicken and Martin Davis were scalded.

Wheel Factory (132).— One of the most disastrous boiler explosions ever known occurred Oct. 25th, at the hub and spoke factory of Pinneo & Daniels, Dayton, Ohio. The rear of the building was entirely demolished, and the dwellings for several squares round badly injured. Henry Rhael, fireman, and a little girl two squares away, were instantly killed. Three workmen seriously, and many others more or less injured, were taken from the ruins. There was no insurance, and the loss will reach from $12,000 to $15,000. The coroner's verdict was to the effect that the explosion was caused from the sudden overcharging of said boiler with steam, by the use of light and excessively inflammable material as fuel by an inexperienced fireman, there being no fireman employed as such regularly; also that the engineer, through his carelessness in allowing such inexperienced person to fire for him, has been the cause of the death of the three persons whose deaths have been the result of said explosion. The individuals composing the firm are found through the negligence in not employing a competent fireman regularly, jointly responsible with the engineer for the deaths of the said persons.

Saw-Mill (133).— The boiler in Stewart's saw-mill, near Sturgis, D. T., exploded Oct. 25th, killing Howard Smith, the fireman, and seriously injuring two or three workmen.

Threshing Machine (134).— A terrible explosion of a threshing-engine boiler occurred on the farm of Evan Railson, at Norway Lake, Minn., Oct. 25th. The engine was an Ames straw-burner. Mr. Railson was running it himself, and had stopped the engine and gone over to the separator to fix some part of the machinery. Just as he was about to return the engine blew up with terrific force, injuring A. Strand, Everson, and Christian Solberg. Strand died in two hours. Solberg was badly scalded in the face and burned. Everson was scalded in the back. A 14-year old boy by the name of Peter Peterson, was blown straight up and over the straw-stack, falling without injury. Mr. Railson's hat was knocked off by one of the flying pieces. So complete was the destruction that no part of the engine or boiler was left where it stood before the explosion. Pieces were thrown far and wide over the large field in which they were threshing. The cause of the explosion is unknown. There was a full head of steam on, and the water-gauge indicated plenty of water, but it is supposed Railson was detained longer than he thought at the separator, the steam ran up rapidly, and was beyond control before he could reach the engine.

Locomotive (135).— The engine of a freight train on the Indiana, Bloomington & Western road exploded its boiler Oct. 25th, just as it was starting from Champaign, Ill., with a freight train. The force of the explosion was downwards, lifting the engine from the track and throwing it over. The fireman was fatally scalded and a brakeman hurt.

Threshing Machine (136).— A steam threshing machine, belonging to the Timersons of Martville, Cayuga Co., N. Y., while being repaired in front of a blacksmith shop at that place, Oct. 28th, exploded. Nine persons were injured, several fatally. One of the Timersons was killed. James Dodge had his head badly cut. Daniel Demill had both legs broken. The sons of Mr. Mosher, the hotel keeper, were also hurt, and one of them has since died. There are several others that cannot live.

Blew out a Cylinder Head.— The steamer John C. Maude, en route from St. Louis to Memphis, blew out a cylinder head about a hundred miles above Memphis, Oct. 24th. Her freight was reshipped on the City of Greenville, and the Maude returned to St. Louis for repairs.

The Locomotive.

HARTFORD, NOVEMBER, 1881.

We clip the following from the *Scranton Daily Times* of July 19, 1881, which was handed us, together with a good sized specimen of the substance under discussion, by the Rev. J. H. Twichell of this city, who visited Scranton about the time of the excitement over the discovery.

The Young Coal Plant.

Two or three weeks since, when, in digging through the peat in the Court House lot, a black substance was discovered very much resembling coal, so much interest seemed to be felt in the matter that the *Times* boxed up a small specimen and sent it to Mr. P. W. Sheaffer at Pottsville, whose well-known researches into the coal geology of the State, and connection with the State Geological Survey, seem to point him out as the proper person to apply to, to bring the subject before the scientists, and get their explanation of it. We received a reply from Mr. Sheaffer immediately, stating that he had sent the specimen to Mr. Lesley, the chief of the survey, and a day or two later we received a response from Mr. Charles A. Ashburner, acknowledging its receipt, and stating that it had been sent to the State chemist for a report on it, as also a postal from H. Martyn Chance, Esq., of Wilkesbarre, Penn., with reference to the matter. As none of these communications threw any light upon the subject, we did not publish them. We received the following yesterday from Mr. Lesley, which we publish, that our readers may have the benefit of the opinion of the geologists, and the analysis made by the State Chemist, which it gives. We may repeat here the conditions under which this deposit is found. There was about twelve feet of cinder and ashes on the top of this lot, which had been dumped there by the L. I. & C. Co. to fill the swamp. Then the workmen, after removing this, came to the surface of the swamp, which was covered with stumps from the size of the smallest swamp-jungle, to pines of large size. From this surface, from which the stumps were removed at the depth of some ten to thirteen feet, a bed of peat was cut through, varying in compactness from the latest formation at the top, in which the plants it contained could almost be named by looking at it, to the more compactly pressed material at the point where this black material was found, at the bottom of the peat-bed. Under this from eighteen inches to three feet of a bluish gray clay is found, which changes from the unquestionable peat to the clay so gradually that it is hard to determine where the clay begins and the peat ends. It is at a junction of the clay and peat in the latter, and on the top of the former, that the matter under consideration is found. It lies in seams or veins that run apparently in every direction, but are perpendicular. In some places it is only a black stain, which nevertheless divides the muck like a seam or crack, and varies from that up to two and a half inches in thickness, which is the thickest we have seen or heard of. When first taken out, it is in color and grain exactly like anthracite coal, the fracture when parted being so much so in appearance that to the sight it is coal, and only upon handling it can the observer find that it is not. It is to the touch like a stiff jelly, or like half chilled glue. Since sending the specimen to Mr. Sheaffer, we have seen a piece of it dried, and that is still more like coal. It fractures exactly like a piece of pure, bright anthracite, and is nearly as hard. An attempt to burn it by holding it in a gas jet, was followed by its heating red as anthracite does, and throwing off a strong pungent odor something like that of gas tar. We presume the following will dispel the fancy so many have taken, that it is coal in its primary formation, but it is nevertheless most interesting as one of the freaks of nature so puzzling to the observer.

Pottsville, July 16, 1881.

Scranton Times:

Dear Sir: The specimen of black carbonaceous matter which you obtained from the excavation now being made for the building of the new Court House, which you had sent to Mr. P. W. Sheaffer and which Mr. Sheaffer referred to me for examination, has been analyzed by the assistant of Mr. McCreath, State Chemist. I enclose a copy of analysis which has just been received.

I am unable to account for the formation of this material from an examination of a hand specimen, and the facts which you sent to Mr. Sheaffer. I hardly think it possible, however, that the occurrence of the substance would indicate the primary process of change from peat to coal as you suggest. The 15 feet of turf or peat which you state occurs directly under 12 feet of cinder, and immediately above the black substance in question, which you say varies from ½ to 2½ inches in thickness, is probably the accumulation of forest debris, which had been washed in and afterwards sunk to the bottom of the lake and buried in the silt and mud. The black carbonaceous substance which you have found underneath this peat is probably the result of infiltration of carbonaceous matter from the overlying peat. It is hardly probable that a true explanation of this interesting occurrence would be of any practical value. It is, however, of scientific interest to demand a thorough study of all the facts which might throw light upon its formation. I hope to call upon you at the earliest opportunity with the hope that more extended facts may have been recorded than those which you have already sent to Mr. Sheaffer. The following is the analysis of the State Chemist:

Water, - - - - - - - @ 212° F.	66.758
Volatile matter, - - - - - - -	9.826
Fixed carbon, - - - - - - -	4.012
Ash, - - - - - - - -	19.404
	100.000

Color of ash, light brown.

I remain, Sir, very respectfully, your obedient servant,

Chas. A. Ashburner, Asst. Geol.

When this formation was first discovered it was in a soft but rather tough condition, containing much water. The specimen before us, which has been exposed to the air for some months, is now hard, and portions of it break with a sharp shining fracture similar to true coal. Other portions contain a very high percentage of ash. This in our opinion is due mainly to the impurities which have been washed in from the surrounding soil, and from the ashes which have for years been dumped upon the surface of the bed.

The following analyses which were made by our chemist show that in the purer portions, selected with care, the percentage of ash is small, and the fixed carbon and volatile matter large, while in the less pure portions the percentage of ash runs high and the fixed carbon and volatile matter small. We are inclined to the opinion that the ash in the first case is the true ash of the vegetable matter in the transition state, while in the latter case the ash is largely the result of foreign matter that has washed into the bed.

Hartford, Conn., Nov. 17, 1881.

J. M. Allen, Esq., *President Hartford Steam Boiler Ins. Co.*

Dear Sir: — The specimen of carbonaceous matter from a peat bed in Scranton, Pa., which you submitted to me for examination seems to consist of two distinct portions.

An analysis of the shiny black, friable portion gives:

Water,	11.47
Volatile matter,	54.77
Fixed carbon,	25.33
Ash,	8.43
	100.00

The other portion was of a dull grayish black, of a tough nature and broke without regular fracture. It gave:

Water,	4.85
Volatile matter,	24.67
Fixed carbon,	8.37
Ash,	62.11
	100.00

The first of these specimens seems to correspond with a foreign peat formation mentioned by Dana under the heading Dopplerite. (Mineralogy, p. 749, § 826.)

Respectfully,

GEORGE H. SEYMS, *Chemist.*

We will not presume to answer the question, Is this coal? But we think the following from Dana's Mineralogy will be read with interest in this connection:

"The *origin* of coal is mainly vegetable, though animal life has contributed somewhat to the result. The beds were once beds of vegetation, analogous, in most respects, in mode of formation to the peat beds of modern times, yet in mode of burial often of a very different character. This vegetable origin is proved not only by the occurrence of the leaves, stems, and logs of plants in the coal, but also by the presence throughout its texture, in many cases, of the forms of the original fibers; also by the direct observation that *peat* is a transition state between unaltered vegetable debris and brown coal, being sometimes found passing completely into true brown coal. *Peat* differs from true coal in want of homogeneity, it visibly containing vegetable fibers only partially altered; and wherever changed to a fine-textured homogeneous material, even though hardly consolidated, it may be true brown coal."

Dana in speaking of the derivation of coal from woody fibre further says: "It is obvious that the vegetable material, in changing to ordinary mineral coal, has not passed necessarily through the stage of brown coal. When the material was long steeped in water, and buried under fine mud so as to exclude almost entirely atmospheric air, the decomposition in progress may have carried off most of the oxygen by its combination with the carbon of the plants to form carbonic acid. Thus it happened probably with the cannel coal, as explained by Newberry, and also, though in general less perfectly, with most of the best bituminous coals. But when the bed had as free access to the air as occurs in the case of peat-beds there would have been a loss of carbon and hydrogen as marsh gas, and also, probably through combination with external oxygen, forming carbonic acid and water, while a large part of the oxygen would remain. Between these extremes, of excluded air,—and very imperfectly excluded,—and of pressure from heavy superincumbent earthy beds, and little or no pressure, lie the conditions which attend the origin of the various kinds of coal, and determine, in connection with the nature of the vegetation itself, the transformations in progress."

We will further quote from Dana's Mineralogy— under the head *Dopplerite,* is the following: "A substance from a peat-bed near Berchtesgaden. It is soft, plastic, elastic, black, of a waxy luster, tasteless: on drying in the air it resembles compact coal, is brittle and velvety black, and has H.=2.5, G.=1.439, luster vitreous, with powder brownish black. The air-dried material loses at 80° C. 12 per cent. of water. Unlike Dopplerite it burns with a bright yellow flame, is partially soluble in alcohol, and the alcoholic solution affords a resin."

An Account of Lloyd's.

We clip the following from *The Lloyd's Mirror*, published by J. G. Beemer, 176 Broadway, New York:

A large number of the great commercial houses and corporations of England, and indeed of all countries, are carried on under names no longer borne by the members. Lloyd's is still more singular in this respect, for there has never been a prominent, certainly not a leading member, of the Association bearing that name. Mr. Lloyd, to whom thousands of letters are addressed annually by shipowners, captains, and crews, is a myth. From about 1705 to 1750 there was one Lloyd who kept a chop or coffee house on Lombard street, London, to which many merchants engaged in maritime adventures resorted for meals. But, though his house was the focus of news, Mr. Lloyd seems to have had no direct agency in making it so beyond the preparation of the roast beef and the dispensing of the ale so enticing to all Britishers. He doubtless made a point of listening to and then repeating to new comers the maritime news which he had heard from his customers, so that his place became noted therefor. But he probably never took risks on vessels at sea, as merchants who dined at his house were accustomed to do. He simply knew how to keep a hotel, and doubtless died without dreaming that the name of his obscure coffee house was to be given to the busiest and most peculiar department of that busy institution, the Royal Exchange, of London, the greatest Bourse of the world. Entering the open court of the Royal Exchange, in which the merchants and brokers meet, the seeker for Lloyd's is referred to a glazed mahogany door which forms the entrance to the place he seeks. On opening this he finds himself at the foot of a high broad staircase. Passing the statue of Huskisson, the tablet to the *Times*, the red-robed beadle in his box, and the numerous officials of the numberless life and fire assurance companies, he reaches the great hall to which the merchants daily resort to pick up seafaring news, and which is known by the name of the old coffee house, Lloyd's.

The first object which attracts the attention of the merchant, and which is to be explained to the stranger on entering the hall, is the bulletin board. There are, in fact, many bulletin boards, but each is a duplicate of the other, and a number of them is used for the greater convenience of the crowd. These bulletins contain the news of the day, showing the vessels cleared at the Custom House, those which have sailed, those which have arrived at home and at various foreign ports; the latitude and longitude, and the whereabouts of vessels spoken at sea, giving also the date when seen and the condition of the vessel; the vessels in port at all sorts of places; such events occurring at sea as would affect the rate of insurance, as, for instance, changes in the lighthouses, signal stations, etc., and everything of the kind interesting to shippers, insurance men, captains, and pilots.

On a high desk by itself on one side of the room is the loss book, or, as it is commonly called, the "Black Book." This volume contains all the information not usually registered on the bulletins in regard to disasters at sea. In fact, the bulletin board is the register of good news; the "Black Book" is the recorder of bad news. The announcements in each are made in the most laconic style which the practical clerks at Lloyd's can command. They seldom occupy more than a couple of lines, and are, of course, written by hand. In the black book the number of pages thus covered varies with the season. In Summer, one or two pages are used daily; in Winter, the season of heavy gales, as many as a dozen pages are filled. It is seldom that anything is said in the loss book of the loss of life. Lloyd's takes no cognizance of the doomed beings; it is property, not life, which the underwriters of Lloyd's insure.

The entries on the bulletins and the black book, the indications of the meteorological instruments, and reports of the various insurance inspectors on vessels, combine to make up the daily paper published by Lloyd's and known as *Lloyd's List*.

There are other peculiarities of Lloyd's, such as the chart room, where are displayed maps of every sea, ocean, bay, and port in the world, each on a roller and arranged with great care; and there is the reading-room, where the files of newspapers, maritime gazettes, commercial circulars, etc., are arranged according to nations and continents on two large tables, which may be said to represent the two hemispheres.

The method of collecting ship news by Lloyd's is not materially different from that of the New York Associated Press, but it is more thorough and perfect and far more reliable. Lloyd's has its agents in every part of the world,— on every habitable rock in the sea, as well as in every open port of every nation. Lloyd's is a signboard to be found in every port that a ship can enter. The agents employed are either England's foreign officials (generally consuls) or English merchants of repute residing in foreign countries, and always men of such official or commercial standing and reputation as enables them to obtain the earliest shipping intelligence. These agents are in constant communication by letter and telegraph with the central office in London, and here their reports finally concentrate. At the same time that their information is on its way to London it is circulated in every port touched at by the vessel bearing the communication to Lloyd's, and thus Lloyd's news is disseminated.

From the office the accumulated information goes in bulk and not piecemeal. Besides these agencies of information the merchants of London who are subscribers to Lloyd's furnish their news, received by letter or otherwise, to the institution, and the captains and crews of vessels often report to Lloyd's before they go to their owners. It costs $50,000 annually to sustain such an institution and pay for the news. This is not so large a sum as the New York Association puts out for news, but it must be remembered that the London institution is confined to one branch of news collecting, while that of New York embraces all kinds of news.

The business of Lloyd's is conducted by a committee of twelve members, one of whom, generally a leading merchant and a member of the British Parliament, is chosen as the chief. The working staff is headed by a secretary, who is an admiral of the British navy, and is otherwise composed of a large number of assistant secretaries, clerks, and waiters, the latter title being given to the messengers in remembrance of Lloyd's coffee house. The revenue of the association consists of the subscriptions of the members ($125 to $250 each per annum), by the sale of the news to the English newspapers, and the subscriptions to the *List*, which has a large circulation in all parts of the world.

A Singular Accident.

The engine house of the Nightingale Brothers' silk mill in Paterson, N. J., was demolished by the bursting of a fly-wheel, Oct. 19. Pieces of casting weighing five or six hundred pounds were thrown half a block away, but fortunately no lives were lost. The engine, of about 100 horse power, had lain idle for years, a smaller one having been used since the mill was turned from a cotton to a silk factory. The addition of new machinery however required the use of the big engine for additional power, and machinists had been at work on it several days. On Tuesday afternoon it was run experimentally, and seemed to go all right. The governor was arranged for it to make 60 revolutions a minute. Wednesday morning, when the fireman started up the boilers, the engine started off on its own account and could not be stopped, as the steam supply-valve was already closed, and there was no apparent reason for its going. It continued to increase its speed until it was estimated that it was running at the rate of 150 revolutions a minute. The limit of safety was considered to be 75 revolutions. In alarm the few men about the building fled for their lives, except fireman Carlough and a workman named James Killen, who were still trying to turn off the steam valve, when the fly-wheel broke and the pieces flew in every direction. The fly-wheel was 15 feet in diameter, and weighed eight tons. The engine-house, which was about 30 by 15 feet and two stories in height, was almost demolished. The cause of the engine's sudden starting was discovered to be a fracture in the seat of a new supply-valve in the main steam pipe leading to the engine. In shutting off steam on Tuesday night it is supposed the pressure broke off the fractured seat, which left the pipe open for the passage of steam from the boiler.—*Scientific American.*

Another Keeley Motor Exhibition.

Keeley has just given another exhibition of his celebrated motor, or, rather, of a combination of cylinders, plungers, pumps, globes, and connecting rods, somewhere within which his motor was alleged to be at work. The trial was a very peculiar one. This motor has been threatening, for the last six years, to run a train of cars to New York and a vessel to Liverpool on about a cupful or bucketful of water. What Keeley actually did was to turn a wheel, as one experiment; to fire a bullet through three inches of plank as another; and to perform two or three other trivial feats, any of which could be produced by a very ordinary use of very familiar forces. When it is added that the exhibition was given in Keeley's own workshop, and that the room directly underneath, also occupied by him, was kept locked and bolted, and that he refused, in some confusion, to allow his visitors even to look into it, the value of the trial is obvious. To make the thing complete, the inventor, before each experiment, scraped a large tuning fork with a fiddle bow, in order to get the right pitch for the motor, which was hinted to be derived from the force of cohesion. Instead of the presto! agrimento! change! of mere conjurers, Keeley gave an explanation that, by means of the introductory impulse and the fifth compound, he so impinged on the molecular lead as to disturb the equilibrium, and then to multiply the atomic ether or liberated interatomic impulse. The only thing in the workshop, visible or invisible, which the assembled party seemed to understand, was the collation. But there is no denying the fact that by dint of some qualities Keeley has kept this sort of thing going for six years, and that he still finds stockholders who have abundant faith in him.—*N. Y. Sun.*

Cause Unknown.

Up in Minnesota, the other day, the boiler of a steam thresher exploded, killing one man, seriously injuring two others, and blowing a small boy over a high straw-stack without injury. So complete was the destruction that no part of the engine or the boiler was left where either stood before the disaster. It is not our province to criticise the report of the explosion, as given in the dispatches, nor do we care, so long as the small boy was blown over the lofty straw-stack, without injury to himself or the stack, whether the explosion was in Minnesota or Florida. We do object, however, to the concluding sentence of the telegram, which reads: "The cause of the explosion is unknown." The most important portion of the news is thus omitted. We should in all information of the kind be told whether the boiler was defective or whether an incompetent man had charge of it. Half, nay, two-thirds of the boiler explosions that occur are occasioned by one or the other, and frequently by a conjunction of both. Not long since several men were killed by the bursting of a boiler in a wheat-field near Belleville, Ill., and the coroner's jury found, upon investigation, that not only was the generator of steam defective, but that the man in charge of it was a "pick-up" from the highway, whose first experience with machinery was indubitably that which hurled him and several of his fellows into eternity without a moment's warning. It is about time that everybody, who has machinery of whatever kind, should learn to employ workmen who understand their business, and to purchase machinery which is guaranteed to be of undeniable character and from reputable makers. In this connection, the following remarks from *Iron*, London, will be found pertinent. That paper says:

It is hardly necessary to remark that in ninety-nine out of every hundred cases of fatal boiler explosions there is nothing more accidental than there would be in the deaths that might be caused by firing a gun in the midst of a crowd. If a steam boiler explodes the inference that negligence has been displayed may at once be drawn with almost absolute certainty; and the business of a court of inquiry in such a case is to fix the responsibility for the occurrence in the proper quarter. To talk of "accidents" in these matters is sheer nonsense. If the cupidity which induces owners to work boilers long after they should have been broken up as old iron, or to withhold the outlay for keeping them in satisfactory repair, and the carelessness of boiler tenders are accidents, then the verdicts of coroners' juries are sound; otherwise they are simply meaningless. It is high time that public opinion should undergo some degree of education in such matters, and it clearly rests with the authorities to impart the training required by instituting criminal proceedings in every case of gross negligence.—*St. Louis Miller.*

The Earliest Castings in Iron.

Cast-iron is now in such general use that one might be apt to imagine that it had never been invented. But cast-iron was not in commercial use before the year 1700, when Abraham Darby, an intelligent mechanic who had brought some Dutch workmen to establish a brass foundry at Bristol, conceived the idea that iron might be substituted for brass. This his workmen did not succeed in effecting, being probably too much prejudiced in favor of the metal with which they were best acquainted. A Welsh shepherd boy named John Thomas had some little time previous to this been received by Abraham Darby into his workshop on the recommendation of a distant relative. While looking on during the experiments of the Dutch workmen, he said to Abraham Darby that he thought he saw where they had missed it. He begged to be allowed to try, so he and Abraham Darby remained alone in the workshop all night struggling with the refractory metal and imperfect moulds. The hours passed on and daylight appeared, but neither would leave his task, and just as the morning dawned they succeeded in casting an iron pot complete. The boy entered into an agreement with Abraham Darby to serve him and keep the secret. He was enticed by the offer of double wages to leave his master, but he continued faithful, and from 1709 to 1828 the family of Thomas were confidential and much valued agents to the descendants of Abraham Darby. For more than one hundred years after the night in which Thomas and his master succeeded in making an iron casting, in a mould of fine sand contained in frames and with air-holes, the same process was practiced and kept secret at Coalbrookdale with plugged keyholes and barred doors. —*Van Nostrand.*

Using Fine Anthracite Coal.—Until lately, the smallest size of marketable coal was termed pea; lately two smaller sizes are being prepared. They are buckwheat and diamond, the latter only at one or two colleries in the Lehigh region. Wootten's so-called dirt-burning engines are supplied with the buckwheat, and the motive power is thus created out of what was formerly cast away as waste. These engines use up about 1,000 tons a day, and to supply them a large jig house containing 24 coal-cleaning and slate-separating machines is being erected in the St. Nicholas district near the Elmwood colliery, to which the buckwheat-bearing dirt will be shipped from the different collieries. The culm from only a few colleries can be used, as that which is freest from bone and slate is alone used.—*Republican.*

Weldless Ring-plates for Boilers.

A new process for rolling weldless ring-plates for boilers, with a view of avoiding the longitudinal seams which are necessarily a source of weakness in boilers constructed of ordinary plates, has just been designed and patented by Mr. J. Windle, of Manchester, and formerly of the Railway Steel Plant Works, Newton Heath. In the rolling mill, which has been specially designed for this work, a fixed and a movable roller are employed. The axles of these rollers are provided with top bearings, and to enable the metal to be rolled to be placed in position and the rolled ring to be removed, the upper bearing of the movable roller is arranged to be withdrawn. This bearing is fixed on the outer end of a lever hinged to a sliding standard, connected with the carriage carrying the movable roller and actuated by means of hydraulic cylinders. Vibrating frames are also employed, carrying two, three, or more rollers, and a number of the carrying rollers are connected by gearing with revolving shafts, so as to assist in carrying round the ring. In working out this method of rolling, a hole is punched in a steel ingot or a bloom of metal, and, a mandrel having been inserted, the metal is placed under a steel hammer, until a rough cylinder of sufficient length is obtained or a hollow cylinder is cast, and the ring then rolled to the requisite size and shape in the mill above described. These rings can be produced with either thickened or flanged edges, and by their use a much stronger construction of boiler, it is claimed, can be secured.—*Boston Journal of Commerce.*

A Cohoes, N. Y., man writes us that he has a block of cast iron four feet square and four feet high that he wants to break up for the foundry, and wants to know how he can do it. "It stands in a lot away from any house," says the writer, who asks for our opinion in the matter. We cheerfully give our advice: Invite those scientific gentlemen who are inventing and manufacturing explosive machines and compounds for blowing up ocean steamships to a free test of the efficiency of their most powerful agents upon this fourteen and a half-ton block of iron. Any compound or device that will effectually shiver it into pieces small enough for the foundry can be trusted to blow the strongest steamship to smithereens. This course will save money. Drilling and blasting upon the old plan might cost as much as the iron is worth.—*American Machinist.*

A Midget Motor.—A little curiosity in engineering has been constructed by an ingenious clockmaker, Mr. D. A. Buck. This is in all probability the smallest steam engine in the world, for it is almost microscopic in its dimensions. The whole machine weighs only about a gramme, or 15 grains, and is entirely covered by an ordinary thimble. The stroke of the piston is a little over 2 millimeters or $\frac{1}{12}$ inch, and its diameter is something less than a millimeter and a half. Nevertheless it is built up of 140 distinct pieces fastened together by 52 screws; and three drops of water suffice to fill the boiler, and set the toy mechanism in motion.—*Van Nostrand's.*

We have heard much of toughened glass of late, but Mr. Frederick Siemens now proposes to adapt that made by his process to the manufacture of street lamp-posts, water mains, and other articles made of cast-iron. He claims that his glass is stronger than iron castings, imperishable, and incorrodible. The cost per pound, allowing more profit to the maker than can be obtained from iron, is twice as much as the cost of the latter, but the specific gravity is so much less that the consumer will be able to obtain glass articles about 33 per cent. cheaper than similar goods in cast-iron. We shall see.—*Industrial World.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES — VOL. II. HARTFORD, CONN., DECEMBER, 1881. No. 12.

Machine Riveting.

There has been no little discussion among engineers as to the relative merits of hand and machine riveting. Those belonging to the old school class of engineers have been slow to recognize any advantage in riveting by machinery, and in many boiler shops hand riveting is the practice to-day. Sir William Fairbairn advocated machine riveting

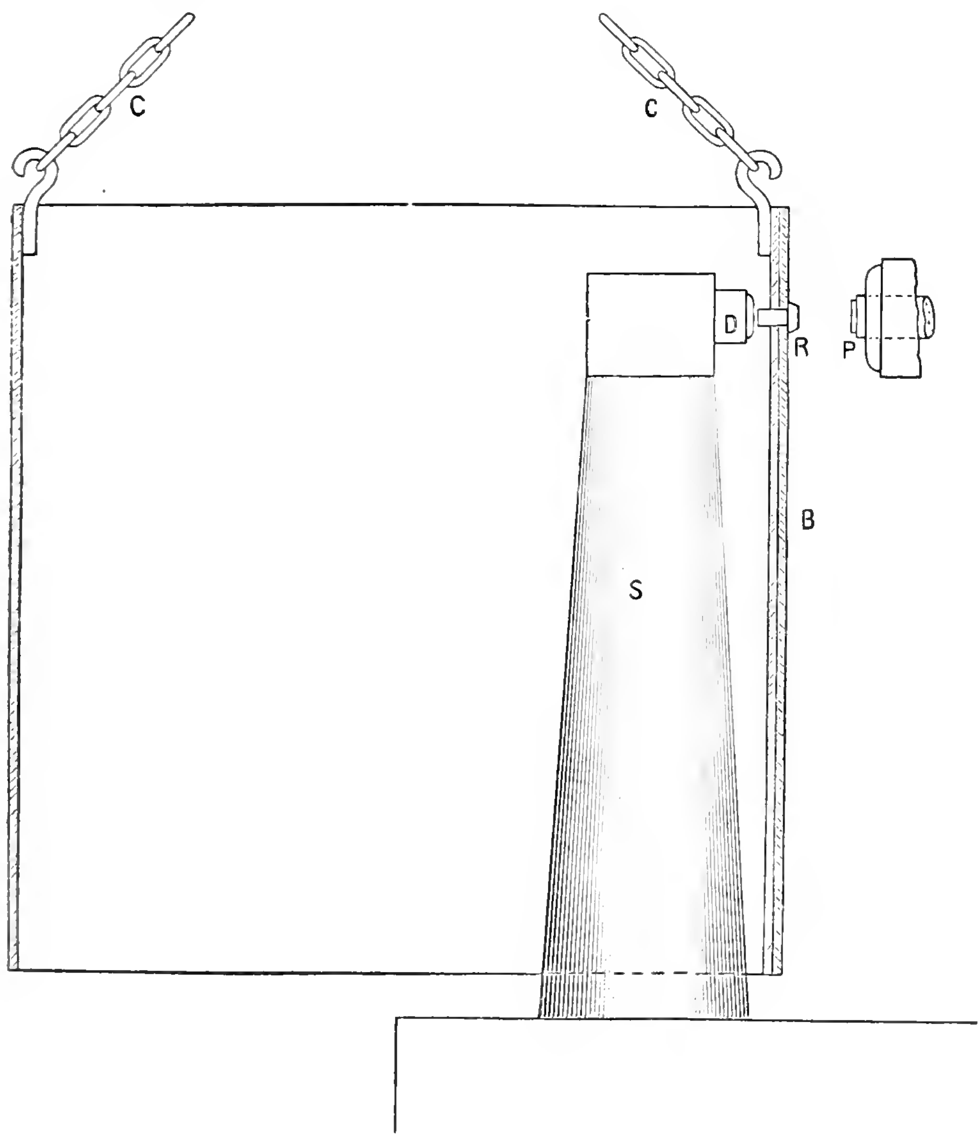

FIG. 1.

more than twenty years ago. He says, "In hand riveting it will be observed, that the tightness of the joint and the soundness of the work depend upon the skill and also upon the will of the workmen or those who undertake to form the joint and close the rivets. In the machine riveting neither the will nor the hand of man has anything to do with it: the machine closes the joint and forms the rivet with an unerring precision, and in no instance can imperfect work be accomplished so long as the rivets are heated to the extent compressible by the machine. This property of unvarying soundness in the work constitutes the superiority of the machine over hand riveting." Sir William says much more, and while in the main his statements are correct there are certain important qualifications which will appear farther on. The machine which he used and which is illustrated in one of the vols. of *Useful Information for Engineers*, was driven by a belt and far inferior to the steam and hydraulic riveting machines of to-day. Still with this machine he accomplished some good work as is shown by the experiments on the strength of joints riveted up with it. The steam and hydraulic machines as first constructed were too light to accomplish the best results; there was more or less vibration and consequent imperfection in the joint. This difficulty has been mainly overcome by the additional strength and weight which has been given to the machines.

Fig. 2.

Fig. 3.

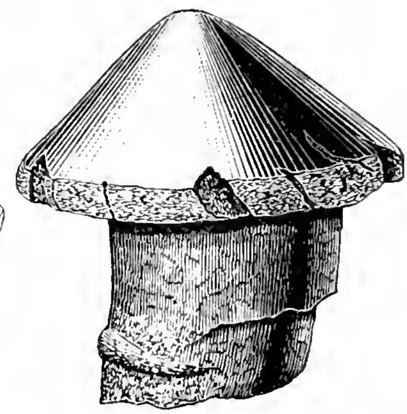

Fig. 4.

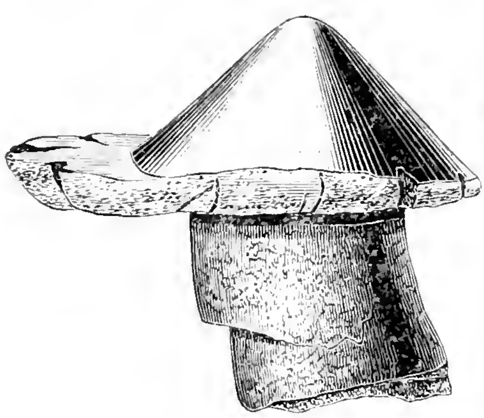

Fig. 5.

Fig 6.

If, however, careful men and men of good judgment are not employed, very poor and inferior work may be done with the best machines. It is well known to those familiar with steam or hydraulic riveting machines that there is a cup-shaped die on the end of the piston rod which presses against a fixed die. The work is brought into position for riveting by cranes. The rivet is placed in position by hand, the pressure is admitted to the cylinder and the die on the piston rod presses against the rivet head which finds resistance against the fixed die and is pressed into shape. Fig. 1 will show the relative position of the several parts of a riveting machine. S is the standard on the top of which is the fixed die D. The piston rod die is indicated at P. The rivet R, and the section of the boiler to be riveted by B, C C show the chains which support the section of boiler, which are attached to the crane above. Now it will be seen that to do good work the axes of the two dies must be in exact line. If one is higher than the other, or if the piston varies to the right or left, the result will be an imperfect rivet.

These errors we should not expect to find in a well made machine, under the supervision of a careful, intelligent man. But another difficulty, and one which even the best machine cannot overcome, is carelessness in the adjustment of the rivet holes in the plates to be riveted. If the axis of the rivet hole is not coincident with the axes of the dies, an imperfect rivet will be the result, and the imperfection will be increased in proportion to the variation. To make this plainer. If the man in charge is careless in adjusting his work to the machine, that is if he elevates it too high or lowers it so that the rivet hole is a little below the dies, or if the material swings or sways to the right or left, the result will be an imperfectly formed and weak rivet. This is a difficulty that is not confined to any one shop. We have it in connection with the work of some of the best shops. The following Figs. are specimens of rivets which have been carelessly driven, and which we have selected from a collection of rivets that have been gathered up from different places. From the foregoing it will be readily seen that this class of imperfect work is solely the result of carelessness on the part of the man in charge of the machine. When the boiler is all riveted up it may be next to impossible to detect the true character of the work. But when leaks begin to appear and repairs become necessary the defective workmanship becomes apparent. Boiler makers cannot be too careful in having competent workmen for such service, for in addition to the risk of impairing a well earned reputation, a very weak boiler may be unwittingly put to service.

Inspectors' Reports.

OCTOBER, 1881.

Below is given the one hundred and eighty-first monthly summary of the work done in the Inspectors' department, which will be found of more than ordinary interest. From it we learn that a greater number of visits of inspection were made during the month of October last, than during any other month since the company was organized, while the number of boilers inspected was also greater by 163 than for any other month, and exceeds the number made during the corresponding month last year by 623, or nearly 17 per cent.

The total number of visits of inspection made foots up 2,147, and the whole number of boilers inspected was 4,452, of which number 1,494 were annual internal inspections. 466 boilers were subjected to hydraulic pressure. Of this number the greater portion were new, the remainder were principally boilers which had required repairs, and were so treated to test the tightness of the joints.

The following is the detailed summary of defects found: —

	Whole Number.	Dangerous.
Furnaces out of shape,	106	17
Fractures,	207	99
Burned plates,	96	35
Blistered plates,	298	26
Cases of deposit of sediment,	228	44
Cases of incrustation and scale,	373	43
Cases of external corrosion,	109	28
Cases of internal corrosion,	92	15
Cases of internal grooving,	18	11
Water gauges defective,	27	13
Blow-outs defective,	17	7
Safety-valves overloaded,	29	19
Pressure gauges defective,	160	35
Boilers without pressure gauges,	67	2
Cases of deficiency of water,	9	7
Braces and stays broken,	26	17
Loose rivets,	10	
Loose tubes,	4	
Total defects,	1876	418

Boilers condemned, - - - - - -	19
Heads condemned, - - - - - -	1

The item of loose tubes refers to a very glaring case of defective construction and management of upright tubular boilers, the furnace being altogether too cramped in height, and sediment being allowed to accumulate, sometimes to a depth of 6 inches on the lower tube-sheet, the natural consequence being, that whenever fresh fires are lighted, the lower tube-sheet and ends of the tube become very much overheated, so much so, in fact, that nearly all of the tubes are in a chronic state of leakage, being many of them so loose that they can easily be shaken about with one hand, and the tube-sheets bulged to the extent of seven-eighths of an inch. In the above case the distance from the top of the grates to the crown-sheet is but 32 inches, and the fires being carried nearly a foot deep, there remains only about 20 inches for the height of the combustion chamber, which is not nearly enough for soft coal, which is used in this case. In boilers set in this manner for burning soft coal, it may safely be assumed that the height of the furnace, to give proper combustion of the fuel, should not be less than three to four feet above the top of the layer of fuel. Furnaces for upright, and internally fired boilers also, are in nine cases out of ten made very much too shallow and restricted in their proportions to give good results. Too little attention is generally given to this subject. The direct contact of *flame* with the surface of the shell under such circumstances is very detrimental to economy.

Boiler Explosions.

NOVEMBER, 1881.

SUGAR-MILL (137).—An explosion occurred at Atwood's sugar mill in Cal., Sept. 27th, by which two boilers were destroyed, the boiler-house blown down and the main mill set on fire.

SAW-MILL (138).—The boilers of Samuel Johnson's saw-mill exploded near Gestville, Ky., on Monday, Oct. 31st, killing David Hoover, and mortally wounding John L. Johnson, Pleasant Huesley, and Jennes Hall, and seriously hurting five others.

ROLLING-MILL (139).—A flue in one of the large boilers of the Columbus Rolling-Mill, Columbus, O., collapsed Nov. 2d, with a terrific report that startled the entire northwestern part of the city. The dust, broken brick, and steam filled the mill in a dense and blinding volume, making it impossible at first to learn the extent of the injury to life and property. After the steam and dust had cleared away it was found that John Secrist, the fireman of the nest of boilers, was seriously though not fatally scalded about the neck and shoulders. Another workman named John Fineron was blown some twenty feet by the escaping steam, but was not injured. There were three hundred men working in close proximity to the collapsed boiler at the time, and it was surprising that a number of them were not killed under the circumstances.

SAW-MILL (140).—A terrible boiler explosion occurred near Coalton, Ohio, Nov. 2d, in a portable saw-mill owned by Davis & Jones, resulting in fatal injuries to John Davis, one of the owners, and serious, if not fatal, injuries to David Griffiths, the sawyer. The boiler was an old one, and the same old causes — low water and carelessness — were the reasons for the fearful result.

——— MILL (141).—A boiler flue in Smith Brothers' mill, West Bay City, Mich., collapsed, Nov. 10th, seriously injuring two of the employees. Moses Dubey's injuries were thought to be possibly fatal. He was blown through a partition an inch in thickness, striking against a cart beyond; he was also badly scalded, as was Clement Brabo, the other injured man.

SAW-MILL (142).—A terrific explosion occurred at the saw-mill of Hamilton, McClure & Co., at Zilwaukee, six miles below East Saginaw, Mich., at a quarter before 5 o'clock, Nov. 13th. A battery of ten large boilers exploded with terrible force, and wrecked everything in the immediate vicinity, pieces of the boilers, bricks, and timbers, being thrown hundreds of feet in every direction. The brick boiler-house and brick smoke-stack 100 feet high were leveled to the ground. The west end of the saw-mill was badly shattered and the salt block considerably damaged. The roof and tower of the drill house, 200 feet distant, were badly shattered. Eight of the boilers were torn into shreds and hurled hundreds of feet away, and the other two considerably damaged. Only four men were at work in the boiler-house, and all were killed. Michael Lebeau, head fireman, was found under the debris, his body wound around a large post, mangled terribly. It took an hour to dig him out of the debris. His brother, Joseph Lebeau, and Charles Carpenter, were thrown thirty feet away, their clothing torn off, and bodies blackened and bruised. Frank Blanchard was thrown 250 feet away into the mill boom. The accident was caused by low water, and the damage will amount to $25,000.

STEAM TUG (143).—The boiler of the steam tug Lehigh exploded Nov. 13th, at Glen Island, N. Y., tearing the vessel to splinters and instantly killing James Tillotson, deck hand and cook. The explosion terrified the inhabitants of the surrounding country, many of whom imagined that there had been an earthquake, and ran out of their houses in alarm. The tug was made fast to a scow anchored one hundred feet from shore near the southern end of Glen Island. The tide being too low to tow the scow out the captain and the engineer went to the "flats" which lie between Glen and Hunter's Islands to dig clams and rake for oysters. While they were engaged in this occupation, about half an hour later, the explosion occurred. Tillotson was the only person on the boat. He was blown high into the air, and descending, he fell into the water about one hundred and fifty feet from the scene of the explosion. The tug was blown all to pieces, and the debris was scattered around in the water and on the shore for 1,000 feet. The boiler was torn to fragments. A large portion of it was thrown fully 700 feet over Judge Emmett's house, and here it buried itself in a field. Another piece was blown over on Hunter's Island, and other fragments still were blown on to the main land. The scow or "waterboat," as it was called, to which the Lehigh was made fast, was ruined. The side was torn out, the deck was lifted off, and the boat was made almost a total wreck. Tillotson's skull was crushed, his left side stove in, both legs were shattered, and he was scalded from head to foot.

——— (144).—A boiler explosion at Knapp's creek, a few miles east of Bradford, Pa., Nov. 21st, demolished the boiler house, wrecked the residence of Superintendent Allison, and fatally injured Mrs. Allison, who was terribly lacerated on the left arm and shoulder by flying boards. She is not expected to live. A portion of the boiler flew through the side of the house, passing over the head of Mr. Allison's sister. Two of the children playing in the yard had their faces filled with flying splinters and shattered fragments of glass from the windows.

TANNERY (145).—The boiler in D. Milliken & Son's tannery, Bangor, Me., exploded Nov. 22d, nearly demolishing the building, which was old and of little value. Seven men were in the building at the time of the accident. A man named William Barston, standing within four feet of the boiler, was blown twenty feet through a window. His left arm and a portion of his left side were badly scalded, his right arm and thumb somewhat injured, and was also scalded on the right side of the face. Albert Milliken was blown through the roof, but received only slight injury. A man named Ames was knocked down, but was uninjured. The boiler was located in a pit below the level of the floor, and when the explosion occurred, it was lifted up and went out through the side of the building, and the roof fell in.

SAW-MILL (146).—The boiler at Hubers' steam saw-mill, two miles south of Clyde, exploded, Nov. 24th, tearing the mill to atoms. No one hurt. Cause, placing a scantling on the safety valve, and leaving it to attend customers.

SUGAR-MILL (147).—A boiler explosion occurred on Thanksgiving day at Mr. John Dymond's Belair sugar house, Plaquemine parish, La. The cause of the disaster was the explosion of the drum, which spread general ruin in the shed adjoining the sugar house where the boiler was placed. The shed was torn to pieces, and slates, brick, and timber, were scattered in every direction. It was dinner hour at the time, and the hands were congregated in the building. A freezing wind was blowing outside. On clearing the debris, seven of the hands were found among the injured. They were Joseph Mulladon, fireman, leg broken and badly scalded; Martin Van Miller, body, face, and limbs badly scalded; Henry C. Lade, terribly scalded all over—all residents of New Orleans; John McNorton of Cincinnati, badly scalded; Edward Battye of Yorkshire, England, hands and face scalded; Charles Creel and Edward Dellard, both colored, badly scalded. The injured men were taken to the Charity Hospital at New Orleans, immediately, and every attention afforded them. Joseph Mulladon expired in great agony shortly after he reached the hospital. John McNorton died at four o'clock the next morning. The condition of the others is very precarious, and it is not supposed that any of them can survive their injuries.

SAW-MILL (148).—A boiler in James Henry's shingle mill, Grand Rapids, Mich., exploded Nov. 27th, killing Joseph Slater, the engineer, and David Hardy from Maple Hill. George Bland was also slightly hurt. The mill was entirely destroyed and a residence adjoining was badly injured.

——— MILL (149).—A boiler explosion at the mills of Douglass & Sons, Mud Creek, Texas, Nov. 29th, killed three white men, the engineer, Oliver Wilson, two laborers named Burkell and Billips, and fatally injured a colored man. The mill was blown to atoms.

THE NEW YORK ELEVATED ROADS.—But few persons who have not been in New York since the construction of the elevated roads, and witnessed their equipments and operations, can have any adequate idea of the extent of them, and of the people, machinery and appurtenances required in working them. A recent inventory discloses the fact that there are 24 miles of roadway, 161 stations, 203 engines, and 612 cars, while 3,480 trains a day are run. There are 3,274 men employed on these roads, 309 of whom are engineers, 258 ticket agents, 231 conductors, 308 firemen, 395 guards or brakemen, 347 gatemen, 4 road inspectors, 106 porters, 33 carpenters, 27 painters, 69 car-inspectors, 140 car-cleaners, 40 lamp men, 470 blacksmiths, boiler makers, and other mechanics employed on the structure and in the shops. Most of the ticket agents are telegraph operators, but there are 13 other operators employed. There are four double-track lines in operation. The aggregate daily receipts vary from $14,000 to $18,000; and as many as 274,623 passengers have been carried in one day. Engineers are paid from $3 to $3.50 per day; ticket agents, $1.75 to $2.25; conductors, $1.90 to $2.50; firemen, $1.90 to $2; guards or brakemen, $1.50 to $1.65; and gatemen, $1.20 to $1.50. The above items do not include machinists and other employees in the workshops, or the general officers, clerks, etc. One of the elevated railroad companies owns a curiosity shop of articles lost or left on their trains. There are 1,000 umbrellas and half as many canes; shelves filled with shop parcels; children's school books; laborers' tools and dinner pails; novels; a handsome new Bible; lunch baskets; black bottle; two large baskets full of pocket books, mostly women's on their way home from shopping, and consequently little in them; bushels of traveling bags; a big bass drum; a rabbit and a poodle-dog. One woman who recovered a casket of jewels not only did not give any reward, but did not even say "thank you" on recovering them. Umbrellas are generally left behind in the latter part of a day that began raining and cleared up in the afternoon.—*The Review.*

The Locomotive.

HARTFORD, DECEMBER, 1881.

Volume II. of The Locomotive, New Series, closes with this number, and the business of another year will shortly have been finished. The *Hartford Steam Boiler Inspection and Insurance Company* congratulates itself on having done the largest business in any year of its existence. It now has between 13,000 and 14,000 boilers under its care, and employs thirty (30) inspectors in their supervision. It will be seen that no small burden of responsibility rests upon the company in the care of so large a number of boilers. The explosions during the year have been numerous and destructive, and yet but one boiler under the care of the company has exploded with serious consequences.

The tendency to employ cheap and irresponsible men as engineers no doubt contributes largely to swell the number of these accidents; but it is also true that when business is good and heavy orders roll in upon manufacturers, their inclination is to work their boilers up to their full capacity and more. We have often called attention to this danger, and have used our utmost endeavors to keep them within bounds. When unable to do this, we have canceled our obligations and declined to assume any responsibility beyond a point which, in our judgment, was absolutely safe. The different opinions of "experts" is an interesting study. One will pronounce a boiler of a certain type and construction perfectly safe for certain duty; another will condemn it in toto, and represent it as almost incapable of sustaining its own weight. These contradictions we are obliged to meet, and are called upon to use our best judgment, based upon an experience with thousands of boilers for many years. It is not our purpose to controvert the opinions of men of intelligence, experience, and judgment. We are always gratified to receive their suggestions, and adopt any that are really valuable and that have been practically proved; but we cannot afford to run our business on fine-spun theories that have had no practical test, for, unlike experts, we guarantee our judgment.

Experience teaches us that nine-tenths of the boiler explosions in the country are attributable to carelessness on the part of the engineers, or to the cupidity and avarice of the owners, who, to save the expense of additional boiler power, will order their boilers to be run at excessive and dangerous pressures. Another question which arises is, What is the safe pressure at which a boiler may be run? This has occasioned no little discussion of late. There is no rule, nor indeed can there be any, for boilers of inferior material and workmanship. All rules are based on the assumption that the tensile strength and ductility are known and that the type and workmanship are in all respects correct. But, even with these conditions, there is a wide difference of opinion as to the safe working pressure of boilers. Extensive experiments are being made on the strength of riveted joints. This problem involves the size and pitch of rivets, and we predict that the result will be a very considerable change in the practice of many boiler shops.

The aim of all this is to render the use of boilers as safe as possible, and all boiler-makers will, we trust, be in full sympathy with the movement. The results of experiments will be published in The Locomotive from time to time, as well as comments on methods of construction and the care and management of boilers, and we trust that the efforts of the coming year will gain for it the same high commendations which it has received in the past.

We are pained to learn of the death of Horace McMurtrie, Esq., which occurred in Boston about the first of December. Mr. McMurtrie was in our Boston office a few days before his death. At the time he was suffering from a severe cold, which speedily terminated in pneumonia. Mr. McMurtrie had a wide circle of friends who will miss his genial face and companionship. During the war he was in the naval service, attached to Farragut's squadron, acting in the capacity of chief engineer. He was with the renowned admiral at the battles of Mobile and New Orleans. Mr. McMurtrie was a mechanical and steam engineer of no ordinary abilities. He had had wide experience, and was unusually intelligent on subjects connected with his profession.

Chimneys.

We think we may safely venture the assertion that at least one-half of the chimneys in use to-day in connection with boilers are altogether too small to economically serve the purpose for which they are used. There seems to be a very general misunderstanding in regard to their correct proportion among those most deeply interested in their efficient performance, viz., the owners of the chimneys themselves.

The object of a chimney is, of course, well known to be the means by which the draught necessary for the proper combustion of the fuel is produced, as well as to furnish a means of discharging the noxious products of combustion into the atmosphere at such a height from the ground that they may not be considered a nuisance to people in the vicinity of the chimney.

Regarding the second of the above purposes for which chimneys are built, we need only say that it is of secondary importance only, and that where due attention is given to the proper methods of setting boilers and proportioning grate areas, furnaces, and rate of combustion, the smoke nuisance is comparatively unknown, and is of no practical importance whatever.

The main points, then, to be considered in designing chimneys are the right proportions to insure first, a good and sufficient draught; and second, stability.

Without entering into any demonstration of the velocity of the flow of the heated gases through the furnace and flues leading into and up the chimney, we will briefly state a few of the principles governing the dimensions of chimneys. The motive power or force which produces the draught is the action of gravity upon the difference in the specific gravities of the heated column of the gases of combustion inside the chimney, and the atmosphere at its normal temperature outside of the chimney, by which the former is forced up the flue; and the laws governing its velocity are the same as those governing the velocity of a falling body, and it can be proved that its velocity, and consequently the amount or volume of air drawn into the furnace, and which constitutes the draught, is in proportion to the *square root* of the height of the chimney. It is a common error that the force of the draught is in direct proportion to the height; so that with two chimneys of the same area of flue, one being twice the height of the other, that the higher one would produce a draught twice as strong as the other. The intensity of draught under these circumstances would be in the proportion of the square root of 1 to the square root of 2, or as 1 to $1\frac{42}{100}$. To double the draught power of any given chimney by adding to the height it would be necessary to build it to four times the original height. Practically, there is a limit to the height of a chimney of any given area of flue, beyond which it is found that the additional height increases the resistance due to the velocity and friction more rapidly than it increases the flow of cold air into the furnace. For chimneys not over 42 inches in diameter the maximum admissible height is about 300 feet.

From an investigation of the same laws, we find that the velocity of the flow of cold air into the furnace is in proportion to the square root of the ratio between the density of the outside air and the difference in the densities of the outside air and the heated gases in the chimney, from which we may deduce the fact that very little increase of draught is obtained by increasing the temperature of the gases in the chimney above 550 or 600 degrees Fahr. By raising the temperature of the flue from 600 to 1,200 degrees we would increase the draught less than 20 per cent., while the waste of heat would be very considerable. Conversely, we may reduce the temperature of the flue about one-half when the temperature is as high as 600 degrees by means of an economizer, or otherwise, and the *reduction* of draught force would be only about 20 per cent., as before.

It is found that the principal causes which act to impair the draught of a chimney and which vary greatly with different types of boilers and settings are : the resistance to the passage of the air offered by the layer of fuel, bends, elbows, and changes in the dimensions of the flues, roughness of the masonry of brick flues, holes in the passages which allow the entrance of cold air, and generally any variation from a straight, air-tight passage of uniform size from combustion chamber to chimney flue, and the resistance to draught is in direct proportion to the magnitude of and number of such variations.

In designing a chimney, it is, therefore, always necessary to consider the type of boiler, method of setting, arrangement of boilers and flues, location of chimney, and everything which will be likely to, in any way, interfere with its efficient performance. Much, of course, depends upon the judgment and experience of the designer, and it would be impossible to give any general rule which would cover all cases. When only one boiler discharges into a chimney, for instance, the chimney requires a much larger area per pound of fuel burned than when several similar boilers discharge into a chimney of the same height, and, taking all these varying circumstances into consideration, a great deal of judgment is in many cases required to determine the proper dimensions.

It is a common idea that "a chimney cannot be too large,"—in other words, the larger the area of the flues the better the draught will be, but this is not always the case. In many cases where a chimney has been built large enough to serve for future additions to the boiler power, the draught has been much improved as additional boilers have been set at work. The cause of this is to be found in the increased steadiness of draught where several boilers are at work and are fired successively, as well also as in the better maintenance of the temperature of the flue, as the velocity of the gases necessarily increases with the increased amount required to be discharged, and they do not have time to cool off to so great an extent as when they move more slowly.

(To be continued.)

In the Special report of the Boston Manufacturers' Mutual Fire Insurance Co., is given the following receipt for a cheap and simple non-conducting covering for steam-pipes :

Four parts coal ashes sifted through a riddle of four meshes to the inch, one part calcined plaster, one part flour, one part fire-clay. Mix the ashes and fire-clay together to the thickness of thin mortar in a mortar trough ; mix the calcined plaster and flour together dry, and add to it the ashes and clay as you want to use it ; put it on the pipes in two coats, according to the size of the pipes. For a 6 inch pipe put the first coat about $1\frac{1}{4}$ inches thick ; the second coat should be about $\frac{1}{2}$ inch thick. Afterwards finish with hard finish, same as applied to plastering in a room. It takes the above about two hours and one-half to set on a hot pipe.

The Abatement of the Smoke Nuisance.

In referring to the International Exhibition of Smoke-Preventing Appliances, now being held at the Exhibition Buildings, South Kensington, *Engineering* says :

The Exhibition is mainly divided into two classes of exhibits, Sections A, B, and C comprising domestic appliances, and Section D those for industrial use. Besides these, there are also Section E, for various fuels applicable to domestic or industrial purposes, or both, and Section F for foreign exhibits of all classes. Section A includes "open coal fire-grates, stoves of all kinds, kitcheners, kitchen ranges, draught regulators, base burners, and other appliances devised to prevent smoke from bituminous coals, or to consume anthracite or other smokeless coals or fuel for domestic use." Section B comprises "gas fires, open grates and stoves, gas-producers, and gas heating apparatus of all kinds for domestic use." Section C includes "appliances for heating rooms and buildings by hot air, hot water, and steam circulation"; and Section D "gas engines, boiler furnaces, varieties of fire-bars, mechanical stokers, smoke preventing bridges, and other appliances for steam engine and general industrial purposes." The greater part of the exhibits are comprised in Sections A and D. Section B is fairly represented, but the foreign section is small, so that the "International" character of the Exhibition is not extensive.

It will thus be seen that, while the abatement of the domestic smoke nuisance is the first object of the Exhibition, the range of subjects is considerably extended in Section D, and a wider interest is given to the Exhibition, which might not otherwise have been of great interest to the engineer and the manufacturer.

An important part of the programme of the exhibition is the trials and testing of domestic heating appliances for "heating power, cost, convenience, quality of combustion, and their comparative freedom from smoke and noxious vapors," and of furnaces and apparatus for industrial purposes with reference to "the combustion of fuel and the prevention of smoke, having regard also to evaporative performance." The Committee have engaged the services of Mr. D. Kinnear Clark to superintend the trials under the direction of the Executive Committee.

We trust that a detailed examination of the exhibits will show that the few and elementary scientific principles upon which the solution of the problem depends have been carefully kept in view by the designer of the varied apparatus shown. The mingling of the products of *partial* combustion with a sufficient supply of air at a temperature and under conditions adequate for *total* combustion, is the chief thing to be borne in mind. Total combustion means not merely the rendering of the products of combustion invisible. It means the conversion of the carbonic oxide produced into carbonic acid, and of the sulphurous acid produced into sulphuric acid, in fact, of the highest degree of oxidation of the products of partial combustion being effected of which the nature of the case will admit. What change in the nature of a London fog would be brought about by the general adoption of "smoke-preventing appliances," we do not venture to prophesy. How far the mere rendering of the smoke invisible — that is, the mere removal of the particles of carbon in suspension — will effectuate this object, depends upon the extent to which a London fog will lay hold upon and bring down into our lungs the irritating gases which remain when the soot has gone, and this is still only a matter for speculation. To breathe an air loaded with carbon dust and water vapor, linked in an unholy alliance, is no doubt trying, but perhaps, after all, the invisible carbonic oxide and sulphurous acid contribute most to the nuisance under which we suffer.

The clogging of the pores of plants and animals is referred to by eminent authorities as one of the worst effects of the presence of smoke in our atmosphere ; but perhaps, in the end, it may appear that the gaseous concomitants may be our worst enemies.

Whether anything but an absolute absorption of these products by efficient absorbents will effectually relieve us, remains still to be seen.

Perfect oxidation, it is hardly necessary to say, results in the greatest available amount of heat being produced by the combustion of the fuel, and hence the same conditions under which the minimum of noxious products are produced are also those under which the maximum of efficiency is obtainable. Thus from an economical point of view the results arrived at should be valuable, and a still further collateral economical advantage may be hoped to arise from the application of the scientific mind to the domestic grate; in that the designer who shall give us a stove which will produce the maximum of heat will hardly be content to see 90 per cent. of that heat go up the chimney. The same remark applies to furnaces for industrial purposes, except that science has long ago turned in this direction, and that the desideratum has been already to some extent achieved.

A Use for the Keely Motor.

Keely has come to the front again, or perhaps we should say an effort is being made by his stockholders to bring him to the front, and make him divulge the secret of his wonderful alleged "motor" to some of them and obtain his patents thereon. In other words, at the annual meeting of the stockholders of the Keely Motor Co., held in Philadelphia a few days ago, "the annual report of the directors was submitted, and was to the effect that the inventor should, for the protection of the stockholders, communicate to some other person than himself the secrets he had discovered, and take out patents to cover his invention." We also learn that legal proceedings are to be instituted at once to compel him to do so, in case he refuses.

The only remarkable thing about this piece of news, is the fact, that it (the news) should have any occasion whatever to exist. We do not know exactly what is the extent of the claims made by Keely as to the capabilities of his alleged motor, but it is certain that he was going to revolutionize the entire motive power of the world, as well as to overturn several of the fundamental laws of mechanics; but thus far he seems to have signally failed of doing anything but swindle several people out of a good round sum of money.

But perhaps herein lies the wonderful "power" of the aforesaid motor, as it is well known that nothing in the shape of a prime mover that has yet been discovered has been able to extract anything more valuable than buttons from the capacious pockets of some people. Herein lies, without doubt, the broad field of its future usefulness, for we will wager a hat that it will never seriously rival that much abused machine known as the steam engine. We furnish the hint gratuitously. Let every demand for money made by political managers, or those valiant and much esteemed citizens who are engaged in the very honorable and laudable business of soliciting funds for the purpose of defraying the expenses of construction of infernal machines, designed to blow up innocent and inoffensive people when they are quietly pursuing their daily vocations, be couched in the form of a double improved Keely motor, with patented "introductory impulse," "fifth compound," and "molecular lead" attachments and supplemented by a combination of "red gas on one side, and grey gas on the other," and we will guarantee a quick and favorable response to each appeal. As the motor seems to be far too powerful and mighty to use for ordinary manufacturing purposes, we would respectfully suggest the above use for it, and then, if fatal accidents happen occasionally to those engaged in the use of it, then ———— so much the better.

Why Green's Boiler Exploded.

We clip the following from a Pittsburgh paper:

Mr. Green lived on the outskirts of town and owned a mill. He had started in life a poor boy and by industry and practical economy had accumulated a competence. His close attention to business made his enterprise a success and his mill was in constant operation.

Of late years he devoted much of his time to the study of scientific problems, and one of his chief studies was steam, and particularly relating to boiler explosions. His opinions on that subject were decided, and he believed that gases were formed from decomposed organic matter and by some mysterious process accumulated in the boilers which caused their explosions.

Mr. Green owned a fine estate, on which was built a handsome residence. Mrs. Green was proud of it, the position that she held in society, and the success attending the enterprise of her lord and master. Every rose has its accompanying thorn, and every house its secreted skeleton.

There was a thorn in the rose-tinted life of Mrs. Green which saddened her brightest moments of happiness. Immediately adjoining the princely manor of Green, was a detestable hovel owned in fee-simple by Tompkins. The Tompkins estate was an eyesore to Mrs. Green, and marred the beauty of the landscape. Many were the overtures made for its purchase. Tompkins was an erratic, independent Irishman, and detested aristocracy, and, although the price offered was many times the value of Tompkins' "bit of lot," he, from pure spitefulness and love of power to inflict a member of the detested aristocracy, refused to sell.

Tompkins, like many Irishmen, owned a "lump of a pig." The hog made predatory incursions on the Green estate, and notwithstanding closed fences, watch dogs, and cross gardeners, Tompkins' hog did much mischief to the gardens, and made picturesque the landscape set out in beautiful squares, diagonals, and diamonds of monthly blooming roses, geraniums, and dahlias. The hog was worried by Green's dog, and imbibed feelings of hatred akin to those possessed by his master for the entire Green fraternity, their retainers and dependents.

Mr. Green made a visit to a distant city on business pertaining to his mill. Before leaving he cautioned his engineer to be careful with the boilers and guard against the accumulation of gases.

The gardener fed Tompkins' pig some poison. He became thirsty and going to the creek where the pipe entered to feed the boilers, he drank largely to quench his thirst and fell over and died, covering the end of the pump pipe.

The day after Green's departure, the engineer went down town, leaving the engine in charge of the fireman. The boilers were fed by a double-acting rotary pump, with no dead centers. Soon after the engineer left, the pump, although in operation, stopped forcing water into the boilers. The fireman, lacking experience, did not know this, but supposed, as the pump was revolving, that all was right.

When the bell rang for six o'clock the machinery was stopped for the night, the fireman banked the fires and departed for home. The water was low in the boilers and the engineer had not returned from town.

Immediately over the fire-bed there was a defective sheet in one of the boilers. Mr. Green did not know of this sheet being bad, the boiler-maker did not know, and the firm that sold the iron did not know of its being defective. The iron was of the best brand of Sligo charcoal, and made from Knobling blooms. The roller that made the iron knew of the bad spot; he worked by the ton and a bad sheet knocked something off from the profits. The bad sheet was made in this way. When the bloom came from the heating furnace and after going through two or three passes of the rolls, there appeared a large blister that would swell and expand after each pass. This blister was prodded by the roller with a sharp pointed iron, allowing the gas to escape. The iron at this place did not weld, but when it was finished no appearance of the defect could be observed, and the roller passed it as No. 1 iron. This sheet was put in Green's boiler, and right over the hottest portion of the fire.

The next morning the fireman was late, and hurried up the fires. As the boss was gone, the engineer did not put in an early appearance. From the fires there soon rolled heavenward a dark volume of unconsumed carbon. The fireman tried the water. The upper gauge showed no water. He hastily tried the second, when nothing but dry steam escaped. With a nervous hand he tried the third and last gauge, and, to his horror, there was a hissing of blue steam! He rushed to the pump to start it. Fatal step! It was the match to the magazine.

It was a December morn. Frost covered the face of nature, forming beautiful crystalline flakes and making crisp the atmosphere. The moon in its last quarter shone peacefully in the heavens. Aurora was seen approaching in the east, when a crash was heard, loud, long, and deafening. The boiler had exploded, carrying death and destruction in its wake. The fireman was killed outright, and some others who had arrived early were wounded. The engineer, who lived close to the mill, was the first on the scene. Some experts arrived, and, gathering fragments of the boiler, began to investigate for the cause of the explosion.

The engineer was examined, and gave as evidence that the boiler contained "plenty of water," and could not explode from that cause. The only one that could contradict his evidence was the fireman, and he was dead.

Mr. Green arrived and was energetic in observations; he examined the feed-pipe in the creek and found the defunct Tompkins hog. He at once mounted his hobby, and showed how decomposed vegetation and decayed organic matter with a devilish intent united their gases, with a hellish purpose they entered their boilers, and with a damning result caused disastrous explosions; and very many other persons agreed with Mr. Green, and could not be convinced that a lack of water had anything to do with it.

Wanted.

"Wanted.—A boy about 17 years old, to run a steam engine. No men need apply."

The above advertisement appeared one morning not long since in the columns of a Philadelphia paper. We were much surprised to find that steam-users were obliged to advertise for *inexperienced* persons to take charge of one of the most important departments of any manufacturing establishment. We supposed that that class of engineers was common enough to be obtained without advertising; but such, it seems, is not the case in Philadelphia, at least. The only explanation of this singular dearth of incompetent engineers in the above-mentioned place, that we can offer, is that perhaps they have all gone into the *expert* business.

But, seriously, this matter of employing boys and inexperienced men for engineers and firemen is productive of more mischief than most people are aware of. No sane man would think of employing a clerk or book-keeper through whose blunders hundreds of dollars were annually lost; yet they, in many instances, will put a man in charge of boilers and engines who has no sort of an idea how much coal he is burning or ought to burn, and who will actually throw away ten times the wages of a good man every year, and think they are making money by employing him because they get him twenty-five cents a day cheaper than they do some one else.

We have a case in mind now, where a man was employed to run a new Corliss engine, which was first-class in every respect. After the engine had been running a short time it was found that the cylinders were badly "cut," then it commenced to pound badly, and could not be remedied by the engineer, and the bills for coal showed that about four pounds per hour were required to develop a horse power. After a while, this so-called engineer was "relegated to the limbo of past errors," and a new man put in his place. The "pounding" of the engine stopped immediately, and the expense for coal also immediately decreased about three-eighths, and the engines have been running beautifully ever since, without any accident whatever. In justice to this concern we will remark, that they thoroughly appreciate an *engineer* now, and it would be simply impossible for any one to hire that man away from them.

Another case which occurs to us just now is as follows: A new engine of large size had just been put into an establishment, and a man put in charge who was paid one dollar and seventy-five cents per day. The first time the crank pin brasses were fitted, this fellow neglected to replace them properly, and, before the engine had run half an hour afterwards, there was the biggest kind of a smash-up, and the damage was over twenty thousand dollars.

We could go on indefinitely citing cases similar to the above-mentioned ones, but we fear it would do little good. Owners of engines have to learn these things by experience, and refuse to be instructed in any other way.

The consequences resulting from putting an incompetent man or boy in charge of boilers are generally more disastrous than those which arise from accidents to engines alone. In the majority of accidents to engines, the damage is generally confined to cost of repairs and losses from delay of work, but where a boiler explodes, several lives are nearly always lost, and, in addition, the pecuniary loss is generally much greater.

If manufacturers would look at these things in their *proper* light of self-interest, we would never have occasion to blush at such advertisements as the above. S.

The Action of Oxygen on Mercury.—It is currently believed that oxygen combines to a small extent with mercury at ordinary temperatures; but recent experiments of M. Amagat, communicated to the French Academy of Sciences, have demonstrated that when both of these bodies are pure and dry they are without action upon one another, at least for a considerable time. The above error was introduced into science on the high authority of Regnault. M. Amagat arrived at his results by means of a Pouillet apparatus, having nitrogen in one manometer and oxygen in the other, with the metal in presence of both. Although kept for more than a month in the apparatus, the surface of the mercury in presence of the oxygen remained as brilliant as that in presence of the nitrogen.

Night work in cotton mills by the aid of the electric light is a new feature in the spinning and weaving industry in India; and the management of the Nagpur factory has shown a commendable spirit of enterprise in introducing it. The mill is lighted by forty-five lamps, the illuminating power of which equals some 36,000 candles. The system is kept going, with the aid of double shifts of work people, night as well as day. The light is produced by three Gramme machines, two of which are worked by the large engine that drives the mill machinery, and the other by a small horizontal fixed engine. Each of the three machines can keep twenty lights burning, but in practice it is found that forty lights only are required for the whole building.—*Boston Journal of Commerce.*

Explosive Force of Coal-Dust.

The Rev. H. C. Hovey has communicated to the *American Journal of Science* the results of the investigations of Mr. Gilpin, Inspector of Mines for Nova Scotia, into the part played by coal dust in spreading and augmenting the explosions which took place in the Albion mine in November of last year. The mine was thoroughly ventilated, and was reported by the night watchman, an hour before the explosions began, to be free from gas, except in small and harmless quantities. Yet the explosions, once begun, were continued at intervals till the mine was all aflame and had to be flooded. On examining the gallery shortly after the original explosion, dead bodies of men and horses were found six hundred yards from the shafts, and the wood-work was splintered, but nothing bore any mark of fire, "and the conclusion was plainly justifiable that the flame of the explosion had not extended thus far. The walls of the galleries had been swept clear of timber, and presented the appearance of having been brushed with a broom. Volumes of coal dust had been driven along by the force of the blast and lay in waves and drifts on the floor of the levels, into which the party sank to their knees. It was found that clouds of the finer particles had been carried to the shaft and beyond it into the main north level, where a secondary explosion had taken place. . . . Secondary explosions caused by extracted or generated gas are nearly always in the vicinity of the first one; but here is a case where the second was half a mile from the first, with an intervening space of at least a quarter of a mile known to have been free from flame and presumed to be free from gas, because men were in it with lamps which showed no indications of its presence." The conclusion is drawn that the fine, dry particles were driven on by the force of the first explosion across the shaft, where the dampness preserved them, into the "lamp cabin," where they were readily ignited by the lamp which was kept burning openly, and thus caused the second explosion; "and it is probable that the same agency was efficient in producing, or at least augmenting, the subsequent explosions that made it necessary to flood the whole mine." A competent explanation on chemical principles of the remarkable exhibition of force and heat accompanying dust-explosions is needed. —*Popular Science Monthly.*

Does Sea-Water Contain Free Carbonic Acid Gas?

M. P. Martin Duncan maintains that carbonic-acid gas is not present in sea-water in a free state, and cites in support of his views, Tornö, of the Norwegian Deep-Sea Expedition, who has been quoted, erroneously it seems, on the opposite side. It appears from a careful examination of Tornö's essay that that author, in the course of his experiments, found that sea-water had an alkaline reaction, and then began to believe that the carbonic-acid gas which had been taken from the water in other experiments had been produced by the decomposition of neutral carbonates during the boiling. He then proved by experiment that the saline mixture in sea-water, on the temperature being raised to the boiling point, decomposed neutral carbonates, and that all previous experiments for measuring the carbonic-acid gas in sea-water had been faulty. Of ninety-seven milligrammes of gas per litre of water found in one specimen, he estimated that about fifty-three milligrammes entered into the formation of neutral carbonates, and that the remaining forty-four milligrammes, instead of occurring free as gas, united with the carbonates to form bicarbonates. In one passage of his essay he speaks of sea-water as "an alkaline fluid which does not contain the smallest trace of free carbonic acid." —*Popular Science Monthly.*

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