HARTFORD STEAM BOILER ★ INSPECTION AND INSURANCE CO. ★

HARTFORD,

CONN.

The Locomotive.

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A Peculiar Case of Corrosion.

In our July issue we gave a cut illustrating the corrosion to which brass pipes are liable, when used *inside* of a boiler for conveying the feed-water from the shell to the place of discharge. We have no objection to the use of brass feed-pipes, *outside* of the boiler, provided they are not exposed to high temperatures; but we have repeatedly had trouble with them when they are used internally. In the case illustrated in our July issue, it was the brass feed itself that corroded, and this is the usual form the trouble

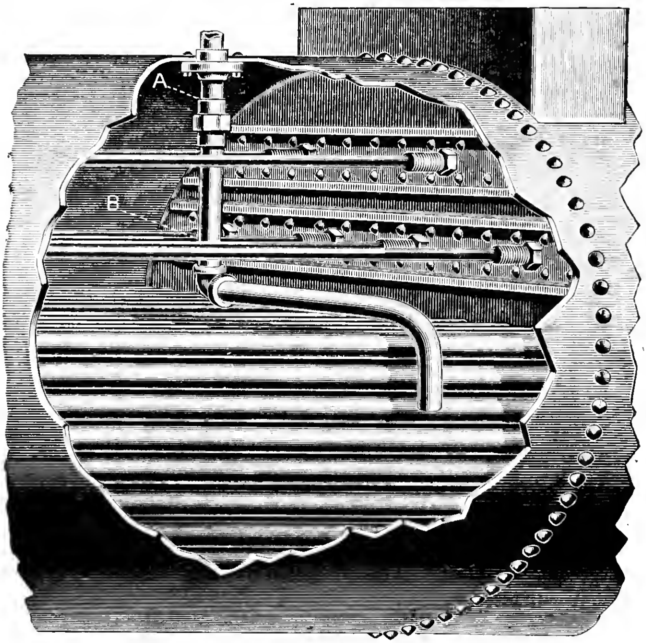
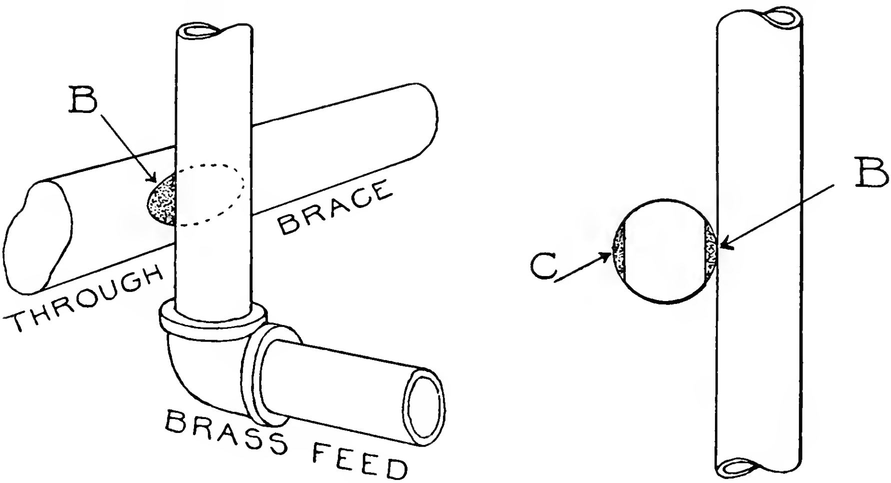


FIG. 1. — ARRANGEMENT OF THE FEED PIPE AND BRACES.

takes when brass pipes are used; but it sometimes happens that the corrosion appears in some *other* part of the boiler, — usually close to the brass pipe: — and it is a case of this kind that we have selected for illustration in the present issue.

Fig. 1 shows the general course of the pipe under consideration. It entered near the top of the shell, towards the front end of the boiler, passed downward until just below the water line, and then turned to the right and discharged downward along the side of the shell. There was a union just inside the boiler, as shown in the illustration, and at the point marked *B* in Fig. 1 the pipe passed very near one of the long through braces that are shown. The reaction of the water, as it escaped from the curved end of the feed-pipe, probably caused the pipe to frequently come into actual contact with the brace in question, at the point *B*. In fact, the pipe was fractured for a considerable part of its circumference, just above the union, at the point marked *A*; the fracture seeming to indicate that the pipe had been subjected to a repeated bending action, which had ultimately caused it to break.

The way in which the corrosion occurred is shown in the outline cuts, Figs. 2 and 3. An elliptical area, marked *B* in Fig. 2, was corroded away to the depth of perhaps an eighth of an inch on the brace, just opposite the point of probable contact of the brass pipe; while the pipe itself showed no signs of deterioration, either at this point or elsewhere. It might be imagined that the action was possibly mechanical in nature, and



FIGS. 2 and 3. — THE CORRODED BRACE.

that the loss of substance of the brace was due to the repeated contact and friction of the feed-pipe against it; but in that case we should expect to find some abrasion on the feed-pipe itself, which was not the case.

Another very curious fact, of which we can offer no reasonable explanation, is that the brace was corroded not only at the point marked *B*, but also over a similar area situated symmetrically to *B*, *but on the opposite side of the brace*, as shown at *C* in Fig. 3. This second corrosion effectually disposes of the friction theory, unless it can be shown that at some time during the history of the boiler the corroded brace has been turned half-way around. We could not learn from those in charge of the boiler that this had ever been done.

We have no theory that seems to give a satisfactory account of the cause of such corrosions as we find in this case, and we present the accompanying illustrations, therefore, not for the purpose of bolstering up such a theory, but simply because we think that they furnish still further evidence that brass should not be used for internal feed-pipes. Heavy iron steam pipe is much better for internal use, and it is also cheaper; and the brass should be reserved for external use, it being especially valuable in cases in which the feed-water is likely to produce *pitting*, in iron pipes.

Inspectors' Report.

NOVEMBER, 1895.

During this month our inspectors made 8,343 inspection trips, visited 17,387 boilers, inspected 6,811 both internally and externally, and subjected 760 to hydrostatic pressure. The whole number of defects reported reached 13,494, of which 1,381 were considered dangerous; 61 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,160	53
Cases of incrustation and scale,	2,331	70
Cases of internal grooving,	181	13
Cases of internal corrosion,	594	41
Cases of external corrosion,	763	44
Broken and loose braces and stays,	177	41
Settings defective,	385	35
Furnaces out of shape,	453	24
Fractured plates,	344	76
Burned plates,	296	24
Blistered plates,	292	1
Cases of defective riveting,	1,541	142
Defective heads,	125	17
Serious leakage around tube ends,	2,722	494
Serious leakage at seams,	497	39
Defective water-gauges,	447	93
Defective blow-offs,	234	67
Cases of deficiency of water,	32	17
Safety-valves overloaded,	95	21
Safety-valves defective in construction,	112	23
Pressure-gauges defective,	604	39
Boilers without pressure-gauges,	1	1
Unclassified defects,	108	6
Total,	13,494	1,381

Boiler Explosions.

NOVEMBER, 1895.

(288.) — A Mr. Barbee, of Joplin, Ohio, was seriously and perhaps fatally scalded, on November 1st, by the explosion of the boiler used in connection with a steam drilling-machine. He was superintending the drilling that is being done on Lafayette Haines' farm, near Galena, Ohio, and was standing near the boiler when it exploded. He was blown about 50 feet, and was terribly scalded about the face, and was also injured internally. At last accounts it was not known whether he would live or not.

(289.) — Two boilers exploded, on November 2d, in Hicks Bros.' mill, at Ashtabula, Ohio. Engineer William Stevens and his assistant, Thaddeus Bowler, were fatally injured. The mill was wrecked.

(290.) — A heating boiler exploded, on November 2d, in the Aberdeen flats, Minneapolis, Minn. The apartments belonging to W. C. Stearns and family were wrecked, and considerable damage was done to other apartments also. A local paper describes the explosion in the following graphic manner: "The heater went straight up like a rocket, breaking two heavy stringers in its flight, crushing the floor as if it had been made of paper, and, continuing in its flight, it struck the ceiling of the flat above, making a large hole. With a crash the heater then fell back into the Stearns flat, wrecking the furniture and making the apartment look as if a cyclone had played an exhibition game there. The parlor was completely devastated. All the plaster was knocked off, and the windows in the basement and first floor were blown out. . . . Mr. Stearns was in his bedroom, just back of the parlor, sick with pneumonia. He had called to his wife, and she had just left the parlor in answer to the summons, when the explosion occurred. Had she remained a few seconds longer she must have been killed. The children were also in a bedroom adjoining the parlor, and hence nobody was injured."

(291.) — A boiler exploded in the Star Iron Works, at Lima, Ohio, on November 4th. The watchman was considerably injured by flying debris. The other employes, forty in number, had just gone to supper, and so escaped injury. The main portion of the building was demolished, and the whole eastern part of the city "was shaken up."

(292.) — Two boilers in William Faloon's flouring mills, at Salineville, near Alliance, Ohio, exploded on November 4th, completely wrecking one building, and entailing a large loss. Engineer William McGilliveay and James White, a companion, had just stepped out of the boiler-room. Had they not done so they would certainly have been killed.

(293.) — A boiler exploded, on November 6th, in the basement of the *Evening Journal* building, at Detroit, Mich., wrecking half of the building, and killing no less than thirty-seven persons. Cornelius George, Charles Hergert, Annie O'Donoghue, H. G. Foye, Albert Weber, A. D. Lynch, James Holt, Martin Meyers, Carrie A. Speck, Andrew Hilderschild, Thomas Williams, Frank Gmeiner, Joseph A. Beresford, Lucy A. Holden, Margaret L. Robinson, Joseph Vinter, Walter Ott, Herman Miller, Thomas Thompson, and Michael Ward, were also injured. The ruins took fire after the explosion, and the bodies of the dead were burned, in many cases past recognition. The property loss is estimated at $100,000. We hope, before long, to illustrate this explosion in THE LOCOMOTIVE.

(294.) — A boiler exploded, on November 9th, at the Osceola Coal Company's mine, at Osceola, Pa. The engine-house was blown to pieces, and a dwelling near by was also wrecked. The pit wagons on the coal road were piled up in a shapeless mass at the entrance to the shaft, so that it was impossible for the 100 men who were below to get out of the mine in the usual way. They made their escape by another entrance, however, and only one man was injured.

(295.) — The boiler of a freight locomotive exploded, on November 10th, on the Lehigh & Hudson railroad, between Sugar Loaf and Lake Station, near Warwick, N. Y., while the train was in motion. The main part of the boiler went 50 feet into the air and fell 25 feet from the track, leaving the engine-trucks uninjured, so that the train ran about a mile and a half before it could be stopped. Conductor Martin O'Neil and engineer William Cooper were dead when found, and brakeman James L. Sloane was unconscious, and died very shortly. Fireman Herbert Beetner was found walking along the tracks, with most of his clothing torn off. He was dazed, and said he remembered going through the air, and found himself in a field, fifty yards from the tracks. He became unconscious shortly after he was found, and died a few hours later.

(296.) — On November 11th, a flue collapsed in one of the boilers in the basement of the *Tribune* building, New York city. Michael Vallely, who was cleaning the fires at the time, was badly scalded about the head, neck, and arms. It is not certain that he will recover. The building was well shaken up, but it does not appear that the property loss was serious.

(297.) — A boiler explosion occurred, on November 12th, in Compton & Beanblossom's mill, in Gettysburg, Ohio. The building was badly wrecked, and a Mr. Doren had his thigh broken.

(298.) — On November 14th, a boiler exploded in the Oakland Paper Company's mill, at Manchester, Conn. The north end of the boiler-house was blown out, and all the windows in the neighborhood were smashed. Patrick Hefferman and John Dolan were badly scalded and burned.

(299.) — Carl Kendall was instantly killed, on November 14th, by the explosion of a boiler at Joetown, near Mannington, W. Va.

(300.) — The boiler at Flinn Hanna's cotton-gin, fourteen miles northwest of Hope, Ark., exploded on November 14th. One man's leg was broken, and three other men received lesser injuries.

(301.) — A threshing-machine boiler exploded, on November 15th, near Morris, Minn., wrecking both the engine and the separator. No one was injured, as the crew were at dinner, and the fireman had just gone for fuel.

(302.) — A boiler exploded, on November 15th, in Edward E. Bruen's new building at East Orange, N. J. The damage was in the neighborhood of $5,000.

(303.) — On November 15th, a boiler exploded on the "pull-boat" *Berwick*, in Bayou Crocodile, on the Southern Pacific railroad, near Gibson, La. One man was killed outright, and two others, Reuben Simms and Daniel Patterson, were frightfully scalded, so that it is doubtful if they can recover.

(304.) — A boiler exploded on November 16th, in George W. Stamper's saw-mill, situated on the Grassy Fork of Laurel Creek, twenty miles southeast of Vanceburg, Ky. The day's work was over, and the men were sitting about the boiler-room, chatting, when the boiler burst without warning. Washington Pierce was decapitated; Cecil Kidwell was blown over one hundred yards, and his body was fearfully mangled; and John Ellison had one leg crushed. Six other employes were badly scalded.

(305.) — A boiler exploded on November 18th, in the W. Dewees Company's mill, at McKeesport, Pa. Several workmen had narrow escapes from serious injury. The smoke-stack was thrown down, and considerable damage was done to the machinery.

(306.) — On November 18th a boiler exploded in Samuel Kelley's mill, at Columbia City, Ind. Joseph Allen and Frank Kelley were killed.

(307.) — A cotton-gin boiler exploded on November 19th, on Powell S. Stuckey's plantation, Yazoo City, Miss. R. C. Brown and Henry Stuckey were fatally injured; and James Stuckey, Jackson Stuckey, and Scott Yarborough were severely scalded, so that it is doubtful if the two former can recover.

(308.) — The boiler in Marks Bros.' mill, near Ligonier, Pa., exploded on November 22d. John Clark was instantly killed, and Aaron Marks and Martin Campbell were fatally injured. Several others received lesser injuries also.

(309.) — The crown-sheet of a boiler in the Consolidated Pin Company's factory, at Bloomfield, N. J., failed on November 22d. Fortunately, there was no one in the boiler-room at the time; the damage was small.

(310.) — A boiler exploded on November 23d, at C. F. Prentice's roller mill, Le Roy, N. Y. Charles Dornbroek, the engineer, was severely scalded.

(311.) — On November 23d a boiler exploded in the Hart slaughter-house of the Meriden Provision Co., at Meriden, Conn. The night watchman, who was standing near the boiler, was horribly burned about the head and shoulders, and it is doubtful if he can recover.

(312.) — A boiler exploded, on November 24th, at the Lauderdale sugar-house of Mr. Bergondy La Pice, about five miles below Donaldsonville, La. Joseph Jackson was killed, and Daniel Kennedy and Sosthene Arceneaux were severely scalded. John Letulle was also blown over the sugar-house, but his injuries are not serious.

(313.) — A traction-engine boiler, belonging to John R. Beach of Fowler, Ind., exploded on November 24th, instantly killing the engineer, James B. Patton. Jacob Monroe and E. P. Mound were badly scalded and otherwise injured, but it is thought that both will recover.

(314.) — A boiler exploded at the electric light plant at Washington, Ind., on November 24th, scalding six men. Daniel Evans and John Welsh were fatally injured, and have since died; and C. O. Lee, Lawrence Ryan, Frank Johnson, and James Ryan were badly hurt, but will recover.

(315.) — A boiler exploded on November 25th, in S. P. Stryker's mill, near Byram, N. J. The building in which the boiler stood was considerably damaged, and three men employed in the mill had a narrow escape from death.

(316.) — A boiler exploded on November 26th, on the big tow-boat, *W. W. O'Neil*, while she was lying to, at Ludlow, Ky. Andrew McRoberts, T. W. McDermott, and William Hyser were badly scalded and bruised. It is thought that the property damage was about $8,000, though it may have been larger than this, since the machinery had not been carefully examined at the time we received our latest report.

(317.) — The boiler of locomotive No. 214, of the Jersey Central railroad, exploded on November 27th, near Penobscot station, Pa. The shell parted near the sand-box, and the engineer and fireman escaped injury. The engine had not been long out of the shops, and was believed to be in good condition, although the earlier reports of the explosion described the boiler as "rotten."

(318.) — The boiler of Runyan Bros.' saw-mill, on Cedar Creek, near Stockton, Mo., exploded on November 29th. John Runyan, one of the proprietors, was fearfully burned and mangled, and was thrown into the creek. He reached the bank of the stream without assistance, and his wounds were dressed, but he died some hours later. The explosion was quite violent. Large pieces of boiler plate, weighing 500 pounds or so, were thrown 200 yards, and a plank was driven several inches into a tree standing 20 yards from the site of the boiler. Houses were jarred for a distance of several miles in all directions.

The Locomotive.

HARTFORD, JANUARY 15, 1896.

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

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

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IT is a new thing for amateur astronomers to have special facilities placed at their disposal for going to a distant part of the world to see a total eclipse of the sun. The eclipse which comes on August 9th of this year will be visible at Vadsö, on the Varanger Fiord, Norway, and the Orient Steamship Line of London will place its fine steamer *Lusitania* at the disposal of those who may wish to go. Any American astronomers desirous of joining the party may obtain further information concerning the Orient Company's plans, and the trans-Atlantic passage, from E. A. Adams & Co., 115 State St., Boston, Mass., or of Mr. H. Maitland Kersey, of the White Star Line, New York city.

His Lesson.

In a New England town, some years ago, there was a doctor who was much admired and respected, both for his skill and for his excellent character, but who was a man of few words and abrupt manners. A prosperous farmer who lived in the suburbs of the town was in the habit of sending a fine turkey to the worthy doctor at Thanksgiving and Christmas. The bearer of the fowls was usually his son, a bright, wide-awake boy. This messenger did not especially relish his trips to the doctor's house, complaining to his father that he hardly received a "thank you" for the turkeys when he presented them. His father invariably replied, however, that the doctor was undoubtedly pleased and grateful, "only it wasn't his way to say much."

One cold, stormy forenoon in November the boy, bearing the usual Thanksgiving offering, was ushered into the doctor's sitting-room, where that worthy was talking to a friend.

"Here's a turkey father sent you," said the boy, sturdily, in response to the doctor's gruff "Good morning," "and you can take it, or I'll lug it home again if you don't care for it."

"Why, my boy," ejaculated the doctor in amazement, "that's hardly a gracious way to offer a present."

"What should I do?" inquired the boy.

"Sit down here in my chair, and I'll show you," responded the doctor; and taking the fat turkey from the boy's hands, he marched out into the hall, and then re-entered the room, with a beaming smile on his usually grave face.

"Here is a turkey which my father sends you," he said, advancing to the occupant of the chair; "he begs you will accept it with his best wishes and the hope that it may add to the pleasure of your Thanksgiving feast."

"I thank you," said the boy, rising from his chair with a genial smile; "your father's kindness, not only on this occasion, but many previous ones, is greatly appreciated by me. But I must also thank *you*, who have been the bearer of so many heavy loads; and if you will kindly step into the kitchen, my wife has an excellent mince pie which she has especially prepared for you, and which I trust you will enjoy."

The doctor stared at his impersonator for a moment, and then burst into a hearty laugh. The mince pie was speedily produced,—the doctor's wife being famed for her skill in the manufacture of that toothsome article,—and the boy never again had occasion to complain of the way in which his father's gifts were received and acknowledged. —*Youth's Companion.*

A pleasant "I thank you" costs nothing, and many a boy has been stimulated to do his very best, under the influence of a kindly smile and an appreciative word from his superior. We must remember that the boys around us are forming character, and a gruff, unsympathetic manner may tell seriously on their future success and happiness.

RECENT ACCIDENTS FROM THE USE OF STEAM.—Following is a short list of accidents that have recently come to our attention, but which could not properly be included in our regular list of boiler explosions: On October 14th a boiler exploded on a steamship lying in the harbor of Spezzia, Italy, killing four stokers and badly injuring one of the engineers.—The "Marie" mine, at Deuben, near Wissenfels, in Prussian Saxony, was set on fire, on October 26th, by the explosion of a boiler. Several men were fatally injured.—A steam pipe burst on November 9th in the boiler-room of the Pillsbury "A" mills, at Minneapolis, Minn. Truman A. Redgrave was scalded to death.—James Graham, a young steam-fitter, employed by the Pittsburgh Iron and Steel Company, at Soho, Pittsburgh, Pa., was fearfully scalded and bruised, on November 14th, by the failure of a blank flange on a main steam pipe. Graham fell 35 feet upon a pile of pig iron. Many of his bones were broken, and he cannot recover.—Thomas H. Conlin was instantly killed, on November 15th, by the explosion of a steam chest in the print works of the Pacific Mills, at Lawrence, Mass. His skull was crushed. —The Pacific steamer *Empress of China* reports that on October 18th, a combined boiler and magazine explosion occurred on the troop ship *Kung Pai*, at Kin Chow, China. Six hundred men were killed. The explosion was fraught with peculiar horror, because a rough sea was raging, and there was no chance of life overboard.—The feed-pipe blew out of a boiler in the City Stone Mills, at Fond du Lac, Wis., on November 22d. The brick arch in the rear of the boiler was blown down, and four men who were sitting in the boiler-room were covered with soot and badly frightened, but were not seriously hurt. One of them in running away fell over a wheelbarrow, and when his friends picked him up, he started off again at the top of his speed and ran into a box car.—A steam pipe burst, on November 26th, in the basement of Hammerstein's new Olympia Theatre, New York city. The failure occurred in a six-inch cast-iron connection. Joseph W. Wyants was killed and Andrew Higgins was fatally injured. John Russell, Eugene Cette, Joseph Gillott, George Johnson, William Johnson, Frederick Richards, Robert Taylor, and Andrew Verter, were also injured to a lesser extent. The Olympia was opened only the day before.

Donkin and Kennedy's Boiler Tests.

Several years ago Mr. Bryan Donkin, Jr., and Professor Kennedy, undertook a long series of well-planned and carefully executed tests of steam boilers of various types, using the same coal in every case, with the idea of eliminating the effects of differences of fuel, and enabling the evaporative performances of the different types to be compared more directly than is convenient or possible in the general run of published tests. The tests in question have been described in full detail in *Engineering* (London), from time to time, and the final summary having now been issued, we reproduce the principal parts of it below, for the benefit of readers of The Locomotive. English boiler practice is so different from our own, that the tests do not bear upon American experience quite as closely as might be desired, and yet the data given in the accompanying tables will be found interesting and useful in many ways.

In order to eliminate, so far as possible, the effects of variations in fuel, the experimenters first bought about 100 tons of a standard kind of coal, and had it carefully mixed, so that it might be as uniform as possible; and an attempt was made to carry out all the tests in precisely the same way, so far as this could be done.

The coal used came from Wales, and is known in the trade as "Nixon's navigation." The experimenters say that "it burned freely, and with little or no smoke, caked slightly, and left little ash and clinker." Two independent analyses of the coal were made, special care being taken, in each case, to furnish the chemist with a sample fairly representing the whole lot. The results of these analyses were as follows:

Composition, by Weight, of the Dried Coal.

	I.	II.	Average.
Carbon, C,	88.58	88.94	88.77
Hydrogen, H,	4.10	4.15	4.12
Oxygen, O,	2.76	2.00	2.38
Nitrogen, N,	1.00	0.97	0.98
Sulphur, S,	0.66	0.70	0.68
Ash,	2.90	3.24	3.07
	100.00	100.00	100.00

The heat-equivalent of the coal was determined, calorimetrically, by three observers, and it was also calculated, in the usual way, from the foregoing analyses. The concluded result was, that the combustion of one pound of the dried coal produced 15,560 thermal units; which is equivalent to the evaporation of 16.1 pounds of water, from and at 212°.

The runs were continuous, except in the cases of the locomotives, where short intervals were allowed for meals; and the firing was done by the men usually in charge. The feed-water was measured in gauged tanks. The steam pressure was taken by a self-recording gauge in many cases, and in the others it was taken by frequent readings of the boiler gauge (which was duly tested). The coal was weighed, the day before each trial, in hundred-pound sacks, and each sack was also re-weighed, during the progress of the test. The radiation tests were made by contracting the area of the grate with bricks, or other incombustible material, closing the steam valves, and running a small fire with nearly closed damper, so as to merely maintain the pressure in the boiler at the average value observed during the test. The radiation experiment extended over six or eight hours, and the heat-loss was estimated from the coal burned, after making due correction for the heated gases passing up the stack. The moisture present in the coal was determined each day by drying and weighing selected samples.

"Nine types of boiler were tested — Lancashire, Cornish, Cornish multitubular, small vertical tubular (fire-engine type), vertical tubular, portable tubular (agricultural type), one railway locomotive (first *fixed*, in the shops, and then *running* on rails), the elephant or French type, and a water-tube. Nearly all the boilers were worked with natural chimney draft, the exceptions being the locomotive, the fire-engine boiler, and one Lancashire boiler. . . . In Table I will be found the chief particulars and dimensions of the various boilers, including their heating surfaces, grate areas, and the dates of the issues of *Engineering* in which full details of the respective tests are given. Table II gives the principal observations of steam, water, coal, temperature of furnace gases, etc. Table III contains the analyses of the furnace gases, and calculations connected therewith, as well as the amount of air actually used, and the ratio of this amount to the quantity of air theoretically required." The samples of flue gases used in the analyses were taken hourly in most cases, but in some instances they were taken almost continuously. "It will be noticed, in Table III, that the amount of carbon dioxide (CO_2) varied from 8 per cent. by weight, in test No. V, to 19 per cent. in test No. XX." The quantity of air used was in every case in excess of that theoretically required, and the combustion is shown to have been very perfect, in most of the tests, by the small percentage of carbon monoxide (CO) present in the flue gases. Tables IV and V are self-explanatory, except for a few items which we proceed to discuss. The extraordinary fuel-consumption per square foot of grate, in tests Nos. XIII, XIV, XV, and XVI, is accounted for by the increase of draft due to the blast-action of the exhaust steam in the stacks. In the general run of the Cornish and Lancashire boilers in ordinary work and with natural draft, the combustion did not exceed about 16 to 18 pounds of coal per square foot of grate per hour. The comparative duty, in the last three lines of Table IV, "includes any priming that may have taken place, as the quality of the steam, unfortunately, was not tested. There is little doubt that in the locomotive trials, Nos. XIII to XV, where the heat accounted for was about 4 or 5 per cent. in excess of the heat received, some priming must have taken place." The "thermal efficiency" of the boilers, given in the first line of Table V, was only 51 per cent. in the case of the fire-engine, and in the other types it varied from about 60 to about 80 per cent. The economizers tested, as will be seen, gave a gain in efficiency of from 9 to 13 per cent. "The heat lost by the escaping furnace gases varied from 6 to 30 per cent., and that lost by radiation from 3 to 9 per cent."

The preliminary article, outlining the general method followed in making these tests, is in *Engineering* for July 1, 1890, and the final summary, from which the tables here given are taken, is in the issue of that journal for September 20, 1895. It is promised that the complete series of tests here summarized, together with a series of seven engine tests, performed in connection with them, will shortly be published in book form. In conclusion, we may say that we have attended to the six slight errors in the tables, pointed out by Mr. Bryan Donkin on page 710 of the issue of *Engineering* for December 6, 1895, and that we have recalculated the erroneous quantities, and substituted their correct values in Tables I and IV, as given in this article.

TABLE I.—GENERAL DATA CONCERNING THE TYPES AND DIMENSIONS OF THE BOILERS.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII	XVIII.	XIX.	XX.	XXI.
TYPE OF BOILER.	Vertical tubular, with internal firebox.	Lancashire conical tubes across each flue.		Locomotive type.		Multitubular (water-tube).		Three Cornish boilers, with three cross tubes in flue.	Lancashire boilers, Galloway tubes, Green economizer, Vicar mech. stoker.		Portable boiler, locomotive type.	"Elephant" type, with Green economizer.	Steel freight locomotive, with copper firebox.			Vertical tubular fire-engine boiler.	Cornish multitubular boiler.	Portable boiler, locomotive type.	Cornish boiler, Galloway tubes.	Cornish multitubular, with corrugated flue.	Locomotive (stationary).
													Not running.	Running.	Running.						
1. Heating surface of boiler, square feet,	771	582	582	228	228	470.5	470.5	2,100	936	936	316	430	859	859	859	120	191.5	285	324	804	1,177
2. Heating surface of economizer, sq. ft.,	0	0	0	0	0	470.5	470.5	0	1,142	1,142	0	1,033	0	0	0	0	0	0	0	0	0
3. Total heating surface, square feet,	771	582	582	228	228	941.0	941.0	2,100	2,078	2,078	316	1,463	859	859	859	120	191.5	285	324	804	1,177
4. Area of grate, sq. ft.,	10.5	15	15	10.5	7.4	14.95	14.95	63.0	21.0	21.0	9.68	19.15	12.4	12.4	12.4	5.70	3.55	10.5	16.75	20.0	31.43
5. Ratio of (1) to (4),	73.4	38.8	38.8	21.7	30.8	31.5	31.5	33.3	44.6	44.6	32.6	23.5	69.2	69.2	69.2	20.8	54.0	27.2	19.3	40.2	37.4
6. Ratio of (3) to (4),	73.4	38.8	38.8	21.7	30.8	63.0	63.0	33.3	99.0	99.0	32.6	76.4	69.2	69.2	69.2	20.8	54.0	27.2	19.3	40.2	37.4
7. Details in *Engineering* for	July 18, '90	August 1, 1890.		November 21, 1890.		February 27, 1891.		May 15, 1891.	October 2, 1891.		Mar. 18, '92	July 22, '92	October 21, 1892.			Jan. 27, '93.	Je. 30, 1893.	Dec. 22, 1893.	June 15, '94.	July 20, '94.	Nov. 2, '94.

TABLE II. — PRINCIPAL OBSERVATIONS.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.
1. Duration of test (hrs.)	8.5	9.0	12.0	6.83	6.0	6.6	9.05	10.0	9.0	9.1	8.0	31.8	8.31	4.88	4.7	6.0	9.0	5.3	8.0	7.0	5.0
2. Mean abs. pressure,	49.7	64.7	71.7	14.9	99.9	100.6	90.2	51.7	93.8	92.7	75.7	60.2	145.0	133.7	139.7	115.1	79.2	86.7	66.3	88.7	104.7
3. Corresponding temp. (F.),	280.6°	297.5°	304.4°	212.7	327.7	328.5°	320.5°	283.0°	323.1	322.4°	308.2	292.8	355.6	349.3°	352.7°	338.0°	311.3	317.7	299.1°	319.3°	331.0°
4. Temp. feed (F.),	42.6°	48.6°	71.1°	42.0°	86.0	49.1	49.3°	116.2°	83.5	86.8	59.3	65.3	56.5°	50.7°	52.0°	52.0°	58.7°	60.0	66.1	47.5°	59.2°
5. do. after economizer,	....	....	....	....	....	204.2°	205.3	....	226.3	202.0	....	225.0	....	....	....	....	159.0°	....	....	163.0°	....
6. Tot'l lbs. water evap'd	12,975	11,497	28,427	4,620	2,009	13,374	18,215	44,010	31,969	34,220	8,700	66,737	37,010	17,588	19,011	7,861	3,995	4,869	16,831	28,141	35,492
7. Total do. per hour,	1,505	1,277	2,369	676	335	2,026	1,917	4,401	3,552	3,700	1,087	2,100	4,454	3,620	4,000	1,310	444	920	2,104	4,020	7,098
8. Total coal put on grate,	1,660	1,525	3,374.5	607.5	309.5	....	....	4,623	....	....	....	...	....	....	....	1,249	449	610	2,157	3,084	4,085
9. Total coal drawn,	62.5	137.5	42.0	38.5	31.2	....	....	301	....	....	....	....	....	....	....	63.0	11.0	10.0	57.0	76.0	81.5
10. Total coal used,	1,597.5	1,387.5	3,332.5	569.0	278.3	1,412	1,990	4,322	3,017	3,200	960	6,720	3,663	1,701	1,871	1,186	438	606	2,100	3,008	4,003
11. Total do. per hour,	188.0	154.0	278.0	83.3	46.3	214.0	220.0	432.0	336.0	352.0	120.0	211.5	441.0	348.0	393.0	197.6	48.7	114.0	262.5	420.6	801
12. Total weight ash,	55.5	76.5	54.5	43.2	15.3	58.2	57.5	315	19.0	22.4	100	463	168	64.5	78.0	14.0	1.0	20.0	117.5	54.5	209
Total clinker,	29.0	21.0	73.0	5.7	0.0			86	80.0	44.8	130		42	28.5	26.0	10.0	6.0	15.0	25.5	40.5	
13. Per ct. ash in coal,	3.5	5.5	1.6	7.6	5.5	4.1	2.9	7.3	0.6	0.7	1.04	6.9	4.58	3.8	4.2	1.2	0.2	4.3	5.6	1.8	5.2
do. clinker in coal,	1.8	1.5	2.2	1.0	0.0			2.0	2.6	1.4	1.35		1.14	1.7	1.4	0.8	1.4	2.5	1.2	1.3	
14. Pr ct. moisture in coal,	1.6	5.5	4.2	1.0	0.4	1.26	1.20	0.35	1.05	2.35	1.8	0.8	0.6	0.5	0.5	1.0	0.26	2.0	1.09	1.15	1.5
15. Pure dry coal pr hour,	175	135	256	75.2	43.6	202.5	211	390	318	330	115	195	413	327	369	192	47.8	104	242	412	747
16. Ratio of (15) to (11),	0.931	0.875	0.920	0.904	0.941	0.946	0.958	0.903	0.947	0.956	0.958	0.923	0.937	0.940	0.939	0.970	0.981	0.912	0.921	0.957	0.932
17. Thickness of fire (in.),	14	8.5	6.0	5.5	....	3.5	3.5	9 to 12	11	....	4.5	....	5.5	4.5	....	....	4	....	8	3.5	2.5
18. No. firings per hour,	2.1	1.2	2.75	0.88	....	12	12	0.7	conti	nuous.	3.73	8.0	3	5	5.3	....	2.2	....	....	6	8
19. Temp. air in b.-house,	57.5°	65.5°	69.0°	53.0°	78.0°	42.8°	42.8°	78.4°	98.0°	51.0°	59.0°	79.3°	61.2°	48.5°	55.5°	....	67.5°	....	73.2°	86.4°	55°
20. do. outside do.,	32.0°	34.8°	64.0°	46.0°	....	42.8°	42.8°	45.1°	42.5°	39.0°	59.0°	68.2°	61.2°	48.5°	55.5°	45.2°	....	....	53.1°	47.0°	55°
21. Temp. gases near chy,	392°	399°	630°	560°	555°	329°	324°	485°	372°	278°	625°	264	....	570°	617°	....	498°	575°	533°	732°	....
22. do. bet. boiler and econ.,	....	....	....	....	....	646°	626°	....	566°	401°	....	....	....	....	....	....	....	....	....	....	....
23. Coal per hour to maintain pressure only,	8.5	10.8	16.7	6.2	6.2	13.9	9.2	6.37*	24.1	24.1	9.3	9.6	17.0	17.0	17.0	....	4.0	....	....	....	30
24. Ratio of (23) to (11),	.045	.070	.060	.074	.134	.065	.042	.044	.072	.069	.077½	.045	.038½	.049	.043	....	.082	....	...	...	.037

TABLE III. — ANALYSES AND CALCULATIONS RELATING TO FURNACE GASES, ETC.

Number of Test.	I.		II.		III.		IV.		V.		VI.	
Analysis of Dry Furnace Gases.	By Volume.	By Weight.	By Volume.	By Weight.	By Volume.	By Weight.	By Volume.	By Weight.	By Volume.	By Weight.	By Volume.	By Weight.
1. Per cent. of CO_2,	10.33	15.15	....	13.00	....	18.21	....	11.71	....	7.90	7.12	10.44
2. Per cent. of CO,	2.77	2.59	....	0.00	....	0.24	....	0.00	....	0.00	0.29	0.28
3. Per cent. of O,	6.07	6.40	....	11.15	....	7.55	....	13.13	....	17.00	12.51	13.37
4. Per cent. of N,	80.83	75.80	....	75.85	....	74.00	....	75.16	....	75.10	80.08	75.90
5. Lbs. dry air per lb. of C.,	18.5		27.6		19.2		30.7		46.0		33.1	
6. Lbs. dry air per lb. coal,	16.4		24.4		17.0		27.2		40.7		29.3	
7. do. per lb. pure, dry coal,	16.9		25.2		17.5		28.0		42.2		30.3	
8. Lbs. dry furnace gases per lb. pure dry coal,	17.5		25.8		18.1		28.6		42.8		30.9	
9. Ratio of air used to air theoretically required,	1.58		2.40		1.63		2.61		4.28		2.82	

Number of Test.	VII.		VIII.		IX.		XI.		XII.		XIII.	
Analysis of Dry Furnace Gases.	By Volume.	By Weight.	By Volume.	By Weight.	By Volume.	By Weight.	By Volume.	By Weight.	By Volume.	By Weight.	By Volume.	By Weight
1. Per cent. of CO_2,	7.44	11.00	10.20	14.95	5.77	8.60	11.34	16.50	10.30	15.10	12.40	17.94
2. Per cent. of CO,	0.10	0.10	0.30	0.28	0.00	0.00	0.23	0.21	0.00	0.00	1.10	1.02
3. Per cent. of O,	12.34	13.20	7.80	8.31	13.37	14.40	7.33	7.76	8.30	8.80	6.20	6.53
4. Per cent. of N,	80.12	75.70	81.70	76.46	80.86	77.00	81.10	75.53	81.40	76.10	80.30	74.51
5. Lbs. dry air per lb. of C.,	32.3		23.3		42.1		21.2		23.7		18.2	
6. Lbs. dry air per lb. coal,	28.6		20.6		37.3		18.8		21.0		16.1	
7. do. per lb. pure, dry coal,	29.6		21.20		38.6		19.4		21.7		16.7	
8. Lbs. dry furnace gases per lb. pure dry coal,	30.2		21.80		39.2		20.0		22.3		17.3	
9. Ratio of air used to air theoretically required,	2.76		1.98		3.6		1.81		2.02		1.56	

Number of Test.	XIV.		XVII.		XIX.		XX.	
Analysis of Dry Furnace Gases.	By Volume.	By Weight.	By Volume.	By Weight.	By Volume.	By Weight.	By Volume.	By Weight.
1. Per cent. of CO_2,	11.20	14.90	7.50	11.10	....	11.53	13.00	18.88
2. Per cent. of CO,	0.00	0.00	0.00	0.00	....	0.00	0.37	0.34
3. Per cent. of O.	7.80	6.60	12.18	13.10	....	13.03	5.54	5.85
4. Per cent. of N,	81.00	78.50	80.32	75.80	....	75.44	81.09	74.93
5. Lbs. dry air per lb. of C.,	24.0		32.7		31.2		18.3	
6. Lbs. dry air per lb. coal.	21.3		29.0		27.6		16.2	
7. do. per lb. pure dry coal,	22.0		30.0		28.6		16.8	
8. Lbs. dry furnace gases per lb. pure dry coal,	22.6		30.6		29.2		17.4	
9. Ratio of air used to air theoretically required,	2.05		2.80		2.67		1.56	

TABLE IV.—PRINCIPAL RESULTS : COAL AND WATER.

	I.	II.	III.	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.
COMBUSTION PER HOUR.																					
1. Coal per sq. ft. of grate (lbs).,	17.00	10.20	18.50	7.03	6.25	14.30	14.70	6.80	16.00	16.80	12.40	11.04	35.50	28.10	31.70	34.30	13.70	10.80	15.70	21.50	25.50
2. Coal per sq. ft. heating surface (boiler only),	0.24	0.265	0.48	0.336	0.203	0.450	0.460	0.205	0.350	0.376	0.380	0.400	0.514	0.406	0.458	1.050	0.254	0.400	0.810	.534	0.680
3. Coal per sq. ft. total heating surface,	....	...	....	....	....	0.227	0.234	....	0.162	0.170	....	0.145	....	....	....	....	....	....	...	....	....
HEAT-ABSORPTION PER HOUR.																					
4. Heat Units absorbed per sq. ft. of heating surface (boiler only).	2,250	2,530	4,610	3,350	1,600	4,340	4,120	2,260	3,740	4,060	3,020	4,720	6,040	4,030	5,440	12,650	2,440	3,730	7,180	5,240	6,968
EVAPORATION PER HOUR, FROM AND AT 212°.																					
5. Per pound of actual coal,	0.57	0.92	10.02	0 55	8.45	9.84	9.08	11.40	10.81	11.19	10.78	9.96	12.18	12.51	12.20	7.05	9.01	9.57	9.16	10.15	10.64
6. Per pound of pure dry coal,	10.28	11.34	10.90	10.57	8.99	10.40	9.48	12.61	11.42	11.70	11.25	10.78	13.00	13.50	13.10	8.20	10.10	10.50	0.05	10.60	11.42
7. Per sq. ft. heating surface (boiler only),	2.33	2.02	4.78	3.47	1.72	4.49	4.26	2.34	3.87	4.20	4.05	4.89	6.25	5.10	5.02	13.1	2.52	3.85	7.43	5.42	7.23

TABLE V.—HEAT ACCOUNTS, PER POUND OF PURE DRY COAL, IN PER CENT.

Percentage of total heat of combustion expended in:	Number of Test.																				
	I.	II.	III	IV.	V.	VI.	VII.	VIII.	IX.	X.	XI.	XII.	XIII.	XIV.	XV.	XVI.	XVII.	XVIII.	XIX.	XX.	XXI.
1. Heating and evaporating water,	63.8	70.4	67.6	66.2	56.8	11.9* 62.5†	11.7* 60.1†	78.3	12.0* 69.5†	9.7* 71.3†	69.8	13.0* 65.5†	80.7	82.6	81.3	51.0	62.7	65.2	61.8	65.8	73.2
2. Heat lost up the stack,	9.4	13.6	16.2	22.5	31.8	13.8	13.3	14.0	19.3	....	18.0	6.5	15.9	18.6	20.0	....	20.7	....	20.4	18.0	....
3. Evaporating moisture in coal,	0.1	0.4	0.4	0.1	0.0	0.1	0.1	0.0	0.1	....	0.1	0.0	0.0	0.0	0.0	...	0.0	....	0.1	0.1	....
4. Radiation,	4.5	7.0	6.0	5.2	9.4	6.5	6.3	4.4	7.2	....	5.7	5.5	3.0	3.9	3.4	....	8.2	....	?	8.0	3.7
5. Heat in fire drawn,	0.1	0.3	0.4	0.2	0.4	0.0	0.0	0.2	0.0	....	0.0	0.0	0.0	0.0	0.0	....	0.1	....	0.1	0.1	....
6. Evaporation in ash-pit,	....	3.4	4.6	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....
7. Loss by imperfect combustion,	12.7	0.0	1.2	0.0	0.0	2.4	0.8	1.7	0.0	....	1.2	0.0	4.9	0.0	0.0	....	....	....	0.0	1.6	....
8. Unaccounted for,	9.4	4.9	3.6	5.8	1.6	2.8	7.7	1.4	....	19.0	5.2	9.5	....	....	....	....	8.3	....	17.6	6.4	23.1
Total,	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	108.1	100.0	100.0	100.0	104.5	105.1	104.7	...	100.0	....	100.0	100.0	100.0
Heat lost up the stack, if no economizer were used,	9.4	13.6	16.2	22.5	31.8	25.7	25.0	14.0	31.3	....	18.0	19.5	15.9	18.6	20.0	....	20.7	....	20.4	18.0	....

* In the economizer. † In the boiler.

The Locomotive.

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Flues for Boilers.

A boiler shell, with the pressure acting on it from within, is in a state of stable equilibrium; for if any small deformation is produced in it, from any cause, the pressure tends to remove the deformation and restore the boiler to the form of a true cylinder. A flue, however, with the pressure on the outside, is in a state of unstable equilibrium, for the pressure tends to magnify all deformations and to cause the flue to depart more widely from the cylindrical form. In other words, pressure tends to keep the shell of a boiler in its strongest shape, and tends to force a flue into its weakest shape. Flues, therefore, are elements of weakness in a boiler, and it is particularly important that proper attention be paid to them.

The U. S. Treasury rules for finding the strength of lap-welded flues are as follows (see *Amended Steamboat Rules and Regulations* for 1891): If the diameter of the flue is not less than 7 inches, and not more than 16 inches, and the length not over 18 feet, multiply the thickness of the flue, in inches, by the constant number 4,400, and divide the product by the radius of the flue in inches. The quotient will be the pressure allowable. "For every foot or fraction thereof over 18 feet, deduct 3 pounds per square inch from the pressure allowable on an 18-foot flue; or, add .01 of an inch to the thickness of material required for a flue 18 feet in length for every three feet or fraction thereof over 18 feet." The thickness of such a flue as is described above is to be determined by the following rule: Multiply the radius of the flue in inches by the pressure per square inch that it is desired to carry, and divide the product by the constant number 4,400. The quotient is the required thickness, in inches. "The thickness of lap-welded flues, however, shall in no case be *less* than the diameter of the flue multiplied by .022."

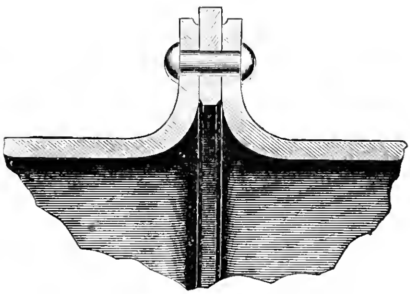


FIG. 1.— THE ADAMSON RING.

It is further provided by the Treasury Department that "Lap-welded flues 7 inches and not over 16 inches in diameter, shall be made in lengths of not over three (3) feet, and fitted one into the other and substantially riveted; or in lieu thereof shall be corrugated to a depth of not less than three-fourths of an inch outwardly and at a distance of not over three feet between such corrugations: *Provided*, such corrugations are made without in any manner reducing the thickness of the material in the flue at the points of corrugation to less than the least thickness of the material in the body of the flue, or that such flues are made in sections of not over three (3) feet in length, and flanged to a width of not less than two (2) inches, and riveted substantially together with a wrought-iron ring (see the cut of the Adamson ring), having a thickness of material of not less than the thickness of material in the flues, and a width of not less than two (2) inches riveted between such flanges."

Flues whose diameter is more than 16 inches and less than 40 inches are separately considered. Of such flues it is required that they "shall be made in lengths of not over three (3) feet, fitted one into the other and substantially riveted; or flanged to a depth of not less than two (2) inches and riveted together with a good and substantial wrought-iron ring between each joint: and no such ring shall have a thickness of less than half an inch nor a width of less than two (2) inches." The steam pressure allowable on such flues is to be determined by the same rule as that given above for the smaller flues, *except* that in the place of the constant number 4,400 that is given above, we must use the constant number 2,840.

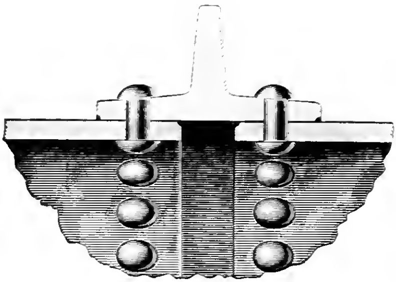


FIG. 2.—T-IRON RING.

In the *Amended Steamboat Rules and Regulations* for 1892 there appears the following modification of the rule given above as applying to lap-riveted flues not over 16 inches in diameter: "But when such flues are used under a pressure of over 60 pounds and less than 120 pounds to the square inch, they may be made in sections of not over 5 feet in length and connected in the manner prescribed for sections 3 feet in length; and all lap-welded flues and tubes using 120 pounds of steam, and under, shall have a thickness of material of not less than the standard thickness. The following shall be the standard thickness of lap-welded flues and tubes from 1 to 16 inches in diameter using steam under 120 pounds to the square inch:"

Outside Diameter.	Thickness.	Outside Diameter.	Thickness.	Outside Diameter.	Thickness.	Outside Diameter.	Thickness.
1 in.	.072 in.	2¾ in.	.109 in.	5 in.	.148 in.	12 in.	.229 in.
1¼	.072	3	.109	6	.165	13	.238
1½	.083	3¼	.120	7	.165	14	.248
1¾	.095	3½	.120	8	.165	15	.259
2	.095	3¾	.120	9	.180	16	.270
2¼	.095	4	.134	10	.203		
2½	.109	4½	.134	11	.220		

Although the foregoing regulations of the Treasury Department relate to lap-welded flues, they would doubtless be also applied to rolled flues when used in the marine service, notwithstanding the fact that the rolled flue is somewhat stronger, on account of its more perfectly cylindrical shape. Rolled flues are used in land boilers to some extent in this country, and very generally in England and other parts of Europe. Until recent years it was not found practicable to roll them in lengths of more than three feet or so, and where they were fitted together at the ends, and riveted, the double thickness of metal at the joint served as a sort of stiffening ring, and unless the pressure to be carried was high, engineers did not consider it necessary to provide additional rings for securing the necessary stiffness and resistance to collapse.

The method of joining the sections of the flues that is referred to in the Treasury rules above given is illustrated in Fig. 1, which shows what is technically known as the "Adamson ring," from its having been first introduced by Mr. Adamson, in 1851. The ends of the sections are flanged outward, as shown, and are securely riveted together with a ring of wrought-iron or steel between. This ring, which should be not less than half an inch thick and not less than two inches wide, is caulked on the outer side of the joint, and, if the flue is large enough to admit of it, it is also caulked on the inside, as indicated in the cut. One of the important features of this joint is that both the flanges and the rivets are entirely protected by water. There is also no thickening of the flue by overlapping pieces, so that the joint is not likely to burn out. Mr. Adamson has submitted these flanged joints to severe experimental tests, which they withstood remarkably well. The only serious objection that has been urged against them is, that in case one of the segments of the flue should burn out, either on account of scale or for any other reason, it could not be replaced without removing the head of the boiler. This objection does not seem to us to have any great weight, because in many cases the flue comes so close to the shell that it is almost impossible to do a satisfactory job of riveting on any kind of a joint, without removing the flue from the boiler ; and if there are projections of *any* sort upon it, it will be necessary, in removing the flue, to take out one of the heads.

Fig. 2 shows a method of uniting the parts of a built-up flue, which may be used with advantage in some cases, though we should prefer the Adamson joint shown in Fig. 1. Fig. 2 shows a ring of T-shaped wrought-iron, which is preferably made in one piece and shrunk on the ends of the segments to be united; though it may be made in halves, if necessary, the two parts being riveted firmly together when in position, by running straps along the web of the flange on both sides near the joint, and riveting through both straps and the web. When the flue is large enough to admit of it, the joint should be caulked both inside and out, as indicated in the cut. If the flue is too small for this, there is no necessity of having the abutting ends of the flue as far apart as they are shown in the cut. T-shaped wrought-iron rings, similar to that shown in the figure, and made in halves, are sometimes riveted directly to the flue, midway between the joints, when the flue, either through age, through increase of pressure, or through faulty design, requires more stiffening than the builder has given it. Rings of angle-iron are also used for this purpose.

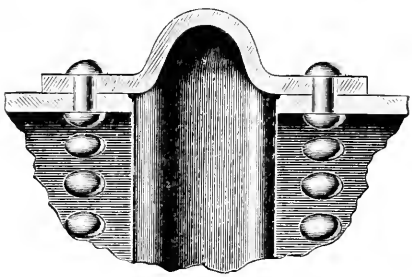
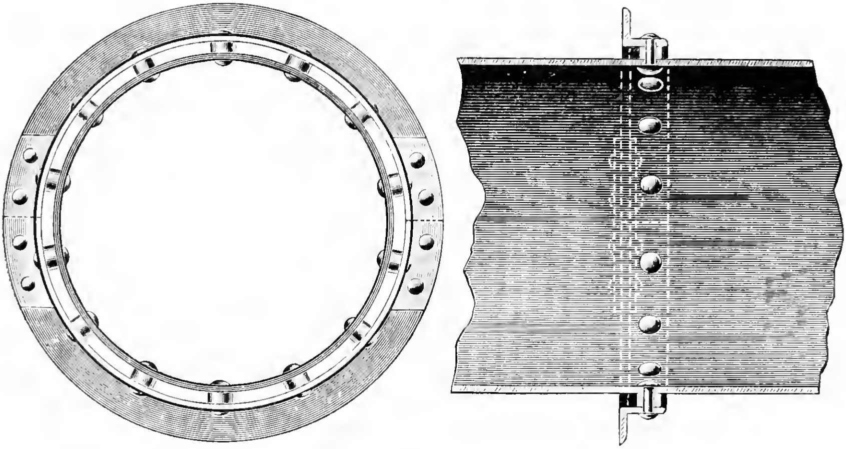


FIG. 3.—STEEL HOOP.

Fig. 3 shows a ring of steel, hoop-shaped in section, which is sometimes used in building up flues in the place of the T-iron ring illustrated in Fig. 2. The advantage claimed for this form of joint is, that it has a certain amount of elasticity, and that it yields sufficiently to prevent any very severe strain from unequal expansion and contraction in the flue and boiler. This form of ring should be made in one piece and be shrunk on, and then riveted. It should be caulked on the outside, and on the inside also if the flue is large enough to admit of it.

At the present time, flues are rolled of all lengths up to 18 feet. If a longer boiler is required, 21 feet long for example, it is customary to use a rolled flue 18 feet long, pieced out with an additional section three feet in length. The joint where the flue sections come together gives stiffness enough, ordinarily, to prevent the collapse of the shorter segment: but the long section should be supported by some additional means.

Rings of angle-iron, or of T-iron like that shown in Fig. 2, may be riveted around the flue at intervals of from 3 to 5 feet, to give the necessary stiffness, or the device shown in Figs. 4 and 5 may be adopted. There is some liability to overheating when the angle-iron is riveted directly to the flue, yet this is often done without giving rise to any such trouble. The ring shown in Figs. 4 and 5 seems superior to the plain ring, however, because water can circulate freely between the rivets, cooling both the rivets and the flue, and greatly lessening the likelihood of overheating. It consists of a ring of angle-iron or U-iron, made in halves, with the ends riveted together by a double strap, as indicated in the cuts. There is a free space of about one inch between the ring and the flue, all around, and the two are kept apart by thimbles that are spaced 5 or 6 inches apart. The ring and the flue are secured to one another by rivets which pass through the thimbles, as shown, and are headed over inside of the flue and outside of



FIGS. 4 and 5.—RING OF ANGLE-IRON, WITH THIMBLES.

the angle-iron or U-iron. These rings are used in England much more than in this country, because flue boilers are much more common there than here. It will be interesting, therefore, to quote the opinion of Mr. Henry Hiller, Chief Engineer of the National Boiler Insurance Company with regard to them, as he is thoroughly familiar with the best English practice. "The angle-iron," he says, "should not be less than 3 in. × 3 in. × $\frac{9}{16}$ in. The ferrules between the hoop and the plate should be about one inch thick [*i. e.* one inch long], and the rivets should be spaced about six inches apart. With the exception of the part that requires riveting over, the rivet should be as cool as possible when it is inserted, as otherwise the excessive contraction in so long a rivet will be likely to induce such a strain as to fracture the head. The ferrules should fit tightly between the hoop and the flue, and the rivets should fill the ferrules." These rings are made in halves, as explained above, and the ends of the halves are made to butt together, and are secured by securely riveting a double strap to the web of the ring where the joint comes, in the manner indicated in the cuts.

Mr. Hiller does not recommend this form of ring for new boilers, nor do we, unless there is some special reason for it. It is often serviceable, however, when the flues of a boiler were originally made too weak for the pressure it is desired to carry. For new work we strongly recommend Mr. Adamson's joint, shown in Fig. 1, or the steel hoop shown in Fig. 3. A few years ago a ferry-boat plying about New York city was built with rings of this sort around her flues, except that in place of the angle-iron shown in Figs. 4 and 5 half-round iron $2\frac{3}{4}$ inches wide and $1\frac{1}{2}$ inches high was used. The rings were placed along the flues at intervals of about 20 inches, and the rivets were spaced 8 inches apart. This stiffening proved insufficient, and a vast amount of trouble resulted. In our opinion the rings used in this case were much too small, and were weak in shape. The flue was 36 inches in diameter, and if this form of strengthening ring was to be used at all, a heavy ring of angle-iron should have been employed in place of the weak, half-round strips. If we remember rightly the trouble was removed by the substitution ot corrugated flues for the plain ones.

It may be well to say in this place that we do not approve of flue boilers, as a general rule. There seems to be no especial advantage in them, and they are inherently weaker than the tubular form. We believe that greater safety and economy and more general satisfaction can be had from tubular boilers than from any other form. Flue boilers are used in some parts of the country in saw-mills, where refuse is burned for fuel; and we have known the owners of these mills to object to tubular boilers because they *were* economical. It was necessary, they said, to burn all their refuse, and if the boiler wouldn't do it, it was necessary to have separate furnaces constructed for the purpose. Nowadays, when all things are put to use and the word "waste" is nearly obsolete, we seldom hear this objection urged.

Inspectors' Report.

DECEMBER, 1895.

During this month our inspectors made 8,563 inspection trips, visited 17,818 boilers, inspected 6,661 both internally and externally, and subjected 715 to hydrostatic pressure. The whole number of defects reported reached 11,652, of which 1,343 were considered dangerous; 43 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	939	52
Cases of incrustation and scale,	2,274	72
Cases of internal grooving,	182	15
Cases of internal corrosion,	634	31
Cases of external corrosion,	754	40
Broken and loose braces and stays,	139	56
Settings defective,	387	55
Furnaces out of shape,	483	21
Fractured plates,	296	61
Burned plates,	282	27
Blistered plates,	210	7
Cases of defective riveting,	1,085	109
Defective heads,	133	31
Serious leakage around tube ends,	1,743	421
Serious leakage at seams,	486	51
Defective water gauges,	468	90
Defective blow-offs,	199	63
Cases of deficiency of water,	22	7
Safety-valves overloaded,	125	27

Nature of Defects.	Whole Number.	Dangerous.
Safety-valves defective in construction,	104	34
Pressure-gauges defective,	582	59
Boilers without pressure-gauges,	10	10
Unclassified defects,	115	4
Total,	11,652	1,343

Summary of Inspectors' Reports for the Year 1895.

During the year 1895 our inspectors made 98,349 visits of inspection, examined 199,096 boilers, inspected 76,744 boilers both internally and externally, subjected 8,373 to hydrostatic pressure, and found 799 unsafe for further use. The whole number of defects reported was 144,857, of which 14,556 were considered dangerous. A summary of the work by months is given below, and the usual classification by defects is likewise given :

SUMMARY BY MONTHS, FOR 1895.

MONTH.	Visits of inspection.	Number of boilers examined.	No. inspected internally and externally.	No. tested hydro-statically.	No. con-demned.	Number of defects found.	Number of dangerous de-fects found.
January,	8,308	17,504	4,355	539	37	10,726	990
February,	7,131	14,576	3,991	414	66	9,892	1,297
March,	8,479	18,136	6,284	569	85	12,154	1,396
April,	6,923	14,833	6,242	621	83	11,859	1,085
May,	8,316	15,960	6,946	755	82	12,046	1,092
June,	7,961	14,887	6,803	667	72	10,967	1,028
July,	7,952	16,077	8,883	750	95	13,983	1,259
August,	8,345	16,188	6,839	811	101	13,431	1,080
September,	7,937	16,072	6,391	845	13	11,712	970
October,	10,091	19,658	6,538	927	61	12,941	1,635
November,	8,343	17,387	6,811	760	61	13,494	1,381
December,	8,563	17,818	6,661	715	43	11,652	1,343
Totals,	98,349	199,096	76,744	8,373	799	144,857	14,556

SUMMARY, BY DEFECTS, FOR THE YEAR 1895.

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	11,808	631
Cases of incrustation and scale,	24,968	899
Cases of internal grooving,	1,732	183
Cases of internal corrosion,	8,429	472
Cases of external corrosion,	9,866	613
Defective braces and stays,	1,820	642
Settings defective,	4,038	392
Furnaces out of shape,	5,509	268
Fractured plates,	3,714	704
Burned plates,	3,210	349

Nature of Defects.	Whole Number.	Dangerous.
Blistered plates,	3,103	121
Defective rivets,	17,878	1,644
Defective heads,	1,647	325
Leakage around tubes,	23,551	3,919
Leakage at seams,	5,621	413
Water gauges defective,	5,107	947
Blow-outs defective,	2,300	682
Cases of deficiency of water,	242	108
Safety-valves overloaded,	954	270
Safety-valves defective,	1,209	369
Pressure gauges defective,	6,282	483
Boilers without pressure gauges,	98	98
Unclassified defects,	1,771	24
Total,	144,857	14,556

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

Comparison of Inspectors' Work during the Years 1894 and 1895.

	1894.	1895.
Visits of inspection made,	94,982	98,349
Whole number of boilers inspected,	191,932	199,096
Complete internal inspections,	79,000	76,744
Boilers tested by hydrostatic pressure,	7,686	8,373
Total number of defects discovered,	135,021	144,857
" " of dangerous defects,	13,753	14,556
" " of boilers condemned,	595	799

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

Grand Total of the Inspectors' Work Since the Company Began Business, to January 1, 1896.

Visits of inspection made,	990,056
Whole number of boilers inspected,	1,971,088
Complete internal inspections,	764,530
Boilers tested by hydrostatic pressure,	118,254
Total number of defects discovered,	1,486,187
" " of dangerous defects,	183,058
" " of boilers condemned,	9,800

We append, also, a summary of the work of the inspectors of this company from 1870 to 1895, inclusive. The years 1876 and 1878 are omitted, because the data that we have at hand for those years is not complete. The figures so far as we have them, indicate that the work during those years was in good accordance with the regular progression observable in other years. Previous to 1875 it was the custom of the company to publish its reports on the first of September, but in that year the custom was changed and the summaries were made out up to January 1st, so as to agree with the calendar year. The figures given opposite 1875, therefore, are for sixteen months, beginning September 1, 1874, and ending December 31, 1875.

SUMMARY OF INSPECTORS' WORK SINCE 1870.

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

Boiler Explosions.

DECEMBER, 1895.

(319.)—A boiler exploded on December 5th, at the New Athens Coal Company's plant, near Belleville, Ill. Jacob Emge was badly bruised and internally injured. Henry Sands and William Sands were also badly bruised, and David Hill and H. Keim were badly scalded. The engine house was completely wrecked.

(320.) — On December 5th a boiler exploded in Dennis Costigan's chandlery, in Albany, N. Y. The building in which the boiler stood was wrecked, and Mr. Costigan was fatally injured.

(321.) — A boiler exploded on December 6th in Jacob R. Rabinowitz's shop, on Willet street, New York city. Rabinowitz was near the boiler at the time, and was seriously scalded.

(322.) — The head of a boiler in Clark's Mill, Jacksonville, Fla., blew out on December 6th. The roof of the building was completely torn off by the explosion, but nobody was injured.

(323.) — A small boiler belonging to Elling Hove, of Albert Lea, Minn., exploded on December 6th. Considerable damage was done, but there were no personal injuries.

(324.) — A boiler belonging to Joshua Heptingstall, of Bremen, Ga., exploded on December 8th. Heptingstall was killed, Henry Robinson was fatally injured, and four other persons (one of whom is not expected to live) were also injured. The mill in which the boiler stood was totally wrecked.

(325.) — According to the Chicago *Tribune*, a fire, which occurred in the Lafayette Bathrooms, Chicago, on December 8th, was due to the explosion of a boiler. The total property loss was about $100,000. One man was seriously injured.

(326.) — A terrible boiler explosion occurred on December 10th in Ezra Post's saw-mill, at Gordon, about twelve miles southeast of Greenville, Ohio. Frank Perkins and Solomon Hastings were instantly killed, and Stephen White and Curtis Johnson were fatally injured. The other workmen had gone away from the mill a few minutes before the explosion. The entire mill was destroyed, and many pieces of the boiler were found 80 rods away.

(327.) — On December 10th a boiler exploded in J. P. Henley's saw-mill, at Orange Heights, near Gainesville, Fla. One man was injured. We have not seen any estimate of the property loss.

(328.) — On December 11th a boiler exploded at Calvin & Young's Flouring Mill, at Mercer, Pa. No one was injured.

(329.) — A boiler exploded in Devaul Bros.' mill at Bloomfield, Iowa, on December 11th. Lewis Battin was killed, and Abraham Deval, Eli Deval, and a man named Spangler, were injured.

(330.) — A boiler explosion took place on December 11th at the Pitts Agricultural Works, in Buffalo, N. Y. George O'Connell was fatally injured, and John Doyle received serious injuries but will probably recover. The head of the boiler blew out.

(331.) — During the course of a fire in D. H. Fritt's & Co.'s factory, Chicago, Ill., on December 11th, a boiler in the basement of the building exploded, causing the whole structure to collapse. The combined loss due to the fire and explosion is estimated at $95,000. Fortunately, the fire occurred in the night, and nobody was in the building at the time.

(332.) — Hugh Conley's saw-mill, near Macon, Mo., was completely destroyed on December 12th, by the explosion of a boiler. The owner and two of his workmen were thrown to a great distance and severely injured. Parts of the boiler were blown over two hundred feet into the air.

(333.) — On December 12th several tubes failed simultaneously in a boiler in the electric light plant which furnished electricity for lighting the villages of Edgewater and New Brighton, Staten Island. James Cahill, a fireman employed at the plant, was frightfully scalded about the face and body.

(334.) — Locomotive No. 524, one of the heaviest freight locomotives on the Cincinnati Southern Railway, exploded her boiler at Emory Gap, Tenn., 77 miles north of Chattanooga, on December 13th. The train was side-tracked at the time, and the engineer was not in the cab. The fireman was found about 50 feet away in an open field. Several of his ribs were broken, and he received internal injuries the extent of which we could not learn; but it was considered doubtful if he could recover.

(335.) — William Thacker's saw-mill, on Camp Creek, near Bluefield, W. Va., was destroyed on December 19th by a boiler explosion. Electrician Yates was killed, and Samuel Bonner was scalded so badly that he cannot recover.

(336.) — A boiler exploded at Havelock, near Lincoln, Neb., on December 19th. John Madden was severely burned about the arms, but will recover. We have seen no estimate of the property loss.

(337.) — A boiler exploded in Plymale Bros.' flouring mill, at Yellowtown, near Gallipolis, Ohio, on December 21st. Nobody was hurt. Our account states that the boiler, "instead of bursting into atoms, broke in twain and fell into the furnace."

(338.) — A locomotive boiler exploded on December 22d, near Clipper Gap, Cal. Fireman Alexander McCullough, perceiving that an explosion was imminent, jumped from the cab. Engineer Martin Tuttle, who did not jump, but who clung to the outside of the cab, was blown violently to the ground and badly injured. Head brakeman Jeter was blown over the tender, but was not fatally injured. Had the explosion occurred a few minutes later, the engine would have been in a tunnel, and the three men could not have escaped instant death.

(339.) — The boiler of a locomotive used on a local freight train of the Pennsylvania Railroad exploded at Princeton Junction, N. J., on December 23d. Engineer Thomas Palmer, who had been on the road about twenty-five years, was instantly killed.

(340.) — A small boiler exploded, on December 23d, at Pendleton, Ind. The engineer, W. M. Hayes, was instantly killed.

(341.) — A small boiler, used to sink piling for the Ocean Grove board walk, at Asbury Park, N. J., exploded on December 26th. It was located on the ocean front, in a building formerly occupied by the Bond Wave Power Company. It went through three inches of cedar planking, cut off a beam, soared two hundred feet into the air, and landed in the ocean an eighth of a mile from shore. Edward Pridham, the engineer, had just left the building, and was about forty feet away when the explosion occurred. He was struck with flying fragments of the boiler and the ruined building, but his injuries were not serious.

(342.) — A steam heating boiler exploded on December 30th, in "The Whitaker," an apartment house in Cleveland, Ohio. Olive Schroeder was painfully scalded, and a colored waiter employed in the dining-room was injured by fragments of glass from a broken window.

(343.) — On December 31st six boilers exploded at Law's shaft, at Avoca, near Scranton, Pa. Thomas McDonald, Courtright Wolff, and Alexander Young, who were in the fire room at the time, were instantly killed. The boiler-house was badly damaged.

(344.) — An oil-well boiler exploded, on December 31st, at Rudolph, a village near Bowling Green, Ohio. William Mason was badly scalded.

The Locomotive.

HARTFORD, FEBRUARY 15, 1896.

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

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Boiler Explosions during 1895.

We present, in the accompanying table, a summary of the boiler explosions that occurred in the United States during the year 1895, together with the number of persons killed and injured by them.

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

SUMMARY OF BOILER EXPLOSIONS FOR 1895.

MONTH.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January,	30	34	32	66
February,	46	28	37	65
March,	26	30	57	87
April,	16	12	22	34
May,	26	23	32	55
June,	23	27	52	79
July,	20	19	30	49
August,	35	70	79	149
September,	26	14	35	49
October,	43	40	58	98
November,	33	60	59	119
December,	31	17	26	43
Totals,	355	374	519	893

which it is abstracted (and which are published from month to month in THE LOCOMOTIVE) it is our custom to obtain a large number of accounts of each explosion, and to compare these different accounts diligently, in order that the general facts may be stated with some considerable degree of accuracy. It may be well to add, too, that this summary does not pretend to include *all* the explosions of 1895. In fact, it is probable that only a fraction of these explosions are here represented. Many accidents have doubtless happened that were not considered by the press to be sufficiently "newsy" to interest the general public; and many others, without doubt, have been reported in local papers that we do not see.

The total number of explosions in 1895 was 355, against 361 in 1894, 316 in 1896, and 269 in 1892. In a few cases more than one boiler has exploded at the same time. When this has happened, we have counted each boiler separately, as heretofore, believing that in this way a fairer idea of the amount of damage may be had.

The number of persons killed in 1895 was 374, against 331 in 1894, 327 in 1893, and 298 in 1892; and the number of persons injured (but not killed) in 1895 was 519, against 472 in 1894, 385 in 1893, and 442 in 1892.

It will be seen from these figures that during the year just elapsed there was, on an average, nearly one boiler explosion a day. The figures in the table show that the average of the deaths and injuries during 1895, when compared with the number of explosions, was as follows: The number of persons killed per explosion was 1.06; the number of persons injured (but not killed) per explosion was 1.47; and the total number of killed *and* injured, per explosion, was 2.52.

There was no explosion in the United States during 1895 that could compare, so far as the number of boilers involved is concerned, with the great Shamokin explosion of 1894 (which was described in THE LOCOMOTIVE of December, 1894). The explosion at Redcar, England, on June 14, 1895, described in our issue of September, 1895, was the greatest explosion of the year, in this respect. But if we pass to the consideration of the *number of persons killed and injured*, we find that our own record exceeds that at Redcar in two cases. There were 12 persons killed and 20 injured at Redcar; while in the explosion at the Gumry Hotel, Denver, Col., on August 19th, there were 22 persons killed and 7 injured, and in the great explosion in the *Evening Journal* building, at Detroit, Mich., on November 6th, there were 37 persons killed and 20 injured.

Dr. Gatling's Address.

The following interesting address was delivered before the American Association of Inventors and Manufacturers, at its annual meeting in Washington, D. C., on January 21, 1896, by Dr. R. J. Gatling, who is, and has been since its organization, the association's genial president:

"*Gentlemen of the Association:*

"The United States, although young, has an interesting and remarkable history. It is the most progressive nation in the world. It is in the van of nations in wealth and the general prosperity of its citizens. It will be interesting and instructive to consider and point out some of the causes and events that have brought about these marvelous results. In studying the history of this country we find its early settlers were men and women of sterling worth. They were imbued with the love of liberty and the highest religious sentiment. They endured many hardships, fought Indians and subdued the forest, and finally, when oppressed by the mother country, they rose up in arms and carried on a seven years' war with England, and after the colonies (now states) had gained their independence they had the good sense to form the National Government, with powers defined by the Federal constitution, which, in many respects, is the wisest document of its kind ever formed by man. A kind Providence favored the colonists in having such wise men as Washington, Jefferson, Franklin, and others, to guide and direct their public affairs. It was fortunate that the people at the close of the Revolution were poor and helpless, as these conditions gave them a realizing sense of the necessity of forming a more perfect union. Had not such a union been formed there would have been thirteen poor and feeble nationalities in the place of our present populous and prosperous nation.

"A number of events have occurred since the formation of our government which have contributed to the extension of the area and prosperity of the country. Among the number may be enumerated the following: Jefferson when president in 1803 bought of France what is known as the Louisiana purchase, which gave us the mouth of the Mississippi river and embraced not only the state of Louisiana, but the country now occupied by the states of Arkansas, Missouri, Iowa, Minnesota, and the most of that vast country lying west of the states mentioned, and east of the Rocky Mountains, and which, with Texas, embrace the best and most fertile agricultural region in the world.

"In 1845 Texas, an empire in itself, was annexed to the United States. Its admission brought on the war with Mexico, at the close of which Mexico ceded to the United States by treaty New Mexico and California. It is needless to say that the acquisition of these extensive regions added immensely to the domain and to the agricultural and mineral resources of the United States. There is no estimating the value of such possessions, which give us access to the Pacific ocean. Florida and Alaska have been added to the Union, but are of little value compared to the area of country before mentioned. The interior water communications of the United States surpass those of any other country. The Mississippi river and its tributaries furnish some ten thousand miles of steamboat navigation. The Great Lakes also furnish extensive navigation. It is eleven hundred miles from Buffalo to the head of Lake Superior, and there is more commerce on the lakes alone than is possessed by most nations.

"There are other causes and influences that have contributed to the nation's greatness: The influence of home life in the United States, which is of the best type, has done much to improve society. Who can estimate the influence for good the mother has over her children? Our free school system lays the foundation of intelligent political action, and the press is also a great educator of the people. The printing-presses of to-day, which print thousands of copies per hour, were unknown to our forefathers; so were railroads and steamships, the telegraph and telephone. The pulpit has an immense moral and religious influence in teaching the thoughtless self-sacrifice and making the masses better citizens. The laws made in accordance with the terms of the constitution have been a boon to the people. Our tariff laws have incidentally encouraged the growth of manufactures, which now produce most of the products and articles that are consumed by the people of this country, and which contribute to their prosperity and independence. The patent laws have also done much to promote the country's progress; such laws have encouraged new inventions and have brought wealth and comforts to the people. The interest of the manufacturers and inventors are co-ordinate. In other words, manufacturing industries are promoted by invention, which in turn is fostered by the manufacturing industries. It may be truly said that these co-ordinate interests go hand in hand and to a great extent dominate the progress of the world. The Patent Office business is the only department of this government that pays its own expenses. The total cost of the Patent Bureau last year was $1,195,557. The excess of receipts over expenditures was over $157,000, and the total receipts over expenditures to the credit of the Patent Office in the Treasury of the United States amount to over four and a half millions of dollars. The Patent Office is worthy of the highest consideration. The very best facilities should be provided for its maintenance. The office of the commissioner of patents should not be of a political character, but should be made continuous as that of the Supreme Court Justices, and the salary of the commissioner should be equal to that of a member of the cabinet. Such increase of salary would be the means of securing the best talent and would be an inducement for the commissioner to continue in office. This would be desirable, as now, after learning their duties they wish to resign and to go into other business which yields them a better income. The number of examiners and their salaries should be increased, and their salaries paid out of the patent fund. Such changes would enable the work of the Patent Office to be conducted efficiently and without delay.

"The government profits to the extent of over $150,000 a year by reason of the income it derives from the Patent Office. Justice should be done to inventors. It is not right that they should pay so largely to the patent fund and also be required to pay their proportion of other taxes assessed by the government. Inasmuch as inventors have contributed so largely to the erection of the Patent Office it would seem to be but right and proper for that building to be dedicated and used exclusively for patent business, and a Museum of Arts. It would be the part of wisdom for Congress to pass an act separating the Patent Office from the Interior Department, and make the Patent Bureau a department of its own, with a Cabinet officer at its head; such a bureau should be required not only to attend to patent matters, but look after the manufacturing industries of the country. Such a department would no doubt be of even more service than that of the Agricultural Department. Our patent laws, although not perfect, are undoubtedly better than those of any other nation, and they have greatly promoted and encouraged invention. The United States have in use more labor-saving machines than are possessed by any other country, and such machinery has materially aided in producing wealth and giving comforts to the people. It is a well-known fact that such labor-saving tools and machinery have been the means of enabling the laboring classes in this country to get higher wages than are paid in any other country. Such in brief are some of the good effects flowing from our patent laws, and it should be the duty of Congress and all good and intelligent citizens to shield and protect our patent laws from the attacks of all enemies.

"Foreign patent laws seem to have been made solely to bring in revenue to the sovereign without any regard to the rights or the interest of the inventor. No features of such laws should be engrafted or incorporated into our patent system. The patent laws of most foreign countries require that the patentee must pay a periodical tax in order to keep his patent alive, and also require the invention to be worked within a certain period of time. It is needless to say these requirements are onerous and discourage invention. It often happens that some of the most valuable inventions are made by poor men who have not the means to pay such taxes or to work their inventions in a given time. It frequently occurs that new inventions are made before there is any demand for the same, and often years may elapse before there is any benefit derived from new inventions, owing to the time it usually takes to perfect them. If a patentee should die before he has fully perfected his invention, his widow and children might not be able to meet the expenses required to keep the patent alive, and in such case there should be some redress. The great questions to be decided are:

"First, Do new inventions benefit mankind ? and

"Second, Do the patent laws encourage the people to make new inventions ?

"If the foregoing questions are decided in the affirmative, it would be proved that no impediments should be put in the way to retard invention, but that all reasonable efforts should be made to encourage inventions. As previously stated, our patent laws, although needing improvement in many respects, are better and give more encouragement to inventors than any foreign patent laws, and have been the means of the issue of more patents in this country than in all the world besides. Invention and discoveries should be allowed to go on. What a blessing it would be to the human race if some man could invent something that would take the place of alcohol and that would be harmless in its use. And would it not also be a comfort and a blessing if some lover of humanity could invent some cleanly and harmless product that would take the place of tobacco? Who can say but what such discoveries may yet be made? Men that lived in the past century never thought or dreamed of the steamship, railroad, telegraph, telephone, steam printing-presses, suspension bridges, reapers, mowers, sewing-machines, iron plows, friction matches, and the thousand other inventions now in common use. Notwithstanding this is a mechanical and inventive age, some men are to be found who seem to be asleep, and who take but little notice, or give any thought to the world's progress. Such persons through their ignorance, would, if they had the power, abolish all our patent laws and be content to go back to the old stage-coach and the sickle. Among the modern inventions that deserve special attention are the bicycle, the electric car, and the horseless carriage, all of which have come to stay, and which will cheapen and facilitate travel, and, to a great extent, supersede the need of horses. It may be stated as a truism, that whatever saves labor, time, and money, will, in the end, result in good to the human race.

"I cannot close without saying a few words in praise of our form of government. All sovereign power in this country resides in the people. In other words, all rights begin with and go from the people, and it should be the duty of all patriotic citizens to educate their children to believe that the mission of the United States is to teach the world the great benefits and blessings that flow from free government. A man that does not appreciate our form of free government is unworthy of American citizenship. The people of this great nation should not allow anger or petty issues to disturb the common good; they should love liberty and be mindful of the prosperity and welfare of all, and they should not lose hope that the nation's flag will be loved and revered as long as time endures."

The boiler in the Harrison street station is considerably past the legal age, and is nothing but a mere shell, while the pipes and the steam valves have nearly rusted themselves out of existence. The plant is located directly underneath Justice Richardson's courtroom, on the north half of the building, and should the boiler explode some day, Justice Underwood's court, in the opposite half, will continue the same as usual. The officers expect to see Justice Richardson hurriedly grasp his valuable papers and shoot aloft, some day, closely followed by the bench-warmers of Court No. 1, who have stood by his honor through thick and thin for many a day, while the defendants on hearing will suddenly take a change of venue. The boiler below is twenty-three years old and suffers with innumerable ills. It is having a hard tussle with the winter and grave doubts are expressed as to whether or not it will live till spring. In speaking of it, Chief Engineer Murphy talks like some one who is trying to uphold an old friend who has gone wrong.— *Chicago Times-Herald.*

Within the past month the discoveries of Lenard and Roentgen, concerning the invisible rays that penetrate wood and flesh, have attracted great attention. An article on this subject is now in preparation for The Locomotive, and will be published shortly.

The Locomotive.

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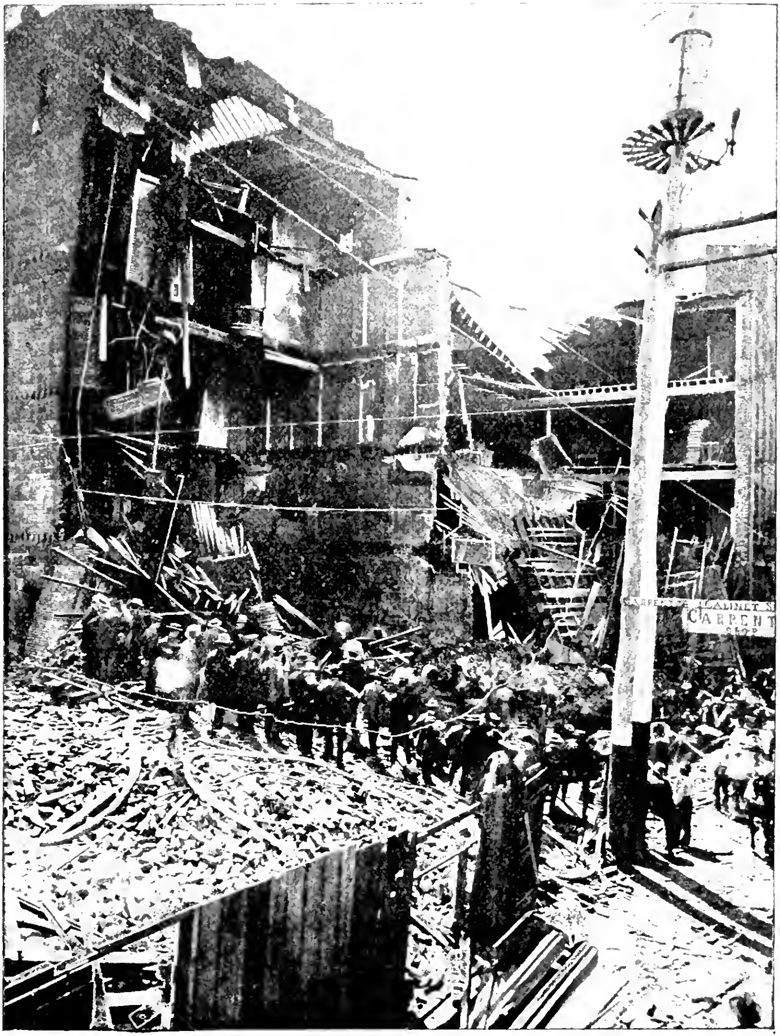

Ruins of the Gumry Hotel.

The Gumry Hotel Explosion.

At midnight of August 18, 1895, a boiler exploded in the Gumry Hotel, at Denver, Col., killing no less than twenty-two persons, and injuring seven others more or less seriously. The building itself was entirely wrecked. Its appearance, shortly after the explosion, is shown in the photo-engraving on the first page of this paper.

On the night of the explosion the hotel was unusually full of guests, most of whom had by twelve o'clock retired for the night. The engineer usually banked the fires at eleven o'clock, but on this occasion he remained later than usual,—a fact which has led to the belief that he had noted something unusual in the behavior of the boiler, or that he was carrying a higher pressure than was ordinarily needed, and that he did not wish to go away until he was assured that no trouble would ensue.

At midnight the boiler exploded with fearful violence, and the entire rear of the building was demolished. The fire department was called out and responded promptly. The walls of the building were cracked, and the street was littered with glass that had been blown out of the windows; but although it was evident that there had been an explosion of some kind, there was nothing visible on the front side of the hotel that would show the true magnitude of the disaster. The guests in the front rooms were at the windows when the fire department arrived, crying for help. They were rescued by the firemen, and attention was then turned to the rear of the hotel, where it was found that five stories of rooms, together with their occupants, had fallen down into an alleyway, in a shapeless heap. The work of rescue was pushed vigorously, and for a time it was hoped that all those who had not been killed outright by the shock, might be saved. A hundred men were working with all their might, and cries of cheer were exchanged between rescuers and prisoners; but about twenty minutes after the work began, puffs of smoke were seen to issue from the ruins, and it became evident that the dèbris had taken fire, below, from the live coals scattered about by the explosion. "And then suddenly the flames broke out, and the workers were driven away, and the voices ceased to cry for help. The great mass was from that moment nothing but a grave. The most that the firemen could do, while the flames and smoke shot up fiercely and drove them back, was to fight desperately for the life of one poor fellow, Joseph Munal, whose head and shoulders protruded from the burning mass." Several of the victims were burned to death before the eyes of the firemen, who were powerless to save them. The heroic rescue of Munal is well described by the Denver *Republican*, from which we take the following extract: "Work was now entirely confined to fighting the fire back from the place where Munal lay, and in endeavoring to save him. Shifts of a dozen men each worked until exhausted by heat or smoke, and then retired for air, others instantly taking their places. Munal was pinned down by several immense beams and timbers, and it was almost impossible to extricate him. Axes, ropes, picks, hooks, and every implement that could be brought into use were eagerly seized and vigorously plied, and still other men tore at the bricks and splinters with their naked hands. Men dived into the hole that was being made, regardless of their lives or persons; and after an hour's toil, enough of the dèbris was removed so that Munal's head appeared. Police-surgeon Jarecki then took his place in the hole, and kept Munal's head moist and cool with a wet sponge, while the rest of his body was being freed. It was a position of great danger for all, on account of the flames, and the overhanging roof, which threatened to come down at any moment; but the men worked on, hauling at beams with ropes, and using every device to clear the space around the suffering man, who bore his agony with great bravery, and cheered on his helpers." After two hours and a half a great cheer arose, announcing that he was free. He was taken to the hospital, and the workers rushed back to the wreck, where a woman's hand had been seen, and her faint calls for help heard; but shortly all human cries were stilled, and out of the blackness and the flickering lights there came no sound save the splashing of water and the hissing of steam. It was two days before all the bodies could be taken out.

So far as the technical side of the explosion is concerned, there is not much to be said. The destruction was so complete that it is difficult to draw any intelligent conclusions from the ruins. The engineer, Heilmuth P. Loescher, was a young man of small experience, who was required to work about sixteen hours a day, and who also had to do odd jobs about the hotel, in addition to his regular work of caring for the boiler. It is said that he never raised the safety-valve, to see whether it was working freely or not, and that he habitually carried a pressure of 60 pounds, when 20 pounds was sufficient to do the work; but we do not attach much importance to this latter point, because the city inspector had certified that the boiler was safe at 75 pounds. Loescher states that he had never cleaned the boiler internally, giving as his reason that Mr. Gumry would never allow him to use any scale preventive. The city inspector, some three months before the explosion, ordered some of the tubes removed and replaced, and we understand that thirty-three of them were taken out and new ones put in in their places. There appears to be some doubt about the quality of the work that was done when the new tubes were put in, for, according to Loescher, some of them were too long, and instead of cutting them off to a proper length, an attempt was made to bead them over against the head. It appears, further, that the boiler was not tested by hydrostatic pressure after the repairs had been completed, on account of the expense (five dollars!) that such a test would involve. There is evidence that the tube-ends leaked after the repairs had been made, and also that one of the girth joints sometimes showed distress, especially when the pressure was low.

Many persons who viewed the ruins inclined to the belief that the explosion was due to low water. Loescher, however, states that when he left the boiler, a short time before the accident, it was well supplied with water, and he was particular to add that although he did not examine the safety-valve, he was in the habit of blowing out the gauge-glass connections every day. We think that Loescher's statement about the quantity of water present is very likely correct; for the violence of the explosion indicates that the boiler contained a considerable amount of water. A dry boiler may rupture and do more or less damage, but the most disastrous explosions are those in which plenty of water is present. In the present case we should not like to speak positively about the cause of the explosion, because we do not know enough about the attendant conditions and circumstances to draw any very definite conclusions; but the general indications are, that the disaster was due to simple over-pressure. Loescher may be right when he states that the pressure on that fatal night was not over fifty pounds, for this might be quite sufficient to bring about an explosion, if the boiler had been weakened by corrosion, by burning, by poor workmanship in making repairs, or from any other cause.

The Gumry Hotel explosion was similar, in many respects, to the one which destroyed the Park Central Hotel, in this city, on February 18, 1889. (The Park Central explosion, which was illustrated in our issue for March, 1889, resulted in twenty-three deaths.) The coroner's jury, after six days' investigation of the Gumry Hotel disaster, found it impossible to fix the responsibility upon any one person, but concluded that the owners, Peter C. Gumry and Owen Griemer (both of whom were killed), were blamable for allowing their engineer to work sixteen hours out of the twenty-four.

They also censured Loescher, the engineer, charging him with negligence, and the city boiler inspector was criticised for not examining the boiler after repairs were made upon it.

The total value of the property destroyed was about $75,000.

Inspectors' Report.

January, 1896.

During this month our inspectors made 10,062 inspection trips, visited 18,713 boilers, inspected 6,068 both internally and externally, and subjected 645 to hydrostatic pressure. The whole number of defects reported reached 10,925, of which 1,212 were considered dangerous; 69 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	780	54
Cases of incrustation and scale,	1,953	77
Cases of internal grooving,	124	14
Cases of internal corrosion,	574	32
Cases of external corrosion,	632	49
Broken and loose braces and stays,	199	86
Settings defective,	327	37
Furnaces out of shape,	388	20
Fractured plates,	328	80
Burned plates,	229	25
Blistered plates,	208	4
Cases of defective riveting,	1,173	89
Defective heads,	109	15
Serious leakage around tube ends,	1,994	308
Serious leakage at seams,	451	72
Defective water-gauges,	365	66
Defective blow-offs,	186	60
Cases of deficiency of water,	22	10
Safety-valves overloaded,	89	16
Safety-valves defective in construction,	138	36
Pressure gauges defective,	503	59
Boilers without pressure gauges,	3	3
Unclassified defects,	150	0
Total,	10,925	1,212

Boiler Explosions.

January, 1896.

(1.) — On January 2d a boiler exploded in St. Louis, Mo., in the basement of a building occupied by the Anchor Peanut Co., and the Excelsior Fireworks Co. The building was shattered, and a number of persons were buried in the wreckage. The ruins of the building took fire, and the entire fire department was called out before the flames could be controlled. Joseph Chemelie, Frank Neihaus, and Paul Hauptner were dead when removed from the ruins, and later on four more bodies were taken out, mutilated so badly that recognition was very difficult, and perhaps impossible. These men, at last accounts, were believed to be Norman McArthur, L. Lay, Charles Axon, and Joseph Cavoreck, who were known to have been in the building and could not be otherwise accounted for. In addition to those instantly killed (or dead when removed), it is said that Alays Schneids and Charles E. Amos were fatally injured. Thirty-one other persons also received lesser injuries.

(2.) — The boiler of a freight engine used on the Columbus, Sandusky & Hocking Railroad exploded on January 4th, between Fultonham and Mount Perry, near Zanesville, Ohio. Herbert Mead, Frank Hesse, and Frederick Kreits were instantly killed, and conductor Ira Morris was fatally injured, so that he died later in the day.

(3.) — A boiler exploded, on January 3d, in Chance & Kruse's mill, at Manchester, near Lawrenceburg, Ind. Colton Cross and Charles Robinson were instantly killed, John Edwards was injured so badly that he died a few days later, and Frederick Geisman received injuries that are believed to be fatal. Four other men were also injured, and the mill was entirely destroyed. The boiler was a new one.

(4.) — On January 4th a boiler exploded in the pump house belonging to the Chicago & Erie Railroad, at Decatur, Ind. The engineer, Thomas Malotte, who was in the basement at the time, thawing out some frozen pipes, was scalded so badly that he cannot recover. The building was demolished, and its fragments were blown high into the air.

(5.) — The boiler of passenger locomotive No. 91, on the Delaware, Lackawanna & Western Railroad, exploded, on January 4th, in the round house at Hoboken, N. J. The tender was blown through the eastern wall, and a big part of the roof of the building was blown nearly one hundred feet into the air. No one was killed. Charles Emmons, the fireman, was thrown from the tender, and was taken home dangerously injured. F. Graesbach was taken to St. Mary's hospital in a critical condition, and Henry Belton, fireman of a neighboring locomotive, was buried under the dèbris, but was taken out only slightly injured. John Peters, Frederick Wells, William Bouge, Peter Mawrey, Jacob Osborne, and five others received trifling injuries.

(6.) — The boiler of a portable pumping engine exploded, on January 4th, at Edgeworth, near Alliance, Ohio. Thomas Moriarty, who was in charge of it, noticed that it was leaking at all the joints, although the steam gauge indicated only 20 pounds. The pleasures of geographical research then occurred to him, and impressed him so profoundly that he dropped his work at once and made a bee line for some distant clime; but he had not gone far when the boiler decided to join him. It exploded with great violence, and Moriarty was thrown to the ground. He was struck by flying cinders and bits of iron, and received many painful bruises, from which he will be confined to his house for some time. Fragments of the boiler were found 2,000 feet from the spot where the explosion occurred.

(7.) — On January 4th a hot-water boiler exploded in the basement of a gymnasium at Manchester, N. H. A considerable amount of damage was done to the lower part of the building, and those who were in the building got a good shaking up and a bad fright.

(8.) — The boiler in the electric light plant at Mt. Gilead, near Columbus, Ohio, exploded on January 4th, and the town was thrown into utter darkness.

(9.)—A boiler exploded, on January 6th, in a fertilizer factory in New York city. Twenty-five men were in the building at the time. Two of them were taken out unconscious, and it was reported that five more were buried in the ruins; but we have not received any corroboration of this rumor.

(10.)—A boiler exploded at the Latrobe Steel Works, Greensburg, Pa., on January 7th, completely demolishing the boiler house. John Rodgers and S. K. Wagner were struck by flying dèbris and badly hurt.

(11.)—A boiler exploded in the creamery at Clintonville, near Oil City, Pa., on January 7th, during the course of a fire there. The explosion and fire, together, destroyed the building entirely.

(12.)—A traction engine boiler belonging to Mr. Samuel Krahenbill of Burr Oak, near Melrose, Wis., exploded on January 7th. Fortunately nobody was injured.

(13.)—On January 8th a small boiler exploded in the butcher shop of C. F. Fenton, at Mount Joy, near Lancaster, Pa. The frame building in which the boiler stood was blown to pieces. Mr. Fenton, who was firing at the time, was fatally injured, one of his legs being blown off. Christian Gingrich was also seriously injured.

(14.)—The crown sheet of locomotive No. 68, on the T. & O. C. road, blew down, on January 9th, at Rushville, near Bucyrus, Ohio. Fireman Samuel Scherer was terribly scalded and burned. Brakeman Burkhart was also severely injured, and engineer Lamb received slight injuries.

(15.)—A boiler in P. H. Wolcott's mill, at Hermitage, near Rochester, N. Y., exploded on January 12th. We have not received full particulars of this explosion, but we believe it consisted in the failure of a tube. No one was injured.

(16.)—A saw-mill boiler, belonging to Frederick Dabner, exploded, on January 14th, near Stewartsville, Mo. Two of Dabner's children were killed, and he was himself badly injured.

(17.)—A boiler belonging to the Garden City Stationery Co., of Elkhart, Ind., exploded on January 15th. The plant was running day and night, and it is marvelous that nobody was killed. Considerable damage was done to the building and stock.

(18.)—On January 16th the crown sheet of freight engine No. 611, of the Pennsylvania Railroad, gave way, at Camden, N. J., near the Haddon avenue station of the Amboy division. The engineer, John D. Clark, was fatally scalded. H. S. Corson, the fireman, was blown from the cab, and was bruised badly, but not fatally.

(19.)—A boiler used in drilling an oil well, on the James Barber farm, near Mendon, Ohio, exploded on January 16th, demolishing the derrick and boiler-house. Fragments of the boiler were found a quarter of a mile away. The men were all at dinner at the time.

(20.)—A crown-sheet failed, on January 17th, on a freight locomotive belonging to the Delaware, Lackawanna & Western Railroad, as the train was entering the yards at Halstead, Pa. Fireman Evans was blown over the tender and two or three cars, and landed some distance away on a bank. Both of his eyes were blown out, and he was otherwise injured, so that it is doubtful if he can recover. Engineer Williams was not injured.

(21.)—A threshing-machine boiler exploded, on January 17th, near Waterloo, Iowa. A teacher and her scholars were near the machine at the time, watching its operation. Several persons were scalded, but fortunately nobody was killed.

(22.) — A boiler in the Platt County Creamery, at Bement, Ill., exploded on January 18th, wrecking the boiler-room. Nobody was injured.

(23.) — On January 20th a small boiler exploded in Gustav Didier's residence, on Dauphine street, New Orleans, La. The damage was not great, and there were no personal injuries.

(24.) — A boiler exploded, on January 20th, in Bartlett, Brown & Blake's mill, at Port Republic, N. J. The boiler was blown through one end of the mill, and the engine through the other end. The fly-wheel was hurled through the roof, and landed in a vacant lot 100 feet distant. We have seen no estimate of the property loss.

(25.) — On January 21st a boiler exploded in George W. Bledsoe's saw-mill, at Dugger, Ind. James M. Taylor was fatally injured, and Theodore W. Sult was injured severely, though he will probably recover. James Gray and Columbus Borders were also injured slightly.

(26.) — A cotton-gin boiler exploded, on January 21st, near Sanford, N. C. Walter Gunter and James Gilmer were killed, and Gilmer's father, who owns the gin, was badly bruised. One end of the building was completely wrecked.

(27.) — The boiler of the locomotive attached to passenger train No. 21, on the Little Miami division of the Pan Handle road, exploded near South Charleston, Ohio, on January 22d. Engineer Clark A. Trimble and fireman George Waters were killed, and the train was wrecked. Trimble was not killed instantly, but walked to the station and spoke with the agent there; but a few moments afterwards he fell upon the platform, dead. The postal clerk and six passengers were injured more or less seriously; one of them, it is reported, having both legs broken. Trimble leaves a family of eleven children.

(28.) — A small boiler exploded, on January 27th, in the basement of Philip Steinmiller's house, at McKee's Rocks, Pa. Mr. Steinmiller's daughter Margaret had one leg broken, and was otherwise bruised, also. A local paper, whose reporter is evidently unfamiliar with the vagaries of exploding boilers, says: "There was something very peculiar about the explosion. The door of the basement, which had been closed at the time of the explosion, and which opens inward, was torn from its hinges and broken into a dozen pieces, and nothing could be found that had struck it."

(29.) — A portable boiler exploded, on January 27th, on the farm of J. Warren Wells, at Aquebogue, near Riverhead, L. I. The boiler and engine were destroyed, but nobody was seriously hurt.

(30.) — A threshing-machine boiler exploded, on January 28th, at Emerson, near Winnipeg, Man., hurling Mr. E. E. Freeman, together with a portion of the engine, through a double partition in a barn. Mr. Freeman was badly scalded, bruised, and cut, but it is thought that he may recover.

(31.) — Two boilers exploded, about January 28th, in Hand Bros'. saw-mill, in Bibb Co., Ala. James Ely and Frank Henry were badly hurt.

(32.) — On January 29th a boiler exploded in the large lumber mill belonging to the Southern Pine Co., at Offerman, near Savannah, Ga., and known as "Mill No. 1." James Baker was killed instantly, four men were scalded so badly that they died within a few hours, and two others were injured so seriously that they are not expected to recover. It is said that the mill was almost entirely destroyed.

(33.) — On January 30th, by a boiler explosion in the Hollidaysburg Iron and Nail Co.'s plant, at Hollidaysburg, Pa., George Lane, Conrad Evans, and Merrill Treese were killed instantly, and Robert McMurray and Samuel Marks died within a few hours. Samuel Kephart, John Woomer, Finley Ferguson, Robert Marks, Frank Cramer, George Moore, Marshall Weir, and John Heffner were terribly scalded, cut, and bruised, and several of them will doubtless die. David McCloskey, George Rock, Daniel Ounkst, William Harsock, and Daniel Ayres were also painfully and seriously injured, but are believed to be on the road to recovery. George Kerr, John White, Mahlon McClure, and James Moore were slightly injured by flying débris. The boiler passed upward through the roof, rose 300 feet into the air, and plunged down into another part of the works. The entire roof of one building was thrown to the floor below, and the works were practically wrecked. Beams a foot thick were splintered like matches.

(34.) — On January 31st a boiler exploded in Joseph Morrison's stave mill, near Freeport, Ohio. Roy Vesey, William Kiefer, and William Laport were instantly killed, and their bodies were dismembered. Isaac Morrison was fearfully injured, and his little son was badly cut. The boiler was blown to fragments, and the mill was wrecked.

WE read, in a Boston daily paper, of a narrow escape from a remarkable accident, in the central station of the Boston Electric Light Co., on the Summer street extension. Coal slack, with occasional large lumps in it, is used there as fuel. The attendant was firing the boilers on the day in question, when he observed that one shovelful of coal that he had taken up was noticeably heavier than usual. He did not throw it into the furnace, but put it down on the floor and examined it. He found what appeared, at first sight, to be a rather large lump of coal; but upon closer inspection it proved to be a grimy tin box. Calling another fireman to his assistance, he pried the box open, and found it filled with a black material that did not look unlike coal dust. The chief of the night force was then called, and he pronounced the contents of the box to be giant powder. If the fireman had thrown it into the furnace, it is likely that the most disastrous results would have followed; for the room contained a battery of sixteen big boilers all working under a pressure of 140 pounds of steam, and if fourteen pounds of blasting powder had been exploded under one of them, it is impossible to guess the amount of damage that might have resulted. It is considered likely that the powder found its way into the coal at the mine, and had afterwards escaped notice until it was taken up on the shovel by the observant fireman. If our opinion were asked, we should probably say that the electric light company ought to do the handsome thing by that fireman.

THE "DRY WEATHER" RECORD. — We take the following list of notably dry summers from the Hartford *Times*. We do not know to what particular region the data here given apply, but presumably they relate to Massachusetts and Connecticut: In the spring and summer of 1621, there were 24 days in succession without rain. In 1630 there was a similar dry spell of 41 days. In 1657 there were 75 successive days without rain; in 1662 there were 80 such days; in 1674 there were 45; in 1680 there were 81; in 1694 there were 62; in 1705 there were 40; in 1724 there were 61; in 1728 there were 61; in 1730 there were 92; in 1741 there were 72; in 1749 there were 108; in 1755 there were 42; in 1762 there were 123; in 1783 there were 80; in 1791 there were 82; in 1802 there were 23; in 1812 there were 28; in 1856 there were 24; in 1871 there were 42; in 1875 there were 26; and in 1876 there were 27. "It will be seen," continues the *Times*, "that the longest drought that ever occurred in America was in the summer of 1762, when no rain fell from May 1st to September 1st, making 123 consecutive days without rain. Many of the inhabitants sent to England for hay and grain."

Appleton's Popular Science Monthly, in a tribute to the late Mr. Henry Seebohm, a distinguished ornithologist, quotes a discovery made by that gentleman, as follows: "Among the many trips which he took to clear up some question of migration or habitat [among birds], the one which led to his discovery of the north coast tundras as the great breeding-ground for a large class of European birds, is one of the most interesting. In looking for the breeding-place of several English birds which regularly disappear every spring, no one knew whither, he was led to visit the Petchora river, which flows from the Ural mountains northward, and empties into the Arctic ocean opposite Novaya Zembla. On the upper river is the great Siberian forest, while lower down on either bank below the limit of trees is the tundra, which fringes the whole length of the northern coast. It is called the region of treeless swamp, is uninhabited, and for eight months out of the twelve is covered with snow. Yet he found this to be the unknown land which drains the Old World of half its bird population every spring. At the beginning of April Mr. Seebohm reached Ust Zylma, three hundred miles from the mouth of the Petchora. The surface of the river was frozen as far as the eye could reach, and the frozen forest was as bare of life as the Desert of Sahara. Suddenly summer came, and with it the birds arrived. The ice on the river split and disappeared, the banks steamed in the sun, and innumerable birds of all sizes and colors appeared within forty-eight hours after the first warmth. The tundra was found to be a moor, with here and there a large, flat bog, and numerous lakes. It was covered with moss, lichens, heath-like plants, dwarf birch, and millions of acres of cloudberries, cranberries, and crowberries. Forced by the perpetual sunshine of the Arctic summer, these latter bear enormous crops of fruit. But the crop is not ripe until the middle or end of the Arctic summer, and if the fruit-eating birds had to wait until it was ripe they would starve. But each year the snow descends on this immense crop of ripe fruit before the birds have time to gather it. It is perfectly preserved by this natural system of cold storage until the next spring, when the melting of the snow discloses the bushes with the unconsumed last year's crop hanging on them or lying ready to be eaten on the ground. It never decays, and is accessible the moment the snow melts. The same heat that frees the fruits, brings into being the most prolific insect life in the world. No European can live there without a veil after the snow melts. Thus the insect-eating birds are provided for. The trip to the Petchora was but one of many similar expeditions which Mr. Seebohm undertook from a pure love of his science."

Some of the animals in the Central Park menagerie have had an uncomfortable time during the past few days. The flue in the larger of the two boilers that supply the various houses with heat gave out on New Year's eve, and the monkey, the lion, and the elephant houses have been without much warmth. Director Smith of the menagerie had the monkeys removed to new quarters in the basement of the Arsenal. These are in the northern half of the basement and are much better equipped and more commodious than the old house. The elephants proved particularly susceptible to the cold. Director Smith procured heavy blankets and wrapped them around the great animals. The elephants took very kindly to the blankets, even though they looked comical to the sight-seers. The lion house, in which, among others, there is a lioness with five cubs, and the hippopotami house were temporarily supplied from the second boiler. Workmen were engaged on the broken-down boiler, and yesterday it was ready to do its work again.—*New York Recorder.*

The Locomotive.

HARTFORD, MARCH 15, 1896.

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

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

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

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

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

WE have received, from the B. F. Sturtevant Company of Boston, Mass., a copy of an artistic pamphlet entitled *A Third of a Century of Progress*, which gives a brief history of the development of the business of that company. The pamphlet is neat in appearance, and highly creditable to its publishers.

Cassier's Magazine, always bright and "up to date," is unusually good in the January issue, which is especially devoted to electricity. A quaint portrait of the staunch old philosopher, Benjamin Franklin, forms the frontispiece, and the body of the magazine is filled with important contributions from well-known writers on electric lighting, power transmission, and other related matters. It always gives us pleasure to say a good word for *Cassier's*, because its publishers are doing a good work, and doing it well.

IN our January issue we referred to the enterprise of the Orient Steamship Line, of London, in placing its fine steamer *Lusitania* at the service of the amateur astronomers, and others, who may desire to go to Vadsö, Norway, to see the total eclipse of the sun which will be visible at that place on the 9th of next August. We have since learned that Messrs. Thomas Cook & Sons are arranging an excursion to leave London on the same steamer. We have also received a pamphlet from Messrs. Henry Gaze & Sons, of 113 Broadway, New York, from which it appears that these gentlemen have secured the steamer *Norse King* for a similar excursion, which is to leave London on July 25th. The pamphlet issued by the Messrs. Gaze is quite interesting, and we append a few extracts from it. "The eclipse which is to occur on the morning of August 9, 1896," we are told, "will be visible as a total eclipse along a line which commences in the open sea some 200 miles to the north of Scotland, enters Norway a little to the south of Bodo, and emerges from Norway at Vadsö. The line of totality then crosses Nova Zembla, traverses Siberia and the northern part of Japan, and ends in the Pacific ocean, in longitude 180° and north latitude 20°." Of all the points along this line, Vadsö is the one which appears to combine the conditions of visibility, accessibility, and general personal convenience, in the best manner. During the voyage of the *Norse King* Sir Robert Ball, who is to go on the vessel, "will deliver a course of three lectures on the eclipse, and on astronomical matters connected with it." The duration of totality at Vadsö will be one minute and forty-six seconds, and the sun will be 15 degrees above the horizon. It is proposed to visit the Lofoden Islands, where 30,000 fishermen are employed during the fishing season. The North Cape (the most northerly point of

Europe) will also be visited. After the eclipse the party will have an opportunity of seeing the town of Hammerfest, which is nearer the north pole than any other town in the world. The trip would be worth taking for its own sake, even if the eclipse were left out; so that the disappointment that would be felt by the tourists, in case of bad weather on August 9th, would be greatly tempered by the many other features of interest that the excursion includes.

We have received from Messrs. Ginn & Co. a copy of A. D. Risteen's *Molecules and the Molecular Theory of Matter.* Most of the books that treat of this subject consider the molecule solely in its *chemical* aspect, and such information as we have concerning the *physical* properties of these infinitesimal bodies must be sought for in scientific periodicals, or in special works on the kinetic theory of gases. In the volume before us an attempt is made to present, in more connected form, some of the facts that have been learned about the mechanics of the molecules. The field covered is pretty broad, and the treatment of special points is necessarily somewhat brief — perhaps too much so in some places. Several of the methods that have been proposed for finding the sizes of molecules are given, and the illustrative examples show that these bodies are astonishingly small. The book also contains what may be described as a speculative section, in which some of the better known hypotheses concerning the structure of molecules are considered. (Ginn & Co., Boston, Mass., $2.00.) J. M. Allen.

The Workings of the Massachusetts Inspection and License Laws.

The *Report* for 1895 of Mr. Rufus R. Wade, chief of the Massachusetts District Police, is at hand, and we find it to be of much interest. That part which relates to the inspection of steam boilers and the licensing of engineers, begins with a reprint of the law passed by the Massachusetts legislature in 1895, requiring all boilers to be inspected by the state, except boilers upon locomotives or in private residences, boilers under the jurisdiction of the United States or under the periodically guaranteed inspection of "companies that have complied with all the laws" of Massachusetts, boilers used exclusively for agricultural, horticultural, or creamery purposes, and boilers of less than three horse power. After this law has been stated, Chief Wade gives the license law of 1895, which provides that "it shall be unlawful for any person to have charge of or to operate a steam boiler or engine in this commonwealth, except locomotive boilers and engines, boilers in private residences, boilers under the jurisdiction of the United States, and boilers used for agricultural purposes exclusively, or of less than eight horse power, unless he holds a license as hereinafter provided; and it shall be unlawful for any owner or user of any steam boiler or engine, other than those above excepted, to operate or cause to be operated a steam boiler or engine for a period of more than one week without a duly licensed engineer or fireman in charge." This law further provides for the examination, by the state inspectors, of persons who apply for such licenses.

"Judging from the reports of the various inspectors," says Chief Wade, "no important difficulty has been met with in the enforcement of these two laws. The law requires that all boilers not periodically inspected shall be reported to me for inspection, and very many of these boilers have not been reported, and the inspectors have spent considerable time in looking up these delinquents; but in the majority of instances the owners apparently had not heard of this requirement of the law, and complied instantly when their attention was officially called to the matter."

The license law provided that those making application for a license before August 1, 1895, should be allowed to continue in charge of their respective boilers until the necessary examination could be given. The number of applications received, in conformity with this provision, was 14,153. Only 1,605 of these had been examined up to the first day of last January, but the work is being carried on as rapidly as is consistent with care and thoroughness.

"I do not understand the boiler inspection law," says Mr. Wade, "to mean that the state desired to obtain a monopoly of boiler inspection, but merely to see that all boilers receive regular and efficient inspection from some reliable source, and are not allowed to run year after year in a dangerous condition with no knowledge on the part of anyone as to what condition the boilers are in. That this has been the case my reports of previous years have clearly shown; and many of these dangerous and neglected boilers have been found and inspected, and their use ordered discontinued, or such repairs made as would make them safe. Very many of the owners of these neglected boilers have now decided, since the boilers must be inspected, to have the work done by the regular boiler inspection companies instead of by this department. It is to be noted that the inspection companies have found many of these boilers not to be in safe condition, and have refused to guarantee them until extensively repaired, or unless run at a lower pressure; and in many cases they have ordered new boilers. This law of itself, therefore, has brought about these safer boilers and conditions in many factories; yet the full benefit of the law can never appear in the detailed reports of this department. It is to be noted, further, that in some instances, where the inspection companies declared boilers to be unsafe and run at an excessively high pressure, the owners declined to accept the report, and will continue to run the boilers, even though informed of their true condition. These dangerous boilers, however, come under the state supervision, and where before there was no means of shutting them down, this law provides the means of forcing the use of a safer boiler if the state inspector, upon his inspection, finds that the boiler is dangerous. One fact that has been very strongly brought to light by the enforcement of this law, is, that a very large number of schoolhouse boilers throughout the state have been absolutely without inspection of any kind for many years. Many of the reports giving the location of these boilers have stated that the writers could not find out that the boilers had ever been inspected since put in. Whether this is due to the conflict of authority over the schoolhouse property that seems to exist in some places between the public buildings department and the school committee, or to some other cause, the boilers appear to have been left to take care of themselves. In some cases the authority over the boilers appears to be vested in the buildings department, but the janitors are controlled by the school committee, and much of the poor condition of the boilers was due to neglect or ignorance on the part of the janitors, which might have been overcome had both buildings and attendants been controlled by one head. As the matter now stands, the law compels the inspection of the boilers, and where they come under this department it will be strictly enforced; and at the same time the license law compels the appointment of competent janitors, and gives the inspector the power to revoke these licenses for neglect, so that not only will the boilers be looked after, but there must be competent janitors, and no neglect of boilers will be allowed."

The importance of looking carefully after schoolhouse boilers is illustrated by the following extract from the report under consideration: "The practice of the janitor (in a certain schoolhouse) was to build a good fire and leave the building before nine o'clock, with about twenty pounds of steam on, depending upon his judgment as to whether the day would turn out warm or cold. One day last spring the boiler was so left, but the day turned out warmer than he expected, and the teachers shut off the steam from the radiators. The natural result was that the steam was bottled up in the boiler and main steam pipes, with a pretty hot fire on the grates. When the janitor returned, according to his usual custom, about twelve o'clock, he noticed a heavy pressure on the boiler, — *how* high he could not tell, as the guage registered as high as it could, and the safety-valve was stuck. Instead of easing off the pressure as gently as he could, the janitor took the poker and lifted the safety-valve from its seat. Instantly the pent-up steam filled the cellar with a tremendous roar, and pouring upstairs, it frightened the scholars so badly that they rushed from the building in a panic, though fortunately they were not injured beyond a few scratches and bruises. Such a condition of affairs is possible in any school where the boiler is so long neglected; and although there is no provision in the law stating how long a janitor shall be absent from a building, such an absence as that described above is certainly neglectful. The janitor who does not know enough not to open a safety-valve with such an excess of pressure, will not be granted a license until he does know what to do in such cases."

THE *Transactions* of the American Society of Mechanical Engineers for 1895 is at hand. It is, as usual, replete with information of great value to the engineering fraternity. Among the papers that especially relate to steam-boiler practice we may mention the following: "Straightening a Leaning Chimney 100 Feet High," by Joseph C. Platt; "Description of Improved Forms of Steam Separators, Steam Jackets, and Re-Heaters," by Charles T. Porter; "Rustless Coatings for Iron and Steel" (second and third papers), by M. P. Woods; "Results of Measurements to Test the Accuracy of Small Throttling Calorimeters," by D. S. Jacobus; "The Strength of Iron as Affected by Tensile Stress while Hot," by De Volson Wood; "The Down Draught Furnace for Steam Boilers," by William H. Bryan; "Pipe Covering Tests," by George M. Brill; "The Effect of the Length of Specimens on the Percentage of Extension," by R. C. Carpenter; "The Efficiency of Boilers — A Criticism of the Society's Standard Code of Reporting Boiler Trials," by F. W. Dean; "Tests to show the Distribution of Moisture in Steam when Flowing through a Horizontal Pipe," by D. S. Jacobus; "A New Coal Calorimeter," by R. C. Carpenter; "Report of the Committee on Standard Tests and Methods of Testing Materials," presented by G. C. Henning; "The Transverse Strength of Cast Iron," by W. J. Keep; and "Keep's Cooling Curves — A Study of Molecular Changes in Metals due to Varying Temperatures," by W. J. Keep. The topical question, "Are there certain general principles underlying the proper connection of steam boilers and engines in a power plant?" also brought out considerable discussion that will be of interest to steam engineers.

THE *Practical Engineer* (London) gives a brief account of the experiments made by Mr. A. W. Haacke on the heat lost from steam pipes by radiation and convection. The facts quoted are not as definite as they might be, but they are nevertheless interesting. The experiments were tried upon bare pipes, upon pipes covered with a layer of insulating "composition" one inch thick, and upon pipe covered with a similar coating of composition, with three additional layers of hair felt. The pipes used in the experiment were five inches in diameter, externally, and six feet long, with blank flanges on each end. The pipes were supplied by steam that had been dried, and were placed so as to be subject to radiation and conduction under precisely similar conditions, one of them being bare, and the other two covered as before mentioned. With steam at a pressure of from 45 to 60 pounds, 83 per cent. of the heat lost from the naked pipe was saved by the single layer of composition. The pipe having an extra covering of hair felt, $2\frac{1}{2}$ inches thick, showed an additional saving of about $8\frac{1}{4}$ per cent. If the performance of the boiler is such that one pound of coal is required for the evaporation of eight pounds of water at 60 lbs. pressure, then (according to Mr. Haacke) every square foot of uncovered steam pipe wastes, on an average, about 625 lbs. of coal per year.

We clip the following from a recent Boston daily paper. It illustrates what a kitchen boiler is likely to do when the supply pipe is frozen up:

"Patrolman Walter F. Higgins of Division 15, who is about to become a benedict, met with a painful accident this morning at the new home on Laurel street, Charlestown, where he will start out on his wedded life. About 9.30, after finishing his duties at the Harvard street station, he visited the apartments, which are located in the Kelley block, for the purpose of starting a fire in the range. Supposing that the boiler contained sufficient water, he put on plenty of wood and coal, and soon had a good-sized blaze roaring up the chimney. Presently there was a report, and the boiler exploded, smashing the range and throwing Higgins across the floor. Tenants of the house, hearing the noise, rushed in and found the patrolman badly cut up. The fire, luckily, did not communicate with the woodwork or furnishings of the room. Higgins was taken to one of the adjoining rooms, and medical assistance summoned. His wounds consisted of bruises and burns about the forehead, face, and chin, and the right arm and left hand. A piece of the range also struck him in the chest, and when he was picked up the front of his coat and shirt were torn, and were completely saturated with blood flowing from this wound. After the wounds had been dressed the Division 15 ambulance was summoned and Higgins was taken to the home of his prospective bride, at 86 Brook avenue, Boston Highlands. It will probably be some weeks before he will be able to return to duty."

The Mistletoe.

Few plants belonging to the English flora have associated with them so much that is of interest as the mistletoe, and the spoils of our orchards and of those of Normandy with which the markets are now crowded testify in no uncertain manner to the high estimation in which this remarkable plant is held by all classes of the community. Nor to those familiar with the traditions with which the mistletoe is surrounded is it surprising that it should be regarded with so much favor by rich and poor alike. The origin of the plant, about which a correspondent inquires, was, according to tradition, an event of the most remarkable character, and it has had ascribed to it almost every conceivable virtue. We read in Norse mythology that Frigga, the mother of Baldr, the Apollo of the north, endeavored to preserve her son from harm by an oath from all, as she believed created things, that they would not injure him. She, however, overlooked the mistletoe, "so small and feeble," that she did not take an oath from it. Loki, an evil spirit, discovering this omission, made an arrow of one of the branches and placed it in the hands of the blind god Hodr, who, throwing it at a venture, fatally wounded Baldr. The gods, however, restored him to Frigga, and, as some reparation, dedicated the plant to her, and gave her control over it for so long a time as it did not touch the earth. From this tradition has probably arisen the practice of suspending a bough from the ceiling and of persons saluting each other under it. The views held by some of the older herbalists and others with regard to the growth of the mistletoe are not less remarkable than the mythological account of its origin, and with reference to this Gerarde writes: "This excrescence hath not any roote, neither doth encrese himself of his seed as some have supposed; but it rather comethe of a certain moisture gathered together upon the boughs and joints of the trees, through the barke whereof this vaporous moisture proceeding bringith forthe mistletoe." We may, however, excuse Gerarde for writing what we now know to be nonsense, for before him Bacon treated with ridicule the views of those who contended that the plants were raised from seeds, and declared that they were produced by sap which "the tree doth excerne and cannot assimilate." As befits a plant with so remarkable an origin and manner of growth, the mistletoe had traditionally many virtues. The Druids attributed to it curative properties of a magical character, and, among other things, water in which a bunch had been dipped was distributed among the faithful as a talisman against witches and sorcerers.

Allusion is made to the magical properties of the mistletoe by Virgil, Ovid, and other old writers, one mentioning the power of opening locks. Clusius asserted that a spray worn as a charm round the neck was a sure protection from the evils associated with witchcraft, and another famous old herbalist, Matthiolius, declared it to be a certain cure for epilepsy, and it was held in considerable esteem as a remedy for that malady as late as the end of the eighteenth century. Since that time the mistletoe has fallen into disuse both as a charm or curative agent, and become popular for Christmas decorations, with the result that it now contributes more to the enjoyment of the Christmas season than at any other period in its history.— *The Gardener's Magazine.*

If Mr. Cutshaw, inspector of buildings for Denver, Col., is correctly reported, he has made some remarkable statements. In testifying before the coroner's jury that considered the boiler explosion at the Gumry hotel, he is reported to have said: "It seems to be a pretty well settled fact that when a boiler is ready to explode, it *will* explode. The Gumry boiler was of the kind most liable to explode. I am convinced of the fact that the steam pressure hadn't caused the explosion; it was a pure and simple explosion, practically instantaneous and irresistible. The boiler might have exploded with forty pounds of steam on. I don't think the steam did it. What *did*, I don't know. It was simply an unaccountable explosion. This government and the British government have spent millions of money in trying to discover the reasons for such explosions, and have finally been forced to throw up their hands." We are not familiar with all the customs of the woolly West, but back here in staid New England we should probably think, in such a case as this, that if our building inspector knew that a given boiler "was of the kind most liable to explode," he would raise his voice in protest *before* the boiler had killed twenty-two people. If this didn't come directly in his own province, we should expect him to give the city boiler inspector a pointer about it. We are told, further, that the catastrophe consisted in a "pure and simple explosion." This scrap of wisdom is a sort of oasis in a desert of words; and it is comforting to know that the explosion was neither impure nor complex. The boiler just plain blew up, and then the building just plain fell down.

Such testimony as this of Mr. Cutshaw's only fogs the popular mind, and doesn't help the jury much.

The Locomotive.

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The Detroit Explosion.

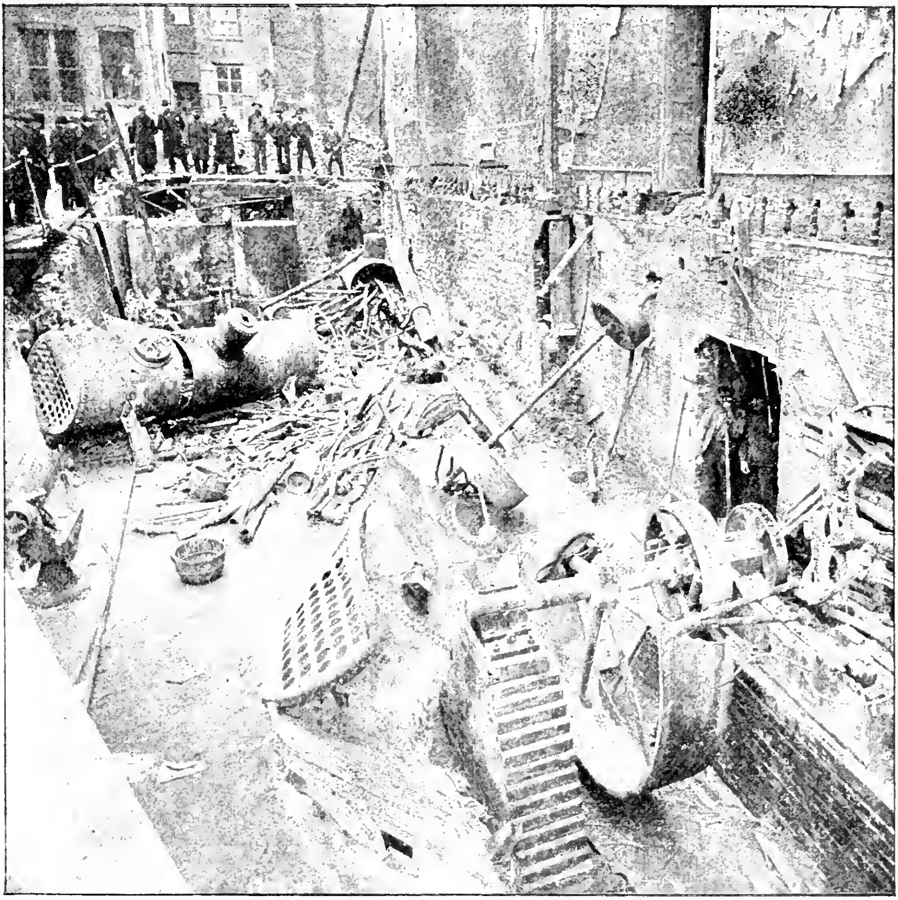

FIG. 1. — VIEW OF THE BASEMENT, AFTER THE REMOVAL OF THE DEBRIS.

[The boiler that rests against the right-hand wall is the one that did the damage. The break in the other one is only incidental.]

The Detroit Explosion.

In the March issue of The Locomotive we gave an illustrated account of the fearful boiler explosion that destroyed the Gumry Hotel, in Denver, Col. We have now to record a still more disastrous one, which occurred on November 6, 1895, in a building owned by the Newberry estate, in Detroit, Mich., and occupied chiefly by the *Detroit Evening Journal.* The loss of life in the present instance was truly appalling, the final count numbering the dead at no less than *thirty-seven*, in addition to seven other persons who were seriously injured, and a dozen or so who received minor injuries.

The building occupied by the *Journal* stood on Larned street, west. It was five stories in height, was strong and well built, and measured 46 feet in width and 87 feet in length. In a single moment the building was transformed into a tangled and intricate mass of twisted iron, heaps of stone, and piles of broken bricks. The only vestige left of walls sixty feet high was a strip of the front as wide as the first window, and a corresponding strip in the rear. Fig. 2 gives a general idea of the magnitude of the disaster, although the clouds of steam and smoke that were still rising from the ruins when the photograph was made obscures much of the detail.

The collapsed building was occupied as follows: In the basement were two boilers, an eighty horse-power engine, two oil-tanks, and two or more dynamos. The first floor was occupied by the mailing department of the *Evening Journal*, a force of 15 men and boys being employed there. The second floor was occupied by William W. Dunlap & Co., who manufactured and repaired the Rogers type-setting machines. The Kohlbrand Engraving Co. also occupied space on this floor. The third and fourth floors were devoted to the book-bindery of George J. Hiller, who employed 15 or 20 persons. The fifth floor was occupied by the stereotyping department of the *Evening Journal.*

Shortly after the building fell the ruins took fire, and all of the fearful horrors described by us, last month, in connection with the Gümry Hotel disaster, were repeated. Many of the victims were doubtless fortunate enough to be killed by the first great shock. Others were pinned under masses of timber and piles of brick and plaster, or among twisted pipes, perhaps to linger in misery for hours, unable to move, crying feebly and piteously for the help that hundreds would so willingly have given them if they could, and at last succumbing to the fires that crept insidiously through the ruins,— or, perhaps, passing away from the sheer incapacity of the human frame to longer withstand the pain they suffered.

At the moment of the explosion Herbert W. Johnstone was looking into the stereotyping room, on the fifth floor, from the composing room, which was in the next building. The two buildings were separated by a thick, fire-proof wall, through which a doorway was cut. "My eye rested upon a man at work at the steam-table," he says, "who, I think, was Lynch. Just at that instant I received the impression that something was wrong. The floor beyond, where Lynch stood, was rising up, while that just beyond the doorway was not. The back part of the floor rose not less than three feet, and sloped towards me as steep in the incline as the roof of a shed. This change in the appearance of the room was effected in an instant — scarcely more than was necessary for the eye to note it — and the next transition required less time. As quick as a flash the floor and all upon it disappeared downward, and was instantly followed by the roof. One instant I was looking at Lynch at work at the table; the next, I was looking across space at the blank wall of the next store. In that brief period there had been a terrific explosion, followed by the crash of the falling building. A cloud of dust rolled up before my eyes, and all was over."

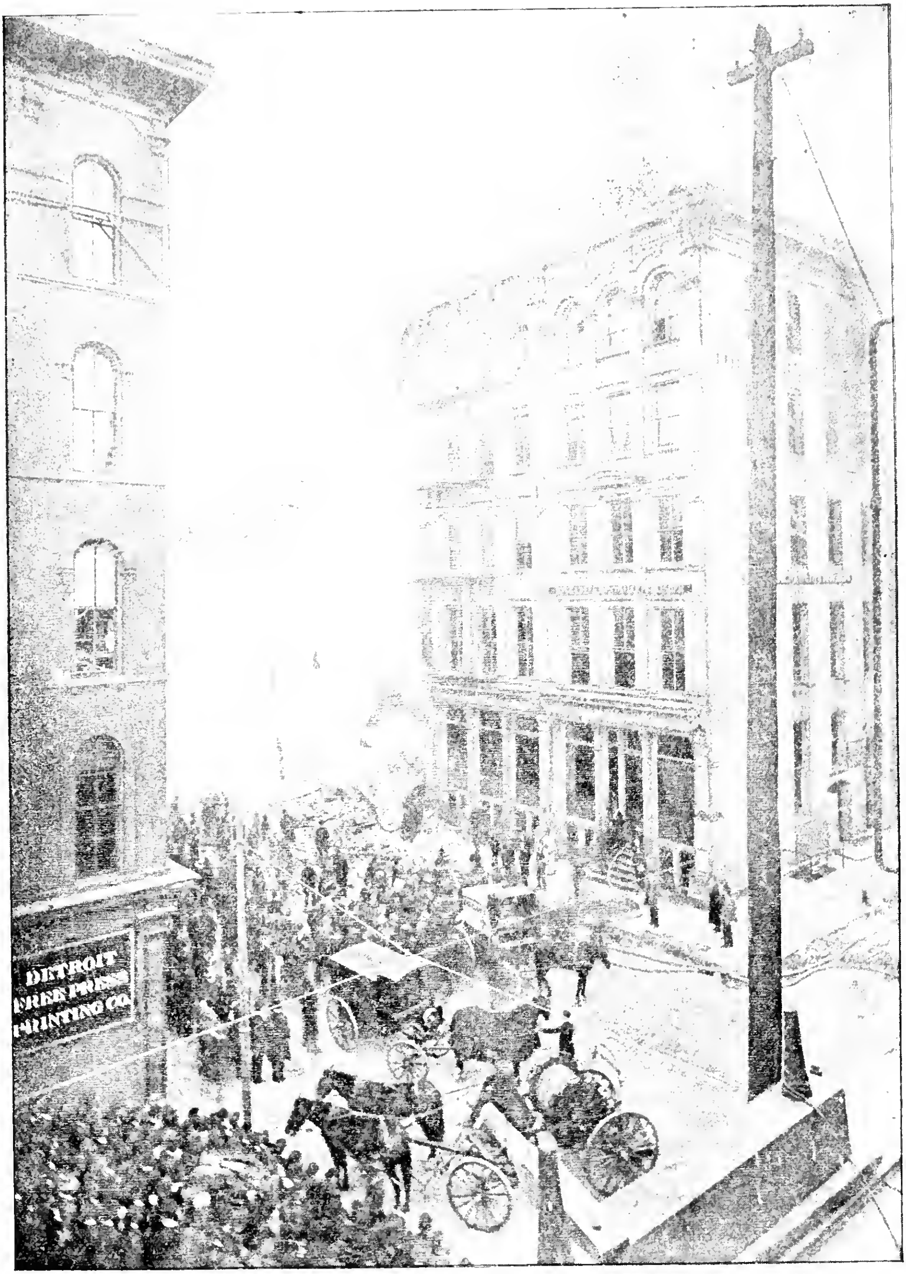

FIG. 2. — GENERAL VIEW OF THE RUINS.

The usual thing, in the case of a boiler explosion, is for the engineer or fireman to be loudly blamed for "letting the water in the boiler get low." The present case is no exception. We even find the *Free Press* saying editorially that "it looks as if the public were to be treated to the old, old story about there being plenty of water in the boilers at the time of the explosion, though there does not appear to be any authentic case on record where a boiler has exploded with a plentiful supply of water in it." We cannot wonder at the public ignorance of the causes of boiler explosions, when their most respected newspapers print editorial opinions of this sort. A small amount of study would satisfy the editor of the *Free Press* that the very *violence* of the explosion is in itself sufficient evidence that there was a large body of water present.

It is also conventional to rake over the past life of the engineer, and to show him up as a worthless sort of fellow, who habitually spent his time hanging about saloons. This was also done in the present case. We have no personal knowledge of Thomas M. Thompson, the engineer who had charge of the fated boiler in the *Journal* building, but we understand that although he is over 40 years of age, he was a constant attendant at the evening classes at the Young Men's Christian Association, where he was studying algebra, mechanical drawing, and some other branches, in which no-account people are not usually interested. We also know that he was a licensed engineer, so that he had presumably satisfied somebody of his competence; and we think that when these facts are properly weighed, it will be apparent that any evidence that may be adduced against Mr. Thompson ought to be construed as favorably towards him as possible.

Passing to the consideration of the probable cause of the explosion, we find that the available data are not sufficient to enable us to draw any satisfactory conclusion. We have already said that, on account of the extreme violence of the explosion, we do not believe that it was due to low water. This inference is also borne out by the photograph from which Fig. 1 was taken. The more distant of the two boilers is the one that wrecked the building, the one on the left having been merely thrown from its setting, and partly broken open about a girth joint. The two boilers were originally side by side, lying lengthwise of the building, against the right-hand wall, and just beyond the piece of shafting with the two pulleys. The greater portion of the exploded boiler passed to the rear of the building, until it struck the rear wall, and came to rest in the position shown in Fig. 1. The remaining portion of this boiler is seen in the foreground. It will be evident, upon examining the picture, that there is no *longitudinal* break in the shell, over any of that part which was exposed to the direct heat of the fire; and that is why we said that Fig. 1 supports the conclusion, previously arrived at, that the water in this boiler was not low.

As nearly as we can judge from the photographs, the initial fracture was longitudinal, passing through the *highest* part of the sheet, where it was weakened by the man-hole. This break forms the upper edge of the sheet that lies in the foreground of Fig. 1, the manhole being also plainly visible. (In connection with this feature, the reader may consult the articles on "The Weakest Point" in THE LOCOMOTIVE for January and February, 1881.) The fracture having once started in this way, the internal pressure caused the ends of the sheet to fly outward and downward, the sheet tearing itself free along the first girth joint, and along the flange of the head. That the sheet opened out in this way with great violence, is indicated by the fact (evident in Fig. 1) that when the sheet struck the side walls of the brick setting, both of the lugs that were secured to it were knocked completely through the sheet with such force that one of them (the one in the immediate foreground) was torn entirely free.

If it is admitted that this is a true account of the way in which the boiler gave out, we may proceed to inquire what conditions would lead to such a result. Here, however, the answer is by no means so easy; and in the absence of more complete data, we can hardly do more than make an intelligent guess. In the first place, Thompson testifies that he had just fired up the boiler that exploded, that the gauge registered 15 pounds when he last looked at it, and that he had not been absent from the boiler room more than fifteen minutes when the explosion occurred. The main stop-valve on the fated boiler was closed, as was afterwards proved by the recovery of the valve itself from the ruins; and it was the engineer's intention to open this valve as soon as the pressure in the newly-fired boiler should rise to that existing in the boiler that was in use (that is, to 60 pounds, or thereabouts). The boilers were fired with oil, and Thompson states that the flame under the one that exploded was low, in order to prevent smoke. It appears likely, however, that the oil was flowing more freely than he thought, so that the pressure ran up somewhat rapidly. The safety-valve may have been corroded to its seat, or prevented from operating in some other way. This, of course, is purely an assumption, for although the valve was afterwards found, it was in such condition that no certain conclusions could be drawn from it. If the valve were unable to blow, however, and the pressure mounted up until the boiler could no longer withstand it, we should have the precise conditions that would seem to be required to produce an initial fracture such as we have described, together with the fearful destruction of life and property that followed.

The general facts of the explosion may be summarized as follows: The engineer was licensed; the boilers were not insured, but were under city inspection; there were 37 persons killed, 7 badly injured, and a dozen or so slightly injured; and a conservative estimate places the property loss at $100,000.

Inspectors' Report.

FEBRUARY, 1896.

During this month our inspectors made 7,735 inspection trips, visited 15,808 boilers, inspected 4,734 both internally and externally, and subjected 525 to hydrostatic pressure. The whole number of defects reported reached 10,215, of which 876 were considered dangerous; 40 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	654	50
Cases of incrustation and scale,	1,675	56
Cases of internal grooving,	93	6
Cases of internal corrosion,	511	29
Cases of external corrosion,	660	35
Broken and loose braces and stays,	118	61
Settings defective,	279	26
Furnaces out of shape,	341	20
Fractured plates,	201	45
Burned plates,	227	22
Blistered plates,	176	8
Cases of defective riveting,	1,136	53
Defective heads,	118	34
Serious leakage around tube ends,	2,243	219

Nature of Defects.	Whole Number.	Dangerous.
Serious leakage at seams,	516	25
Defective water gauges,	403	53
Defective blow-offs,	150	36
Cases of deficiency of water,	22	9
Safety-valves overloaded,	66	26
Safety-valves defective in construction,	110	33
Pressure gauges defective,	437	30
Boilers without pressure gauges,	0	0
Unclassified defects,	79	0
Total,	10,215	876

Boiler Explosions.

FEBRUARY, 1896.

(35.) — A boiler exploded, on February 1st, in a mill at Pittsville, near Marshfield, Wis. The boiler-house was totally demolished, but nobody was killed.

(36.) — On February 3d the boiler of the hot-water heating system in the new hospital at Columbus, Ohio, exploded.

(37.) — A boiler exploded in the Y. M. C. A. bathrooms at Independence, Iowa, on February 3d. No one was in the building at the time. Considerable damage was done to apparatus, and to the Munson Memorial Building, where the rooms are located.

(38.) — On February 3d a violent explosion occurred in the boiler-house at the new Shanty Pond sewer, at South Lawrence, Mass. John Lee and Alexander Gordon were killed. The explosion is said, by the Lawrence *American*, to have been caused by dynamite in the power-house; but we think it not unlikely that it may have been a boiler explosion. This is indicated by two facts, the first of which is, that 200 pounds of dynamite, known to have been in the boiler-house, was afterwards found intact. The other fact above referred to, is that Lee, who was acting as engineer, had been employed, a few weeks before, to operate a drill, and that he was only temporarily acting as engineer, while the regular man was away. The boilers had been found inadequate to do the work required of them, and it is likely that they were pushed pretty hard. The power-shed and the machinery were completely wrecked, and it is difficult to learn precisely what did happen.

(39.) — A boiler explosion occurred, on February 5th, in the electric light station, at Muncie, Ind. Supt. C. R. McCray, who was the only person in the building, was blown out of the front door, but was not injured. The explosion was not serious, and the damage was not great. A local paper says that "there is a suspicion that some miscreant plugged the pipe"; but we guess he didn't plug it very hard.

(40.) — One of the boilers in the electric light station at Bennington, Vt., exploded on February 5th. Engineer J. P. Daily and Fireman William Conlan were severely injured, so that it was feared that they would not recover; but later advices are that they are both improving slowly. The boiler-house was completely demolished. There is not a piece of iron or brick left standing. One of the wooden beams, 30 feet long and 12 inches square, was carried clear over the power-house and fully 40 feet beyond. Those who saw the explosion say that the air was full of débris, and that the boiler must have gone up fully 100 feet. It fell into a small river, about 150 feet from its original site. The power-house, and the dynamos and other machinery that it contained, were considerably injured. The neighboring power-house of the Bennington and Woodford electric railway was also considerably damaged. It was estimated that a month or six weeks would be required to repair the damage.

(41.) — A small boiler, belonging to Mr. Henry Haygood of Wakefield, near Raleigh, N. C., exploded on February 6th, killing the proprietor and his son Ivan, and a workman, Rufus Tucker. Three other men were severely injured. The building in which the boiler stood was demolished.

(42.) — On February 6th a boiler exploded in Londonderry, a small village near Barnesville, Ohio. Three men were killed, and several others were severely injured. The boiler was torn into fragments and scattered in every direction.

(43.) — A boiler exploded, on February 7th, in the electric light station at Iowa Falls, Iowa. The power-house and machinery were partly wrecked. Nobody was injured.

(44.) — On February 10th a boiler exploded at the Ann and Hope Mills, Providence, R. I. Patrick McConnor was killed outright, and Hugh McLaren received injuries from which he died four days later. James Finnegan, James Duffy, John A. Pollitt, and H. H. Studley were more or less seriously injured. The boiler-house was wrecked. The property loss was at first estimated at $25,000, but $10,000 is probably nearer the actual figure.

(45.) — A boiler explosion occurred, on February 13th, at J. R. Plummer's saw-mill, ten miles southwest of Ashboro, N. C. Three men were killed, and three others were seriously and perhaps fatally injured.

(46.) — A boiler in the factory of the Liberty Fuel and Gas Company, at Liberty, Ind., exploded on February 13th. Boyd Nickum was blown through an open door, landing 20 feet from the building. He was only slightly injured. The property loss was not large.

(47.) — The Mid-Continent mill, at Topeka, Kan., had the first accident in its history on February 14th, when an elbow broke on the main steam pipe. Thomas King and Kilmaur King were slightly scalded, but otherwise the accident was not serious.

(48.) — A boiler exploded, on February 17th, in Moore & Wallace's factory, at Chesley, Ont. Fortunately, nobody was in the mill at the time, the employes all being away at breakfast. The whole building was torn to atoms, and part of the boiler was found 100 yards from the ruins. The property loss will amount to some thousands of dollars.

(49.) — A small boiler at Arbela, near Flint, Michigan, exploded on February 18th, after the mill hands had gone home at night. The boiler separated in two parts, one of which passed through the brick walls of the engine-room, and landed in front of a dwelling house, about 350 feet away. Nobody was hurt.

(50.) — The boiler of the locomotive attached to train No. 6, on the Utica division of the Delaware, Lackawanna & Western railroad, exploded on February 19th, near Richfield Junction. The train was going up a heavy grade at the time. The locomotive was blown clear of the tender, and landed, a twisted mass of scrap-iron, in the bottom of a ditch beside the tracks. Engineer John Keach was torn to pieces, and instantly killed. Fireman John Lewis was fearfully torn and scalded, and died in a short time.

(51.) — A boiler in Vollmer Bros'. steam feather-renovating establishment at Harrisburg, Pa., exploded on February 20th. Theodore Anthony was severely scalded, from head to foot.

(52.) — The boiler of freight-engine No. 92, on the Nashville, Chattanooga & St. Louis railroad, exploded at Bridgeport, Alabama, on February 20th. Engineer John Walkup and Fireman William Irvin were instantly killed, and Brakeman Simon P. Ruggles was scalded so badly that he is likely to die.

(53.) — A boiler used to work a steam hammer for breaking up the iron work of the old Machinery Hall of the World's Fair, at Chicago, exploded on February 20th. John Swan and John Obron were scalded so badly that they are not likely to recover. William Murray, Michael Sherry, and John Balzin were also scalded painfully, though not fatally. Murray will lose his eyesight.

(54.) — The boiler in James Wright's saw-mill, at Deer Creek, near Logansport, Ind., exploded on February 21st. The machinery and building were completely wrecked. The explosion occurred at night, when nobody was in the building.

(55.) — The fire-box of the laundry boiler in the Howard House, at Malone, N. Y., collapsed on February 22d. The fireman, who was standing near by, was slightly scalded. The windows were blown out, and the floor of the boiler-room was set on fire.

(56.) — A boiler exploded, on February 22d, in Barnett's flouring mill, at Rockport, near Parkersburg, W. Va. The roof of the building was torn off, and the mill was badly wrecked. Nobody was injured.

(57.) — A boiler exploded in M. F. Suffrage's saw-mill, at Tazewell, Tenn., on February 22d. Joseph Brewster was killed, and Henry Scott was fatally injured.

(58.) — A boiler exploded, on February 24th, in the L. A. Riley colliery, at Centralia, near Pottsville, Pa. Michael Rubeck was instantly killed, and Anthony Zornski was injured so badly that he died next morning. The explosion displaced four other boilers, and ruined two large stacks.

(59.) — The head blew out of the feed-water heater, on February 25th, in the electric light station at North Manchester, Ind. Fireman John Sheak, who was the only person in the building at the time, was scalded by the escaping steam and water. The entire contents of the boiler was blown out into the room, and four of the dynamos were saturated with water.

(60.) — A boiler exploded, on February 26th, in a grist-mill on Major Charles W. McClammy's plantation, near Scott's Hill, Pender county, N. C. Major McClammy and Alfred Spellman were instantly killed. We have not heard further particulars.

(61.) — A donkey boiler exploded, on February 26th, on the British steamship *Sportsman*, while she was lying at the dock at Southport, La. Second Engineer Archibald Dald, who was standing near by, was instantly killed. Messrs. Orthwein & Sons said that the property damage would amount to $25,000 or $30,000.

(62.) — On February 28th a boiler exploded at W. H. Overholt's saw-mill, near Frankford, Greenbrier county, W. Va. Samuel B. Livesay, Clowney Kershner, Woods

Ransbarger, Samuel Hodge, Henry Brown, Henry Dunbar, and Walter McClintic were killed; and James Fleshman, Addison Johnson, J. A. Livesay, and Waldo Ransbarger were injured. Fleshman may die. The engine was broken to fragments, so that there was hardly a piece, even of the fly-wheel, that was too big for a man to lift. The noise of the explosion was heard for 15 or 20 miles.

(63.) — The boiler in the Dallas steam laundry, at Selma, Ala., exploded on February 29th. The shed in which the boiler stood was completely demolished, and the end of the adjoining brick building was wrecked. According to the Selma *Times*, Mr. Marion, the owner of the place, "says that the boiler has been dangerous for some time, and all working around it were warned." Warned, we presume, that they were likely to find themselves in another world, at any moment, without further notice. Up here in the staid North we don't generally do things that way. We are more likely to take some pains to protect the lives of people whom we know to be in danger, instead of merely notifying them to say their prayers, while we shovel on more coal. In the present case it happened that nobody was hurt; which was doubtless a fortunate thing for Mr. Marion, if he is correctly reported.

Generally speaking, the age of a boiler is by no means a criterion of the boiler's safety. Boilers often explode when brand new, and, on the other hand, they often do faithful service when old enough to vote. It is a good plan, though, not to place too implicit a reliance on them, when they get very far along in years. These remarks are called forth by a recent boiler explosion in the South, in which subsequent investigation showed that the boiler was *thirteenth handed!* It was thirty years old, and had been sold twelve times. The last owner had been using it only a few minutes, when it blew up and killed him.

A correspondent informs us that the explosion at the Pitts Agricultural Works, at Buffalo, N. Y., which appears as No. 330 in our regular list for December, 1895, as given in the February issue of The Locomotive, was incorrectly reported in one particular. The head of the boiler did not blow out, but the accident consisted in the breaking of a four-inch pipe, through water-hammer action. We make the correction with pleasure, and will add, for the benefit of those interested, that our information was taken from the issue of the Buffalo *Times* for December 11, 1895. That paper states that "the indicator pointed to 65 pounds. Suddenly there was a rumbling sound, followed by a quick report, and the next instant the engine room was enveloped in a dense cloud of escaping steam. *The boiler head blew out* directly above the two injured men, and they were directly in the path of the hot steam." We trust that this quotation will make our good faith in the matter plain. It is by no means easy to make out a strictly accurate account of the boiler explosions that take place in this country each month. As an example of the minor difficulties we may say that we received seven distinct accounts of the explosion at Centralia on February 24th (which is No. 58 in the list published this month). The name of the man who was instantly killed is variously given as Rubeck, Roback, Roebach, Rhorback, Ruback, and Roeback; while in giving the name of the man who died next day, we have to choose between Zornski (which we guess is right), Sawjack, Sawbuck, Soreasi, Zocoski, and Sawback.

We do the best we can, but we don't always get these things absolutely correct.

The Locomotive.

HARTFORD, APRIL 15, 1896.

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

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The "X-Rays."

History does not record a case in which a scientific discovery has aroused a more sudden and widespread interest than that announced a short time ago by Dr. Wilhelm Konrad Roentgen of Würtzburg, Germany. His discovery was (as everybody knows) that it is possible to produce a hitherto unknown kind of rays, which resemble light-rays in some particulars, but which are nevertheless quite different from them in many important respects. They cannot be directly perceived by the eye, but they are capable of affecting a photographic plate. Dr. Roentgen, being of a mathematical turn of mind, modestly designated his rays by the letter "X," to signify that they were "unknown." Doubtless some better name will be found when their true nature has been discovered; but for the present the scientific world prefers to know them as "Roentgen rays."

Much has been written about these rays in the scientific and popular press, so that nearly everybody may be supposed to have a fair idea of the whole subject; but many of the articles that have appeared have been written by persons who had no actual experimental knowledge of the discovery, and the result is, that the real facts have in many cases been confused with mere idle speculations having no sound foundation. For this reason it has been thought well to prepare for The Locomotive an article which should set forth the main facts of the discovery, as at present known.

In the first place it is necessary to have a clear understanding of the "Crookes tube" that is used to generate the rays, and to gain such an understanding we must know something about the molecular theory of gases. A gas, according to the best modern ideas, consists in a vast number of little elastic particles, called molecules, which are flying about in all directions with great speed, and incessantly colliding with one another, and bounding apart again. The average distance that these particles travel, between successive collisions, is called their "average free path." In atmospheric air, under ordinary conditions of temperature and pressure, the average "free path" of the molecules is only about .000,003 of an inch; and in hydrogen gas, under the same conditions, the average "free path" is about .000,007 of an inch. By lessening the density of the gas in a given enclosure, by means of an air pump, we can increase the average "free path," however, as much as we please. If a great number of bullets were fired at random into a forest, they would not go so far, on an average, if the forest were very dense, as they would if the trees were only thinly distributed. The same idea holds true in a gas; and if we should pump out all of the air from a glass bulb except, say, the millionth part of what was originally there, the average "free path" of the molecules that were left would be a million-fold greater than before. That is, the average "free path" would become 3 inches, instead of only .000,003 inch, as at first.

A vacuum of this degree of perfection cannot be obtained by means of the ordinary piston air-pump, and recourse has to be had, for this purpose, to some form of mercury pump. The form devised by Sprengel is illustrated in Fig. 1. It consists in a long, upright glass tube, through which mercury is allowed to flow, drop by drop. A side pipe leads out from the long tube to the apparatus from which the air is to be removed. As the mercury falls down through the upright tube, a little air is carried away, each time, between the successive drops; and after a while the exhaustion becomes very perfect. The pump is very positive in its action; and as it contains no valves of any sort, leakage is practically impossible, if the connections are once made tight. When a satisfactory vacuum has been obtained, the apparatus that is being exhausted is sealed up by means of a blowpipe flame, at the point indicated by the arrow.

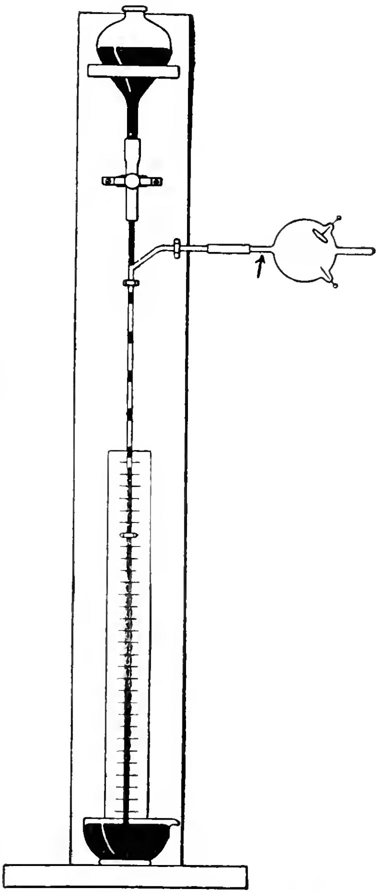

Fig. 1.—A Sprengel Pump.

It might be thought that when all the air in a glass bulb had been removed, except the last millionth, it would be impossible to detect that remaining fraction by any means at our command. Such, however, is not the fact. A vacuum of this sort still contains about 100,000,000,000,000 molecules in every cubic inch of its volume; and hence it is very far indeed from being a "vacuum" in the metaphysical sense of the word. In fact, the English physicist, William Crookes, showed that when the "free path" of the molecules is measurable in *inches* (as it is in these high vacua), a great many new and interesting phenomena may be observed. In the course of his experiments, he constructed bulbs of the greatest variety of shapes, one of which is shown in Fig. 2. This bulb consists of a sphere of glass, into one side of which a round metallic electrode is inserted, as shown at the right in the figure. Three other electrodes, consisting simply of straight wires, are melted in at other points, as shown; and the whole tube is exhausted to about one one-millionth of the original pressure, as already stated. When the electrode on the right is connected with the negative pole of a powerful electrical apparatus (either an induction coil or a static machine) capable of giving a voltage of 100,000 volts or more, the other pole of the machine being connected with any one of the remaining three electrodes of the tube, the tube assumes a very beautiful appearance, which can only be rudely suggested in the engraving. The molecules which chance to come in contact with the disk-shaped electrode are electrified negatively, and are violently repelled towards the center of the bulb. If the air within the bulb was of the ordinary density, these molecules that fly off from the electrode could only travel about three one-millionths of an inch before colliding with their neighbors ; but in the tube as actually constructed with the high vacuum within, they can travel clear across, so as to strike the glass on the opposite side. The course of these molecules, as they stream across the tube, is indicated by a pale purplish beam or streak of light, which is known as the "cathode ray"; and where they strike against the glass, they cause it to shine with considerable brilliance, as indicated by the bright spot on the left. The "cathode ray" is unchanged in appearance, whether the positive wire of the electrical machine is connected at the lower electrode, or at the upper one, or at the one on the left.*

FIG. 2.— A CROOKES' TUBE IN OPERATION.

To show the reality of the stream of flying particles that are traveling across the tube along the course of the "cathode ray," Crookes devised a great many forms of

* We are well aware that the explanation of the "cathode ray" that we have here suggested is by no means universally admitted to be true. It is the one suggested by Crookes himself, however, and as no better explanation has yet been offered, we have no hesitation in repeating his theory in regard to it.

apparatus, one of which is shown in the diagram in Fig. 3. It consists of a glass tube within which there is a very light paddle wheel which can roll back and forth on a pair of glass rails. When this tube is connected with the electrical machine as indicated in the diagram, the "cathode ray" proceeds from the left-hand electrode horizontally towards the right; and when the swiftly moving molecules that compose it beat against the vanes of the paddle-wheel, the wheel is made to rotate, so as to roll down the tube toward the right-hand extremity of the rails. If the electrical machine be then reversed so that the negative terminal is at the right, the wheel may be made to revolve in the opposite direction, and roll back to its starting point. In this form of tube, as in the preceding, it will be noticed that it is the *cathode* (or *negative* electrode) that is primarily concerned in the production of the phenomena. The positive electrode, or anode, appears to be of minor importance. This is true of all Crookes tubes, and is one of their most marked features.

As might naturally be supposed, these strange phenomena of the "cathode ray" have attracted very wide attention among scientific men, and have formed the basis of numerous interesting experimental researches. Of these various researches one of the most striking is that carried out by the young German physicist, Lenard, who was

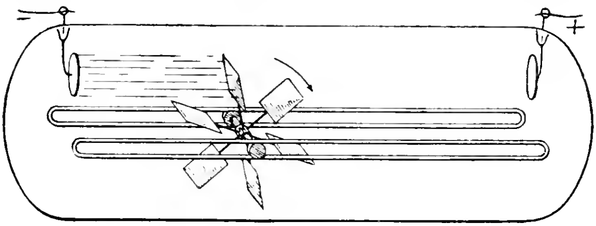

Fig. 3.—Crookes' "Railway" Tube.

assistant to Dr. Heinrich Hertz at the time of that philosopher's lamented death. Lenard seems to have been impressed with the idea that it is possible to make the "cathode ray" come out of the vacuum tube, into the open air. The explanation of the "cathode ray" that we have given above, would seem to preclude any such possibility; but Lenard worked at the problem patiently until he at last found that if the vacuum tube be provided with a very thin pane of aluminum, at the place where the "cathode ray" strikes it, his hopes could be realized, and the "ray" could be made to continue through the thin sheet of aluminum, so as to be visible outside of the tube. Lenard's apparatus is shown in Fig. 4. It consists of a vacuum tube, exhausted to about the millionth of one atmosphere, and provided with two electrodes, the positive one, or "anode," being composed of a short piece of brass tubing, while the negative one, or "cathode," consists in a small circular disk, as shown. When the electrical machine is in action, the "cathode ray" is seen streaming away to the left, as a faint horizontal beam of light (represented in the diagram by the parallel broken lines). The tube is closed, at the left, by a metal cap, the central part of which consists of the thin piece of aluminum foil, already referred to. The whole apparatus was surrounded by screens, as indicated, so as to shut off all the light that proceeds directly from the tube itself. When the apparatus, thus arranged, is set in action in a darkened room, the "cathode ray" is seen to emerge into the air at the left of the tube, in the form of a diffuse brush of light, as represented by the diverging broken lines. *Lenard found that this brush of light is deflected by a magnet.* He also found that it affects a photographic plate, and he investigated the transparency (or opacity) of various substances for it, and gave a table of the results. One of his experiments is strikingly similar to Roentgen's. Finding that glass is relatively opaque to the "cathode ray," and aluminum relatively transparent, he placed a photographic plate inside of an aluminum box, and laid a piece of glass upon it. He placed this apparatus so that the "cathode ray" should fall upon it, and after a time he developed the plate, and found that the "cathode ray" had passed through the metallic box and affected the sensitive plate everywhere except where it had been protected by the comparatively opaque slip of glass.

Roentgen had been repeating the experiments of Crookes, Hittorff, Lenard, and others, and in the course of his work he was led to the discovery that the vacuum tubes produce *two* kinds of radiation, one being the previously known "cathode ray," and the other the now famous "X-rays." The X-rays resemble the cathode ray in some particulars, but differ from it in the important respect that *they are not deflected by a magnet.* Roentgen tried to find out what *part* of the vacuum tube his newly-discovered rays came from; and he was led to the conclusion that they are generated at the spot where the cathode ray strikes against the inner surface of the glass wall of the vacuum tube. This idea is illustrated in Fig. 5, which shows, at the same time, the way in which Roentgen pictures are taken. A plate-holder containing a sensitive plate is placed upon the table, the slide of the plate-holder remaining *closed* throughout the experiment (it being transparent to the X-rays, although opaque to ordinary light). Upon the slide of the plate-holder the operator places the object whose image he wishes to obtain, and the Crookes tube is suspended a few inches above the whole, in such a way that the cathode ray is directed downward, towards the plate-holder. The electrical machine is then set in action for from twenty minutes to an hour, according to the exposure that is considered necessary, and the sensitive plate is afterward developed in the dark-room, in the usual way. A shadow-picture of the object is then found to have been produced upon the plate, through the seemingly opaque slide of the plate-holder. The curious effects obtained in the Roentgen shadow-pictures are due simply to the fact that substances that are opaque to light may be transparent to the X-rays, and *vice versa.*

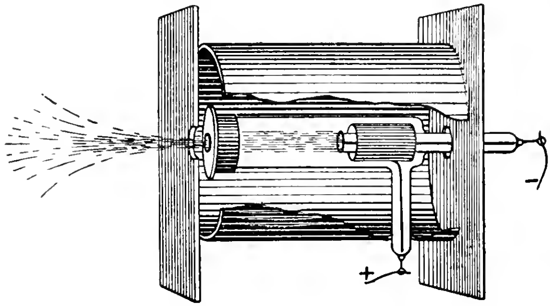

Fig. 4.—Lenard's Apparatus.

Professors Rowland and Carmichael have carefully investigated the *source* of the X-rays, and their conclusions concerning this point differ widely from those reached by Roentgen himself. They find that in some tubes the rays emanate from the *anode*, or positive electrode, and that the cathode ray has nothing to do with them. So broad a difference as this, in the results reached by different competent observers, suggests that in all probability the *form* of the tube has something to do with the place where the rays originate.

We need say nothing about the application of X-rays pictures to surgery, because that phase of the subject has been discussed in great detail by the press in general. Our own interest in the discovery, apart from the purely scientific interest that it must arouse in every educated person, lies in the possibility it offers of detecting flaws, blowholes, and other imperfections in metals; but at present this can only be done on a small scale, with very thin specimens. Iron and steel are so opaque that a far more powerful source of the X-rays must be found before the method can be successfully applied to braces and man-hole frames.

Various suggestions have been made concerning the *nature* of the X-rays, but none of them have been proved to be true. The most that can be said is, we think, that the X-rays are not in any sense identical with *light*. All the kinds of light that we know about exist in sunlight; and yet there are no X-rays in sunlight, so far as has yet been discovered. It is true that their existence in the sun's light has been repeatedly announced; but the various "discoveries" of this sort that have been made will not bear examination. A plate-holder that gives a shadow-picture in sunlight simply has too thin a slide. If a piece of yellow paper and a piece of glass be exposed to the sun on such a plate-holder, a strong image is cast by the yellow paper, and hardly any at all can be found under the glass. This shows that it is ordinary light that does the work in this case. If the X-rays did it, the *glass* would cast a strong shadow, and the image of the *paper* would not be distinguishable.

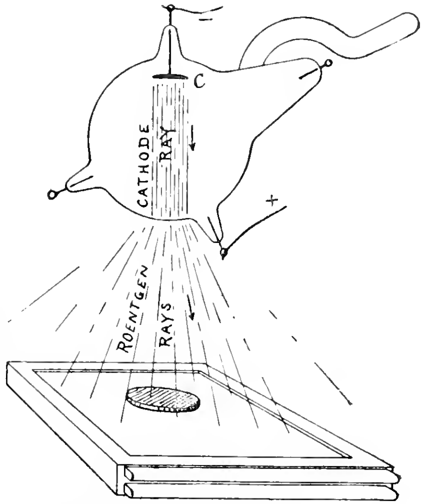

FIG. 5.—SHOWING THE RELATION OF THE ROENTGEN RAYS TO THE CATHODE RAY.

The first fact that Roentgen discovered about his rays was, that they are capable of exciting a sort of fluorescence, or phosphorescence, in certain substances. This led immediately to the construction of a fluorescent screen, on which the X-ray images could be seen directly by the eye. Roentgen's lead in this direction was followed by Professor Salvioni of Rome, who devised a practical instrument for this purpose, which he called the "cryptoscope." Mr. Edison has since done good work in this direction, still further improving Salvioni's apparatus by substituting tungstate of calcium, as the fluorescent substance, for the compound of barium that Roentgen and Salvioni had used.

In closing, we must caution our readers against the sensational "discoveries" that have been reported with such frequency by the daily press. The few real facts that have been learned about the X-rays since Roentgen's first paper appeared are all of a purely scientific character, and not one of them would have the least interest to the general public. The most conspicuous thing that has been done, from the popular point of view, is that the *technique* of the exposure and development have been much improved, so that we can get better pictures now than we could at first.

A. D. RISTEEN.

ACCORDING to *Nature*, calcium carbide, which is used in the manufacture of acetylene, has been produced at Spray, N. C., at a cost of $20 a ton. *Science*, however, doubts this statement, and says that most of the carbide thus far used has been imported from France or Switzerland, where the price is about $200 a ton.

Incorporated 1866.

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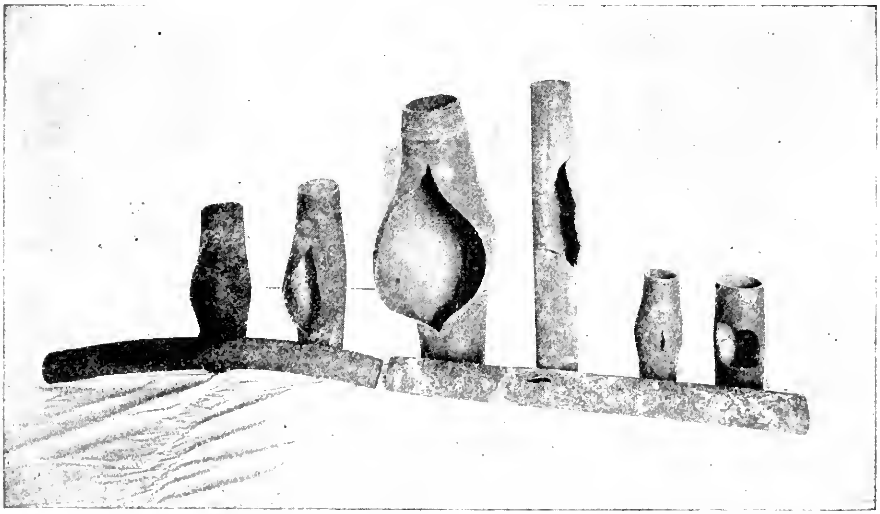
Brass Blow-Off Pipes.

In previous issues of THE LOCOMOTIVE, we have discussed the general arrangement of blow-off pipes, and the proper method of connecting and protecting them, on externally fired boilers, where they are to be exposed to high temperatures. We have also stated that brass is not a safe material for blow-off pipes of this sort, since it softens and loses its strength at temperatures that have no sensible effect upon iron; and in support of this view we have illustrated one or two brass blow-off pipes that have failed



BURSTED BRASS BLOW-OFF PIPES.

in actual service. The cases that we have recorded in this journal have been assumed, by some engineers, to be isolated instances, due, probably, to some defect in the piping, and not representing what may be expected in ordinary good practice. We cannot allow such an idea to become current without entering a vigorous protest, for we find, in our own experience, that brass blow-offs give out very often indeed, when used on externally fired boilers.

In support of this statement we present herewith a photo-engraving which shows a few of the failures of this sort that have occurred during the past year in one of our inspection districts. The significance of these failures becomes clearer when it is remembered that the use of brass for blow-offs is by no means common; so that even a small number of failures represents a considerable percentage of the total number of such pipes that are in use. We do not say that a brass blow-off, on an externally-fired boiler, is *bound* to give way; but we do say that alloys of this sort are unreliable, and that they are quite *likely* to fail, without notice.

The effect of temperature on the tenacity and ductility of alloys of copper was investigated quite fully, some time ago, by the British Board of Admiralty. It was found that cast brass experiences a marked loss of tenacity and ductility at about 250° Fah., while at 350° the change is so pronounced that the material is no longer safe, when exposed to any considerable strain. Gun-metal behaved similarly, the critical and dangerous temperatures being each about 50 degrees higher than in the case of brass, though the individual results varied considerably with the composition of the alloy, as might be expected. Pure copper begins to fall off noticeably in strength at about 450° Fah., and becomes altogether unreliable at about 800°.

The significance of these results will be apparent if the reader will consult a table of the properties of saturated steam. He will see that a temperature of 250° corresponds to a gauge pressure of only about 15 pounds, while a temperature of 350° corresponds to about 120 pounds. These figures mean that a blow-off pipe of cast brass would begin to lose its strength, sensibly, when exposed to the temperature corresponding to only 15 pounds of steam pressure; and it would become quite unreliable when used on a boiler carrying 120 pounds.

The data of the Admiralty Board are given for *cast* brass. We are quite ready to admit that the effect of temperature on *drawn* tubing may be considerably less; and yet we cannot admit that the difference is great enough to make a drawn brass blow-off safe, when it is exposed to the heat of the fire, as it is when used on externally-fired boilers.

Our experience with brass blow-offs abundantly confirms the Admiralty tests quoted above. Some of them stretch considerably before they rupture, showing that the material has lost its tensile strength, but not its ductility. Others break without showing much of any distension, the indication then being that both the tenacity and the ductility have been destroyed. Sometimes a piece of the pipe is even blown bodily out, a case of this kind being shown in the engraving.

We do not deny that brass tubing is valuable for feed pipes and water-gauge connections, and even for blow-offs on *internally*-fired boilers, if it is of good quality and thickness. In fact, we frequently advise its use for such cases; but a large experience has satisfied us that it is not at all reliable when exposed to high temperatures, as it is when used for blow-off pipes on *externally*-fired boilers.

The *Practical Engineer* (London) gives the following statistics of the railroad accidents that occurred in Great Britain and Ireland during 1895: The total number of killed was 1,024 (against 1,115 in 1894), and the total number of injured was 4,021 (against 4,120 in 1894). The deaths and injuries may be classified thus: Passengers killed, 83; injured, 1,109. Employés killed, 442; injured, 2,654. Killed at grade crossings, or while walking the tracks, or from other causes not enumerated, 499 (this item includes suicides); injured from the same causes, 258. "If *all* the accidents occurring on railway premises, in addition to those caused by the movement of railway vehicles, be included, it will be found that the total number of personal accidents reported to the Board of Trade during the year amounted to 1,090 persons killed and 9,318 injured."

Inspectors' Report.

MARCH, 1896.

During this month our inspectors made 8,611 inspection trips, visited 17,076 boilers, inspected 5,812 both internally and externally, and subjected 601 to hydrostatic pressure. The whole number of defects reported reached 11,685, of which 1,049 were considered dangerous; 50 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	993	49
Cases of incrustation and scale,	2,004	78
Cases of internal grooving,	78	9
Cases of internal corrosion,	676	42
Cases of external corrosion,	800	32
Broken and loose braces and stays,	166	76
Settings defective,	346	32
Furnaces out of shape,	420	18
Fractured plates,	272	41
Burned plates,	210	21
Blistered plates,	203	10
Cases of defective riveting,	1,408	23
Defective heads,	166	13
Serious leakage around tube ends,	1,934	298
Serious leakage at seams,	491	57
Defective water gauges,	505	76
Defective blow-offs,	161	44
Cases of deficiency of water,	17	14
Safety-valves overloaded,	67	22
Safety-valves defective in construction,	118	24
Pressure gauges defective,	484	54
Boilers without pressure gauges,	16	16
Unclassified defects,	150	0
Total,	11,685	1,049

Boiler Explosions in Michigan.

An enterprising Detroit paper has published a list of the boiler explosions that have occurred in the state of Michigan during the past dozen years or so. This list, which was apparently compiled from the accounts given in THE LOCOMOTIVE, is not quite as complete as it might be, and we present herewith a corrected version, which has been extended so as to cover the period beginning with January, 1880, and ending with December, 1895. The list is sufficiently impressive. It includes 155 explosions, which have resulted in the death of 251 persons, and in serious injury to 280 others. It has no pretensions to completeness, as it includes only such explosions as came to our notice, in making up our regular monthly lists. We do not doubt that many other explosions have also occurred, which have not been reported to us. It is seldom possible to get a good estimate of the property loss resulting from a steam-boiler explosion, and that is why the figures given are not more complete. We have stated the loss when we could find out what it was. The total of the items of loss that *are* given below is $365,000; and doubtless the actual total loss was much greater. In making out this summary we have not chosen the state of Michigan because its record was in any way exceptional so far as the frequency of boiler explosions is concerned. Any other state, in which there is an equal number of boilers, would probably make about the same showing in this respect. Michigan was selected because the *Detroit Journal* horror has fixed public attention upon that state for the time being.

A Record of Boiler Explosions in Michigan since 1880.

Feb. 9, 1880.—The boiler in the malt-house of the Hawley Malt Company, of Detroit, Mich., exploded, demolishing the engine-house and damaging the malt-house to the extent of $20,000.

April 26, 1880.— John P. Bacon's mill at Chapin. One man seriously injured.

July 26, 1880.— H. Mellen's saw-mill at Bagley, Otsego county. Two men killed and several others injured.

July —, 1880.— Nelson & Brown's mill at Muskegon.

Sept. 24, 1880.— Loose & Son's fruit-drying house, at Monroe. Henry O'Brien, Leonard Martin, and a boy named Chabenau were killed, and nine others were injured. The building was demolished.

Sept. —, 1880.— Two boilers at Bay City. One man killed and two badly injured. The building was wrecked. Property loss, $10,000.

Nov. 2, 1880.— W. W. Cummer's mill at Cadillac. Three men injured.

Nov. 27, 1880.— Andrew Moore's foundry at St. Charlotte. The building was demolished, two men were killed, and four others were badly injured.

Dec. 28, 1880.— Shingle-mill at Vestaburg. Frank Filkins and Frank Ainsley were killed, and three others were badly injured. The mill was blown to atoms.

Jan. 12, 1881.— Union Flouring Mills, Detroit. The building was wrecked and three men were killed.

Feb. 7, 1881.— Henry Stevens's mill, near Fish Lake. William Thompson was fatally scalded.

Feb. 16, 1881.— Dush's mill at Dushville. Andrew Gearhart was killed, and four others were injured.

March 3, 1881.— Closson & Gilbert's mill, near Manton. Benjamin F. Ranney badly scalded.

March 21, 1881.— Aldrich & Willett's mill, near Pentwater.

July 9, 1881.— Patterson's mill, near Vestaburg. The engineer was severely scalded, and the mill was destroyed.

Aug. 22, 1881.—Howe's planing-mill, at Bay City. James Kealey and W. Abrams were instantly killed. Several other men were injured.

Oct. 2, 1881.— Ladue & Phinney's oar factory at Carrolton. John Ricard and James Ricard were killed. Property loss, $7,000.

Oct. 6, 1881.— John Cornish's saw-mill, at Richmondville, Sanilac county. The fireman was instantly killed.

Nov. 10, 1881.— A flue collapsed at Smith Bros.' mill, at West Bay City. One man fatally injured, and another man injured seriously but not fatally.

Nov. 13, 1881.—A battery of ten boilers exploded in Hamilton, McClure & Co.'s mill, at Zilwaukee, near East Saginaw. Everything in the immediate vicinity was wrecked. The four men who were about the place at the time were all killed. The property loss was about $25,000.

Nov. 27, 1881.—James Henry's shingle mill at Grand Rapids. Joseph Slater and David Hardy were killed, and George Bland was injured. The mill was entirely destroyed, and an adjoining residence was badly injured.

Dec. 15, 1881.—T. J. Sheridan's planing-mill, at Sparta Center. The engineer was killed, and the mill was demolished. Loss, about $7,000.

Jan. 24, 1882.—Chickering & Kysor's mill, at Fife Lake. The dome of the boiler blew off. Nobody injured. Damage small.

June 26, 1882.—Cannable's brick and tile works at Jackson. Michael Nugent was killed, and five other men were injured. The property loss was large.

July 21, 1882.—Two boilers exploded in D. J. McCloud's shingle mill, at Saginaw City. William Crawford and Ferdinand Scheum were killed, and seven others were severely injured.

Sept. 12, 1882.—Tatton & Cole's mill, near Luther, Lake county. One man was fatally injured, and several others received minor injuries. The mill was a perfect wreck.

Dec. 28, 1882.—Flouring mill at Perry, Shiawassee county. The mill was demolished and the engineer killed.

Jan. 1, 1883.—H. P. Hollister's saw-mill, at St. Louis. One man killed and two injured.

Jan. 2, 1883.—Telman's flouring mill, at Filmore Center. The proprietor's son was killed, and seven others were injured.

Jan. 2, 1883.—John H. Bates's saw-mill, at Vassar. Two men seriously injured. The mill was destroyed.

Jan. 4, 1883.—Two boilers exploded in the Peninsula Manufacturing Co.'s mill, at North Muskegon. Four men were killed and two injured.

Feb. 9, 1883.—B. J. Grier's saw-mill, at Charlotte, Eaton county. The proprietor and his engineer were instantly killed.

Mar. 20, 1883.—City bakery, Grand Haven. Loss about $200.

Mar. —, 1883.—Lark & Plant's mill, at Round Lake. The building was wrecked. All the hands were at dinner.

Apr. 26, 1883.—Robert Cope's portable saw-mill, in Plainfield township. The outfit was demolished, and the fireman killed. Loss, $1,000.

May 14, 1883.—Merrick & Gibbs's saw-mill, at Green Bay. The rear part of the boiler-house was demolished. One man was injured.

May 21, 1883.—Wolverine Paper Mill, Detroit. The building was blown down, and two men were killed. The mill was only a few months old. Loss, about $55,000.

June 1, 1883.—G. V. Turner & Son's shingle mill, near East Saginaw. Three men were instantly killed. Property loss about $5,000.

July 12, 1883.—Hoogstraat & Cousins's shingle mill, near Custer Village. Three men were killed, and three others were injured. Damage to the mill, about $3,000.

July 17, 1883.—Noble & Benedict's mill, near Sand Beach. The engineer was killed.

Aug. 4, 1883.—The A. W. Wright Lumber Co.'s plant, in Roscommon county. Three men were killed.

Aug. 24, 1883.—The steamer *Mary*, while moored at Detroit. The fireman was severely scalded.

Oct. 8, 1883.—Charles Mears's steam mill, at Little Point, Au Sable. The explosion occurred during a fire. Two men were painfully injured.

Oct. 20, 1883.—Ross Bros.' sash and door factory, at Grand Haven. One man killed and four injured. Loss, about $10,000.

Oct. 24, 1883.—During the course of a fire, seven boilers exploded at Bliss, Brown & Co.'s mill, East Saginaw. Total loss, $60,000.

Dec. 21, 1883.—Oxley & Hill's saw-mill, at Lacosta. Three men killed.

Jan. 5, 1884.—C. N. Nelson Lumber Co., at Lakeland, near Stillwater. One man killed and one injured. Loss, about $2,000.

Jan. 7, 1884.—Heating boiler at Benjamin Vasper's residence, at Ionia.

Jan. 7, 1884.—Hood, Parsons & Co.'s mill at Merrill. One man killed and four injured. Loss, about $5,000.

Jan. 17, 1884.—Dickerson & Anderson's mill, near Edmore. One man killed.

Feb. 1, 1884.—Twitchell's shingle mill, near Blanchard, Isabella county. Three men killed. Loss, $2,000.

Feb. 9, 1884.—Pelgrim's mill, at Mason Center.

Mar. 2, 1884.—Sanitarium at Battle Creek. Three men slightly injured. Loss, $3,000.

Mar. 5, 1884.—Porter's saw-mill, at Onondaga, near Jackson. Three men killed.

Mar. 20, 1884.—Moses Roland's saw-mill, near Albion. Two persons seriously injured. The mill was wrecked.

Apr. 16, 1884.—Dolsen, Chapin & Co.'s drill-house, Bay City. Five killed and four injured.

Apr. 17, 1884.—Batherick's grist-mill, at Davison's Station, Genesee county. One man killed, two injured. Loss, $3,000.

May 1, 1884.—Marian & Wilson's pile-driver, East Saginaw. One killed; one injured. Loss, $1,000.

May 10, 1884.—Green, Ring & Co.'s salt works, Saginaw. One killed; three injured. Loss, $3,000.

May 30, 1884.—Abram Maybee's mill, at Monroe. One man killed.

May 30, 1884.—Two boilers in Wood & Thayer's mill, near McBride's, Montcalm county. Three killed and four injured. The mill was demolished.

July 19, 1884.—A boiler exploded in Wiggins, Cooper & Co.'s mill, at South Saginaw, during a fire.

Aug. 19, 1884.—Threshing-machine boiler, on the Howell farm, Cambridge. Three killed.

Sept. 22, 1884.—The Davis mill, at Shaftsburgh. No lives lost.

Nov. 13, 1884.—Crisper's cooper shop, Hudson. Considerable damage, but no personal injuries.

Dec. 19, 1884.—Plummer's planing-mill at Jackson. One killed, six injured. The mill was destroyed.

April —, 1885.—Chicago Lumber Co., at Manistique. One man fatally injured.

Sept. 15, 1885.—Alfred Hauteberger's threshing-machine, near Reese. Five persons injured.

Nov. 1, 1885.—Tug-boat *Frank Moffat*, at Marine City. Four killed; four injured.

Jan. —, 1886.—Perry & Baker's shingle-mill at Cheboygan. Building badly damaged.

June 1, 1886.—Kimbark's carriage factory at Quincy. Two killed; seven injured.

June —, 1886.—J. H. Breeken's shingle-mill, near Mecosta. One killed; one injured.

July 16, 1886.—Port Austin Mfg. Co., at Port Austin. One killed; one injured. Loss, $800.

Aug. 17, 1886.—Threshing-machine boiler, near Vermontville. Two killed.

Aug. —, 1886.—J. H. Pearson & Son's salt block at Saginaw. Loss, $500.

Jan. 29, 1887.—Joseph Bros.' shingle-mill at Lake View. One killed; one injured. The mill was demolished.

Mar. 8, 1887.—Carr Bros.' shingle-mill, near Alpena. Two killed; one injured. The mill was destroyed.

Mar. 8, 1887.—W. F. Thompson's tub factory, near Ithaca. Three killed; several injured.

Mar. 9, 1887.—Gibb's shingle-mill, near Edmore. Two killed; six injured. The mill was wrecked.

May —, 1887.—Cannon & Shipman's mill, near Big Rapids. No personal injuries.

Aug. 30, 1887.—Threshing-machine boiler, near Flint. One killed; five injured.

Nov. 16, 1887.—Hancock Chemical Works, at Hancock. Six men killed.

Feb. 21, 1888.—Levi Newell's mill, near Morenci. One killed; one injured.

Feb. —, 1888.—Saw-mill at Houghton. The mill was wrecked.

May 14, 1888.—Caro Wooden Works at Caro. One killed; four injured.

June 1, 1888.—Eureka Iron and Steel Works at Wyandotte. Three killed; four seriously injured. The plate-mill was entirely destroyed; loss, $10,000.

Aug. 16, 1888.—Prosser's mill, near Shelby. Three killed; two injured. The mill was wrecked.

Sept. 24, 1888.—J. H. Freeny's shingle-mill, East Saginaw. One killed; three injured.

Oct. 9, 1888.—Leitelt's Machine Works, Grand Rapids. One man killed. Loss, $2,000.

Nov. 12, 1888.—Pile-driver at Detroit. One killed; three injured.

Dec. 31, 1888.—Dush's shingle-mill, near Millbrook. Three men were killed, and the mill was completely wrecked.

Jan. 11, 1889.—Bell's mill, at Pellston. Three men killed.

Feb. 21, 1889.— M. Shanks & Son's planing-mill at Clarksonville. One man killed and several injured. Loss, $2 000.

Mar. 8, 1889.— Warner's saw-mill, near Wayne. One man killed. Loss, $10.000.

Mar. 28, 1889.— Morgan's shingle-mill at Hungerford. Two men killed.

Dec. 26, 1889.— Neff Crother's mill, near Edmore. One killed: three injured.

Feb. 23, 1890.— National Bank building, Big Rapids. One man injured.

Feb. 24, 1890.— Barber-shop at Detroit. One man killed.

Apr. 14, 1890.— Ozeman's saw-mill, near Gladwin. Two men were killed and the mill was destroyed.

Apr. 23, 1890.— Cook Bros.' brick-yards, near Flint. One killed; two injured.

June 19, 1890.— Lumber-mill near Alpena. One man injured.

June 25, 1890.—Frank Gardner's stave-mill at North Star. Seven persons were killed and the mill was demolished.

July 9, 1890.— Portable boiler near Cadillac. Two men killed.

Aug. 15, 1890.— Locomotive boiler at Augusta. Two men killed.

Oct. 8, 1890.— Ducey Lumber Co., at Muskegon. Four boilers exploded, wrecking about one-third of the plant. Two men were killed and seven were injured. Loss, $12,000.

Dec. 13, 1890.— Saw-mill near Big Rapids. Three killed: two injured.

Jan. 28, 1891.— R. C. Herbison's shingle-mill at Meredith. Two men were killed and three were injured. The mill was wrecked.

July 20, 1891.— E. G. Perkins's planing-mill at Lake View. Three killed; four injured. The mill was wrecked.

Oct. 2, 1891.—Evaporating Works at Eaton Rapids. One man was killed and the building was torn to pieces. Loss, about $9.000.

Oct. 12, 1891.— Ashland mine at Ironwood. One man killed.

Dec. 12, 1891.— Threshing-machine boiler on Ezekiel Boyce's farm, at Mayville, near Detroit. Two men killed: one injured. Loss, $1.200.

Jan. 12, 1892.— North Pabst mine at Ironwood. The place was wrecked. One killed: two injured.

Feb. 6, 1892.— Merrill Bros.' shingle-mill at Clarion. The mill was wrecked, and one man was fearfully injured.

Feb. 12, 1892.— A. H. Crane's saw-mill, near Bay City. One man killed.

Mar. 4, 1892.— Charles White's saw-mill, near Port Huron. One killed: five injured. Loss, $4,000.

Mar. 21, 1892.— East Jordan Lumber Co., at East Jordan. Eight killed; twenty injured. The explosion was heard fourteen miles away.

Apr. 15, 1892.— D. A. Welsh's planing-mill at Bender.

Apr. 26, 1892.— Locomotive boiler at Whitedale, near Manistique. One killed: one injured.

May 12, 1892.— Three boilers in the Midland Salt and Lumber Co.'s plant, at Midland. Three men were killed and eight others were seriously injured.

June 14, 1892.—Locomotive boiler, near Battle Creek. One killed; two injured.

July 20, 1892. — Alphonso Whaley's threshing-machine, near Morenci. One man killed.

July 28, 1892.— Hartnell & Smith's shingle-mill, near Gaylord. Five killed: one injured. The mill was wrecked.

Sept. 4, 1892.— E. S. Noble's steam yacht *Cora*, at Elk Rapids. Three injured.

Oct. 20, 1892.— Two boilers in Phillips & Co.'s factory at Fentonville.

Nov. 24, 1892.— Erickson's dry-goods store at Escanaba. Loss, $3,000.

Jan. 21, 1893.— H. B. Hathaway's mill at Blissfield. Nine persons injured. Loss, $3,000.

Jan. 30, 1893.—W. F. Stewart & Co.'s factory at Pontiac. Loss, about $3,000.

Feb. 13, 1893.— Wiltse's mill at Ashley, near Ithaca.

Feb. 25, 1893.— Near Cadillac. One man killed.

Apr. 17, 1893.— Near Hamburg. One man killed.

May 11, 1893.— A factory at Cheboygan. One man badly scalded.

May 25, 1893.— Ring, Merrill & Tillotson's factory at Saginaw. One man injured.

Aug. 13, 1893.— At Detroit. One man scalded.

Aug. 22, 1893.— J. W. Willett's mill at Bushnell. One killed; two injured.

Sept. 5, 1893.— At Highland Park, near Detroit. Two killed; two injured.

Apr. 9, 1894.— At Whitehall. Seven men killed.

May 18, 1894.— F. C. Ross's mill at West Bay City. Two killed; four injured.

Aug. 4, 1894.— Threshing-machine on John Franklin's farm, near Jackson. One man injured.

Aug. 23, 1894.— Office of the *Journal*, at Ithaca. Nobody hurt.

Sept. 14, 1894.—Passenger steamer *Unique*, in the St. Clair river opposite St. Clair. A fireman was scalded to death.

Sept. 19, 1894.— Seely & Mott's feather renovator at South Haven. One man injured.

Oct. 16, 1894.— Heating boiler in a tenement at Grand Rapids. The entire first floor of the building was shattered.

Dec. 18, 1894.—Russell Bros.' mill at West Bay City. Five killed; three injured. Loss, about $7,500.

Jan. 21, 1895.— Brownlee & Co.'s saw-mill on the River Rouge, near Detroit. One killed; one injured. Loss, $3,000.

Feb. 3, 1895.— Gray Bros.' factory at Muskegon Heights. One man killed. Loss, about $7,000.

Feb. 22, 1895.— Freight engine, C. & G. T. R. R., near Imlay City. One killed; two injured.

Mar. 7, 1895.— A. M. Kinney's mill, near Hillsdale. One killed, two injured. The mill was demolished.

Apr. 1, 1895.— Emery & Simpson's mill at Saginaw. Two killed; one injured. Loss, $10,000.

Apr. 22, 1895.—"The Egnew" hotel at Mt. Clemens. Nobody hurt.

May 13, 1895.— Passenger steamer *Unique*, on Lake St. Clair, near Belle Isle. Two killed; one injured.

June 22, 1895.— Alonzo H. Crocker's mill at West Carlisle. Three men were killed and the mill was blown to atoms.

Sept. 5, 1895.— Oscoda Lumber Co., at Oscoda. One man injured.

Sept. 9, 1895.— Lovejoy Machine Shop at Richmond. Nobody hurt.

Sept. 10, 1895.— Marine City Stave Co. at Marine City. One killed; one injured. The boiler-house was demolished. Loss, probably about $15,000.

Nov. 6, 1895.— The *Evening Journal* building at Detroit. Thirty-seven persons were killed and twenty were injured. Half of the building was blown to atoms. The property loss was about $100,000.

The Locomotive.

HARTFORD, MAY 15, 1896.

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

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Obituary.

CAPTAIN A. K. FRANCIS.

It becomes our painful duty to record the death of Captain A. K. Francis, who was for many years an inspector of The Hartford Steam Boiler Inspection and Insurance Company in our southern department, residing in Augusta, Ga. He was born in the city of Hartford, Conn. His father was a well-known and much esteemed resident of this city. His brother, Charles D. Francis, is at the head of the inspection corps in the home office of the company in this city. Captain Francis went South in 1860 and has made his home there since that date. He was well educated, theoretically and practically, in mechanics, and was for some years in the employ of the Georgia Railroad Company. He entered the service of the Hartford Steam Boiler Inspection and Insurance Company in 1888. He was faithful in all that was assigned him to accomplish, and won the respect of the officers of the company by his devotion to its interests. He was a man of genial disposition and kind at heart; and he never swerved from what he regarded as just and right. His associates and numerous friends and acquaintances will deeply deplore his death.

Flues for Boilers.

The article published under this heading in our issue for February has called out a number of letters, in which further information concerning the U. S. government rules is asked for. In reply, we print, below, an extract from page 160 of the *Proceedings* of the forty-second annual meeting of the Board of Supervising Inspectors of Steam Vessels, held at Washington in January, 1894. We have preserved the numbering of the paragraphs, so that reference to the original document may be facilitated.

"THICKNESS OF MATERIAL REQUIRED FOR TUBES AND FLUES NOT OTHERWISE PROVIDED FOR.

"9. Tubes and flues not exceeding 6 inches in diameter, and made of any required length; and lap-welded flues required to carry a working steam pressure not to exceed 60 lbs. per square inch and having a diameter not exceeding 16 inches and a length not exceeding 18 feet; and lap-welded flues required to carry a steam pressure exceeding 60 lbs. per square inch and not exceeding 120 lbs. per square inch, and having a diameter not exceeding 16 inches, and a length not exceeding 18 feet, and made in sections not exceeding 5 feet in length, and fitted properly one into the other, and substantially riveted; and all such tubes and flues shall have a thickness of material according to their respective diameters, as prescribed in the following table:

Outside Diameter.	Thickness.	Outside Diameter.	Thickness.	Outside Diameter.	Thickness.	Outside Diameter.	Thickness.
1 in.	.072 in.	$2\frac{3}{4}$ in.	.109 in.	5 in.	.148 in.	12 in.	.229 in.
$1\frac{1}{4}$	.072	3	.109	6	.165	13	.238
$1\frac{1}{2}$	.083	$3\frac{1}{4}$	.120	7	.165	14	.248
$1\frac{3}{4}$	.095	$3\frac{1}{2}$	.120	8	.165	15	.259
2	.095	$3\frac{3}{4}$	.120	9	.180	16	.270
$2\frac{1}{4}$	.095	4	.134	10	.203		
$2\frac{1}{2}$	.109	$4\frac{1}{2}$	.134	11	.220		

"10. Lap-welded flues not exceeding 6 inches in diameter may be made of any required length without being made in sections. And all such lap-welded flues and riveted flues not exceeding 6 inches in diameter may be allowed a working steam pressure not to exceed 225 pounds per square inch, if deemed safe by the inspectors.

"11. Lap-welded flues exceeding 6 inches in diameter and not exceeding 16 inches in diameter, and not exceeding 18 feet in length, and required to carry a steam pressure not exceeding 60 pounds per square inch, shall not be required to be made in sections.

"12. Lap-welded and riveted flues exceeding 6 inches in diameter, and not exceeding 16 inches in diameter, and not exceeding 18 feet in length, and required to carry a steam pressure exceeding 60 pounds per square inch, and not exceeding 120 pounds per square inch, may be allowed, if made in sections not exceeding 5 feet in length, and properly fitted one into the other, and substantially riveted.

"13. Riveted and lap-welded flues exceeding 6 inches in diameter and not exceeding 40 inches in diameter, required to carry a working steam pressure per square inch exceeding the maximum steam pressure prescribed for any such flue in the table of section 8 of this rule, shall be constructed under the provisions of section 15 of this rule, and limited to the working steam pressure therein provided for furnace flues; but in no case shall the material in any such riveted or lap-welded flue be of less thickness for any given diameter than the least thickness prescribed, in the afore-mentioned table, for flues of such diameter."

The Invention of the Electromagnetic Telegraph.

The claim is sometimes heard made in the western part of Pennsylvania that the telegraph was invented by a resident of that section — a Dr. Alter, who formerly lived at Elderton, Pa. In reply to a letter on the subject addressed to Mr. M. H. Alter, of Kittanning, the following communication was received:

"In regard to my father's part in the application of electromagnetism to telegraphic purposes, I have letters in my possession showing that he had communication with Prof. Henry in 1831. This led him to experiment, and the result was that he erected three lines of wire from the barn to his house in Elderton, this county, a distance of about 100 yards, using double lines, as the ground circuit was then unknown. He used three dials, and by the deflection of the index was enabled to transmit intelligence, but I have no record of the manner in which these indices were used. He never completed a system of registration of electrical messages, but rested with the satisfaction of knowing that such results were attainable, which fact he had no hesitation in telling any one curious to know. There is a legend abroad here, which is believed by hundreds, that Professor Morse obtained his ideas of telegraphy from my father. This is without foundation in fact. He never had any communication with him, and never saw him; there is no similarity in the mechanical application of the principle involved, and I would be pleased to have you correct this impression. From his conversation I would say that he gave credit to Professor Henry as being the prime factor in the development of electromagnetic telegraphy.

"That he was one of the many whose attention had been directed in this channel, I have no doubt, and, without claiming any recognition for him as a factor in the development of the telegraph, he would yet seem to be worthy of mention in an historical sketch.

"I may add that my father was a man of advanced scientific knowledge, utterly devoid of business sagacity, and as bashful as a maiden in asserting any merit he possessed. His mental activity extended in many directions, the new science of electricity possessing a particular attraction for him. In an article in the Kittanning *Gazette* of June 29, 1837, entitled 'Facts Relating to Electro-Magnetism,' he said: 'It will be readily seen that this power will be much more applicable to locomotion than steam,' and proceeded to give details of methods which, of course, have now been surpassed. In 1852, in passing sparks from a static machine of his own construction, he caught the image of the spark in a prism, and wrote the first essay on spectrum analysis, which appeared in the *American Journal of Science and Art* in 1853."— *Electrical World.*

Notes on Coal Mining.

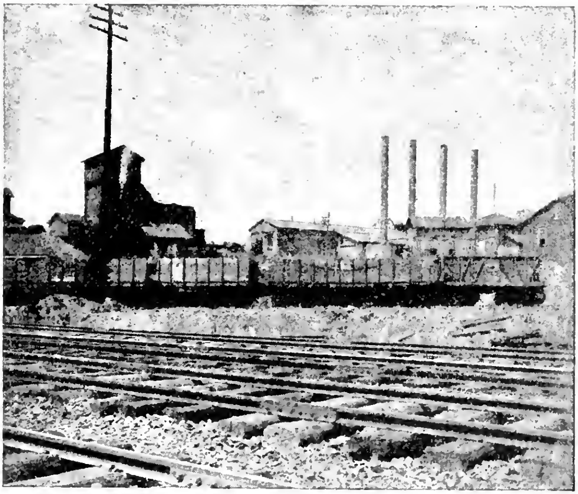
By an Idle Correspondent.

I had never seen a coal mine. There aren't many of them down East, where I came from. But here I was in Pittsburgh, the very head center of coal and iron and natural gas, and all that these imply, and it was out of the question to go back without going to a mine, somewhere ; so after taking counsel with a local sharp who knows all about such matters (or says he does) I took the train for Irwin Station, about ten miles out of Pittsburgh, with the object of looking into the affairs of the Penn Gas Coal Company, and asking the superintendent some foolish questions.

I reached the place at noon, and had some little time to look about, before the superintendent returned from dinner. The place consisted chiefly, as I had supposed, of a hole in the ground. It may seem stupid to mention this fact, but I don't think it really *is* stupid. I thought the same way about an *iron* mine until I saw one, and then I learned better. That belongs to another story, though ; and just for the present I merely want to report the fact, predicted by theory and afterwards verified by observation, that a coal mine *is* a hole in the ground.

Over and around this hole there are the various buildings, which are shown in the accompanying photograph. One of these buildings (the one with the iron smoke-stacks) is the power-house, in which I found a battery of boilers, which did not inspire in my bosom the confidence that I could have wished. I dare say they were all right, though. I have noticed that the boilers out in this region often make one think of home and of mother, when he chances to turn a corner somewhere, and come upon them unexpectedly. The superintendent came back while I was looking them over, and told me with much earnestness that boilers never explode unless the water gets low. I wanted to tell him about the specimens and photographs and other data that you have in the Home Office that prove that this isn't so, but as his opinion seemed to be deeply and firmly rooted, and he was a large and powerful man, I thought perhaps it wouldn't be polite to raise the point.

He showed me about the place with a certain pride, and told me the mine had been worked for thirty-five years. The coal lies in a vein about six feet thick, and the main tunnel is nearly horizontal, stretching away off into the heart of the earth for a distance of two miles or so. The miners, in at the further end of it, break down the coal and load it into trains of cars, each man being credited with the cars that he loads, and



Plant of the Penn Gas Coal Company.

receiving sixty cents a ton for his work. An experienced and able man will make, at this price, about $3.50 a day. When the coal train has been loaded, it is drawn to a point directly beneath the mouth of the mine, by means of a steel cable, which is wound up on an enormous drum in a small building devoted especially to that end. When the superintendent first spoke of the two miles of steel cable, I thought his estimate might be a generous one, and I framed a hypothesis to account for it, by supposing that perhaps miles looked longer in the dark than they do in the daylight ; but when I saw that cable wound up on the drum, it was plain that he was a man of scrupulous accuracy of speech. The cable was certainly two miles long. If he had said twelve, I don't think I should have disputed it. It made me think of an Atlantic cable. The engineer in charge of the winding engines evidently knew every detail of the tunnel through which he was drawing the cars. At times he would turn on a full head of steam, and again, when the train passed over a high point and began to roll down grade, he would shut off the steam almost entirely, leaving only enough on his engines to take care of the slack of the cable. His promptness with the throttle was hard to understand, until I noticed that a sort of indicator was attached to the drum, in such a way that the exact position of the incoming train was shown at every instant on a long graduated scale. Once the winding was stopped for some minutes, and I learned that the coal train was then at some sort of a station, or junction, or perhaps a "grade crossing," deep down under a hill that I could see, about a mile away. I should have liked to visit that desert station. It must be as lonely as Essex Junction in Vermont, and that is no mean distinction.

When the coal train has been hauled in to the shaft, the cars are drawn up, one by one, on a pair of elevators and are weighed. Each miner attaches a tag to his car as he loads it, and by this means the clerk who keeps tabs on the weighing machine knows who mined every ton that is brought up. After weighing, the coal is passed over a screen, which removes the dust and slack, and it is then loaded for transportation on cars that are run in under the screens, on spur tracks from the adjacent railroad.

I wanted very much to go down the shaft, and made a few suggestions of this sort to the superintendent. He was a bright man about most things, but on this one point he appeared to be extraordinarily stupid. He didn't seem to understand me at all, although I gave him several excellent opportunities. He finally intimated that there was nothing to see, unless one went way out to the remote end of the tunnel, and he didn't seem to think he could spare the time to take me so far. It was like going to Philadelphia, he said. Of course I had to accept his explanation, but I couldn't help fancying that the real difficulty was that he feared I would soil my cuffs. He needn't have worried. They had been turned already.

Failing to enlist him in the cause of subterranean exploration, I asked about the ventilation of the mine: for I noticed that the lamps that I had seen about the place all had open wicks, without the least protection, by gauze or otherwise, against the dreaded fire-damp. He said the Davy safety-lamp is a nuisance, and that it is used very little, or not all. He appeared to think that Davy's invention is a good thing to have in the text-books, but a poor thing to work by in the mine.

In a little building near the cable-house he showed me the big fan that draws the air from the mine, so as to keep up a continual circulation, and carry away any gas that may happen to escape from the coal seam. There are two general methods of ventilation in use in the coal regions. In one of them, air is forced into the mine at the power-house end, and allowed to escape through a shaft at the distant end. In the other method (which is the one in use at the mine I visited) the air is drawn out of the mine at the shaft end and allowed to pour into it at the remote end. The fans that are used for controlling the air supply are very powerful. When we opened the door that led to the fan chamber, the draft was such that I was almost drawn bodily in. My guide told me that only two days ago he was showing a party of men and women over the place, and when he opened the door of the fan-chamber one of the women had her hat whisked off. It passed through the fan and was dashed against a pile of stones outside. It was fortunate that the *suction* method of ventilation was in use here, for otherwise the dainty bit of millinery might have been blown far down into the mine. That would have been too bad, for the hat wouldn't have been of much use to the miners down there. I doubt, too, if it would have been of much use to the woman above. Even as it was, it very likely had to have a few new tubes and a couple of patches or so.

When, through any accident to the machinery, the fan stops, the miners below are quick to notice the resulting stagnation of the air, and they make immediate tracks for the upper regions. I think there is a state law in Pennsylvania requiring mine-owners to provide at least two ways of escape for their workmen, so that the danger of the men being imprisoned by a fall of rock, or from any other cause, may be reduced as much as possible. At all events, it is customary to make such a provision, whether it is required by law or not, and the result is, that few of the accidents that occur in modern coal mines are accompanied by serious loss of life.

All of the coal found in the western part of Pennsylvania is soft, but the deposit grows harder as we pass towards the eastern end of the state, and in order to see how anthracite coal is obtained, I took a run over to Scranton. Bituminous coal is mined in a very simple way, and there is nothing spectacular about the process. It is merely dug out of the earth, weighed, screened, and loaded on cars for shipment. Anthracite coal is handled in a somewhat different fashion, and the region about Scranton and Wilkes-barre is filled with evidences of the enormous scale on which the mining is carried on.

I shall have something to say about hard coal in my next letter.

Miscellaneous Accidents from the Use of Steam and Hot Water.— We learn, from time to time, of accidents caused by pipes, heaters, water-backs, and other appliances, which do not come strictly under the head of boiler explosions, and hence are not included in our regular monthly list. A few of the more notable ones that have occurred during the past few months are given herewith.

The main steam-pipe of the starboard engine of the American line steamship *St. Paul* fractured in two places on December 18th, while the vessel was lying at her pier in New York. Five men were killed instantly, and four others died within twenty-four hours. In addition to those killed, three men were painfully injured. The exploded pipe was of cast-iron, 17 inches in diameter, internally, and $1\frac{3}{4}$ inches thick. The boilers were carrying 130 pounds of steam at the time. One of the breaks in the pipe was close to the bulkhead through which it passes into the engine-room. The other break was near the steam-chest.

A similar explosion occurred, three days later, in the basement of Offermann's dry goods store, on Fulton street, Brooklyn, where the feed-pipe blew out of a boiler in the basement. Engineer Cornelius Faulkner and Fireman John Burke were severely scalded on the head, face, arms, and body, so that it was thought likely they would die from their injuries. Herman Altgelt and Edward McLaughlin were also scalded, though to a much lesser extent.

A steam-pipe exploded, on January 6th, on the tug-boat *Henry M. Palmer*, while the tug was lying at the foot of North Sixth street, New York. Martin Flannagan, the engineer, was scalded about the face and hands, but was able to run from the engine-room to the deck.

On February 18th, a steam kettle exploded in the wholesale confectionery establishment of G. W. Chase & Son of St. Joseph, Mo. George J. Ridley was killed, and Edward Ott and Edward Seipp received injuries from which they are not likely to recover. The kettle had been leaking slightly, and the men were about to repair it. It was not in use at the time of the explosion, and only enough steam was turned on to show the position of the leak.

Chief Engineer J. A. Quinlan and Assistant Engineer James McCarmack were seriously burned, on February 17th, by an explosion on the United States government dredge, *General C. B. Comstock*, at Galveston, Texas. The injured men removed a hand-hole plate from one of the boilers and held a light to the opening to examine the interior of the boiler, when a violent explosion occurred. An inflammable vapor of some sort was evidently present, but whether it was generated from benzine that had been used in getting the boiler ready for the regular government inspection or not, we cannot say.

The water-back in the kitchen range in the apartments of Simon Hildesheimer, on Madison avenue, New York city, exploded with great violence on February 19th. The range and an iron shelf above it were torn to pieces, all the windows and doors of the room were broken, and Mr. Hildesheimer and his wife were severely injured. The house was set afire, and the neighbors thought a dynamite bomb had exploded. Investigation showed that the pipes leading to the water-back were frozen up, so that the steam generated by the fire had no chance to relieve itself.

A similar explosion occurred, on February 20th, in the residence of a Mr. Boerlin, in Chicago. The stove was shattered and hot coals were strewn all about. The blaze that followed was promptly put out by the fire department.

The Locomotive.

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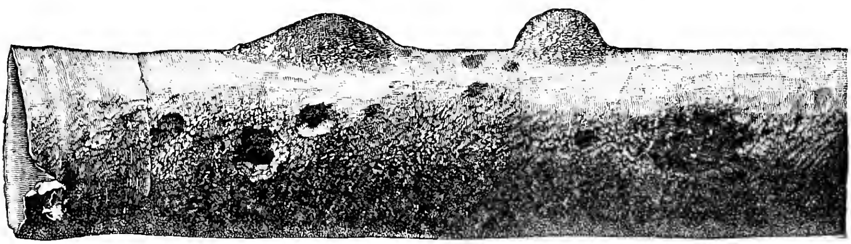
The Corrosive Action of Pure Waters.

It is not generally known that pure, soft water will corrode boilers, and so may be undesirable to use. It would seem that the purer the water, and the more free consequently it is from scale-making matter, and from salt, soluble magnesia compounds, and other substances known to cause corrosion, the better it would be for boiler purposes, and up to a certain point this is true; but it has been found by experience (and experiment shows the same thing), that waters carrying a certain small proportion of solid matter, and perhaps making a little scale, are better for boiler use than those that would be extolled as the finest drinking waters.

There is hardly such a thing as *absolutely pure* water in nature. Water, being almost a universal solvent, takes up more or less of every substance with which it comes in contact. Even rain is charged with soot, dust, acids, and ammonia from the atmosphere, so that only in remote regions of scanty population does rain approach the purity of dis-



A Tube Pitted by Pure Water.

tilled water. Pure water itself has very little solvent power for iron, and a fixed amount soon takes up all the iron it can hold. Indeed, on bright surfaces pure water exerts hardly any action at all; and yet there are cases in which a bad corrosive action can occur from apparently pure water, as, for example, when condensed water is delivered back to a boiler so near the shell as not to first mingle freely with the water in the boiler. The feed, in this particular case, will not only dissolve away all scale near the point of discharge, but will also eventually badly corrode the boiler itself. We shall not attempt to decide whether the particular phase of corrosive action here mentioned is due entirely to the purity of the distilled feed, or whether it arises from other causes; but will merely repeat that the waters that are available for use in boilers are never *absolutely* pure. The purest surface waters always contain *some* foreign matter — a little organic matter from swamps, perhaps, or some leaf-mould from the woods, or mountain moss. At considerable distances from the sea, our ponds may contain more or less salt and saline matter brought inland by fog or wind, and even water from melted snow, on frozen ground, contains much air and other gases. All of these substances are corrosive under certain circumstances, and sometimes remarkably so. That corrosion from these dissolved matters is not more general, is due to the fact that ordinarily our supplies do not approach to a state of purity (using the word "purity" in its exact sense, without reference to contamination by sewage or other similar matter), but contain more or less *scale-forming* matter, and some alkali. Even trap rocks and granite yield *some* soda and potash to water, so that the tendency of the organic matter and decomposable saline constituents to acid decomposition is continually corrected; and in our best waters, from pure sources carrying some organic matter, a varnish-like coating, consisting of compounds of low iron oxides with organic matter, soon covers the iron surfaces, and protects them very perfectly, sometimes for many years.

It is difficult to represent, in an engraving, a typical case of corrosion from too pure a water, because the affected plate usually does not show any very sharp contrast of light and shade; but we reproduce an engraving of a pitted tube, which will show what may be expected under certain circumstances. The tube here shown was not protected by the varnish-like coating that we have referred to, and the water therefore came into direct contact with the iron. The action was most rapid when the boiler stood idle for a time. It showed itself, first, in the formation of thin blisters of rust, two of which are shown. The blisters are easily removed, and the surface of the metal underneath is then found to be of a reddish black color. It may be that no change, other than this discoloration, will be visible when the blister is removed; but by pecking at the spot with the point of a knife, it will be found that a considerable quantity of oxide may be removed before the bright metal is exposed, leaving pits of various sizes. Those shown in the cut were brought out in this way.

New boilers, new tubes, and new work generally, that has not acquired this protective coating, are apt to suffer when first put into service with a very soft, pure water, such as follows the melting of the snow in the spring, or the copious fall rains which fill our streams and reservoirs; and the singular phenomenon is sometimes presented, of new tubes or new boilers giving out, so that they have to be replaced even more than once, while old ones, worked under the same conditions, remain serviceable.

This past spring has been an unusual one in New England in this respect. Two remarkably dry years in succession had exhausted our reservoirs, reduced the flow from our springs and streams, and lowered the ground water to an unusual extent. A considerable fall of snow that covered the ground during the last of the winter was rapidly melted off by heavy rains, re-filling the depleted streams and reservoirs with the softest water possible, — the solid matter present in solution being, in some cases, even lower than 1 part to 100,000. Such water, when used in a boiler unprotected by scale or iron oxide skin, would be very certain to cause corrosion.

The corrosive power of pure water on new or unscaled boilers was well illustrated in the city of Glasgow, when a new water supply was introduced from Loch Katrine, one of the purest waters in the world which is available for city consumption. (The facts are given in Rowan's little handbook on *Boiler Incrustation and Corrosion.*) The former supply had been poor and calcareous, and old boilers were much coated with lime scale. To the dismay of the users, those who had put in new boilers or new tubes found them rapidly corroding, while the old scaled and coated boilers remained as before; and those who had removed every possible trace of old incrustation from their old boilers, by mechanical or chemical means, "in order to get the full benefit of the pure water," were also badly troubled by corrosion; and even the old boilers, as the scale was gradually removed by the unvaryingly soft, pure water from the lake, were more or less corroded when no means were taken to prevent it. It was found, in this case, that introducing a little lime from time to time,— enough to give the boilers a slight calcareous coating,— usually prevented the corrosive action of the water, and in the course of time the lime, organic matter, and iron oxide skin formed a protecting, oxidized surface that prevented further corrosion.

Water similar to that of Loch Katrine,— soft and pure in quality, without alkalinity, containing some vegetable organic matter, and with the natural proportion of acid and gases common to a fully oxidized water,— is what in the non-lime bearing sections of our country is met with at certain seasons of the year in our streams, ponds, and reservoirs, after the melting of snow or heavy rains. Except in certain limited sections, however, this condition fortunately does not long persist, for in dryer times the water soon takes up its normal proportions of lime and alkali, and reaches the point where some scale may form in a boiler.

It will be inferred, from what has been said, that the most perfect boiler water is one which makes a slight deposit in the dryer seasons, and has this deposit largely dissolved off by the soft water of spring and fall, so that the balance of efficient working, without much scale and without serious corrosion, is practically kept. Fortunately, many of our Eastern boiler waters fulfill these conditions. It will not do, however, to rely entirely upon nature to keep the balance, in even the best boiler waters; for the condition of the water will vary from season to season, and even the smallest amount of solid matter, whether soluble or not, will accumulate, in time, to a dangerous extent, if not blown or cleaned out.

Inspectors' Report.

April, 1896.

During this month our inspectors made 8,841 inspection trips, visited 17,920 boilers, inspected 6,575 both internally and externally, and subjected 677 to hydrostatic pressure. The whole number of defects reported reached 11,852, of which 1,313 were considered dangerous ; 84 boilers were regarded unsafe for further use. Our usual summary is given below :

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	989	43
Cases of incrustation and scale,	2,294	50
Cases of internal grooving,	169	7
Cases of internal corrosion,	631	33
Cases of external corrosion,	737	44
Broken and loose braces and stays,	144	47
Settings defective,	330	40
Furnaces out of shape,	459	14
Fractured plates,	277	69
Burned plates,	293	26
Blistered plates,	233	10
Cases of defective riveting,	1,577	110
Defectivo heads,	100	17
Serious leakage around tube ends,	1,756	547
Serious leakage at seams,	503	16
Defective water gauges,	409	74

Nature of Defects.	Whole Number.	Dangerous.
Defective blow-offs.	197	49
Cases of deficiency of water.	10	2
Safety-valves overloaded.	78	26
Safety-valves defective in construction.	79	28
Pressure gauges defective.	560	57
Boilers without pressure gauges.	4	4
Unclassified defects.	23	0
Total.	11,852	1,313

Boiler Explosions.

March, 1896.

(64.) — On February 22d a boiler exploded in the Fostoria Laundry, at Fostoria, Ohio. The boiler-house was completely destroyed, but the laundry machinery was not injured. A fire which started in the ruins was soon controlled. The explosion occurred during the evening, when nobody was in the building.

(65.) — A boiler exploded, on February 26th, in C. M. Hull's mill, near Lockspring, Ind. The workmen were warned by the engineer, who noticed a rapidly increasing leak at one of the joints. They all took to their heels, and had only just reached a place of safety when the explosion occurred. The damage to the mill was small. [We did not learn of the two preceding explosions in time to print them in the proper place.]

(66.) — A boiler explosion occurred, on March 3d, in Parks Bros.' fur cutting establishment, at Danbury, Conn. The roof of the building was blown off, and the ruins took fire. The flames quickly spread to adjoining buildings, and before they could be controlled the loss amounted to about $200,000. Edward Parks and Frank Eastwood were seriously injured, and Eastwood is likely to die. Sadie Carpenter, a woman who lived in one of the burned buildings, broke her thigh in jumping from a window.

(67.) — On March 6th a boiler exploded in Drony & Davis's mill, at Halls, on the Allegheny & Kinzua railroad, near Bradford, Pa. The mill was demolished, and Frank Carlston and Martin Van Orden were severely injured.

(68.) — A blow-off pipe burst, on March 6th, in the basement of the building occupied by the Troy Laundry Machinery Company, in Chicago, Ill. E. W. Graff was killed, and E. Berry, William Dobson, William C. Grant, Theodore Hubbard, Samuel Jerwassa, F. Kain, F. Kelly, Frank Marsalla, and Samuel Marsalla, were fearfully scalded.

(69.) — A boiler exploded, on March 7th, in George Harvey's hot house, at East Rahway, N. J. The building was demolished, and thousands of plants were destroyed.

(70.) — A slight explosion occurred, on March 7th, at J. B. Wathen's distillery, Louisville, Ky. James Willett was severely scalded.

(71.) — On March 11th one boiler in a battery of eight exploded at Rend & Co.'s Laurel Hill mine, No. 1, in South Fayette township, near Pittsburgh, Pa. Two boys, Henry and Albert Leroy, were killed, and the boiler house was reduced to a mass of ruins.

(72.) — The boiler of locomotive No. 4, on the Delaware, Susquehanna & Schuylkill railroad, exploded, on March 11th, between Gum Run and Derringer, near Hazleton, Pa. John Chambers, Jonas Stewart, Michael Boyle, and Frank O'Donnell were killed, and William Timony was badly injured and may not recover. The train was wrecked, and nothing was left of the locomotive except the wheels and axles.

(73.) — A boiler exploded, on March 13th, in C. M. Hull's saw-mill, below Milhousen, near Greensburg, Ind. Mr. Hull and one of the workmen were seriously injured, and several others had narrow escapes. [Explosion No. 65, which is recorded in this issue, occurred at the same mill, on February 26th.]

(74.) — On March 13th a flue failed in one of the boilers in the West Chester Cold Storage Company's plant, at West Chester, Pa. Nobody was injured, and the damage was soon repaired.

(75.) — A boiler exploded, on March 14th, in McClurkin's mill, near Caledonia, in Wilcox county, Ala. The boiler crashed through the mill and buried itself in the ground, 400 feet away. Simon Watts, Alexander Grace, and Allen Hollinger were killed. F. I. Defee was seriously injured, and his recovery is doubtful. The mill was torn to pieces.

(76.) — On March 18th a boiler exploded in H. B. Palmerton's mill, at Charlotteville, near Elmwood, Ont. Lewis Cole was instantly killed, and Michael Absden and Norman Weaver were painfully injured. Mr. Palmerton was also slightly hurt. The boiler was blown 400 feet away.

(77.) — A boiler exploded, on March 18th, in William Curtis' saw-mill, at Waterdown, Ont. Thomas Smiley was fatally injured, and the building was badly damaged.

(78.) — John Gurtis was fatally injured, on March 19th, by a boiler explosion near Williamsport, Ind. We have not learned further particulars.

(79.) — An elevator boiler exploded, on March 19th, on State street, Chicago, Ill. Fortunately nobody was injured, and the property loss was not great.

(80.) — A battery of four boilers exploded, on March 19th, in the Algonquin Coal Company's Pine Ridge Colliery, at Miner's Mills, near Wilkesbarre, Pa. One of the boilers passed through the breaker, landing 100 feet from the boiler house, and another one was found over a quarter of a mile away. The boiler house was demolished. Nobody was injured. The stoppage of the ventilating fan occasioned some apprehension for the men below in the mine, but word was sent to them, and they all got out safely by an old man-way.

(81.) — A heating boiler exploded, on March 20th, in the basement of a dwelling house in Newark, N. J. Parts of the foundation of the building were blown up into the second story, and the front walls were bulged out. Etta Teeson was scalded, but the other inmates received no injury except a bad shaking up. The damage to property was about $3,000.

(82.) — On March 20th a boiler exploded in the Consumers' Ice Company's plant, at Covington, Ky. Charles Tillman and Joseph Carson were fearfully injured. Tillman died shortly after being removed to the hospital. Carson also died, during the next forenoon, and his widow promptly entered suit against the Ice Company for $10,000 damages, on the strength of the coroner's verdict, which declared that the explosion was due to the engineer's negligence. The property loss was about $5,000.

(83.) — The boiler of Larkin & Grigies' mill, at Selma, Ala., exploded on March 21st, killing one man and fatally injuring three others.

(84.) — A flue failed, on March 24th, in a mill at Warren, Tyler county, Texas. Thomas Harlan was badly scalded on the face and arms.

(85.) — Roscoe L. Garland was killed, on March 25th, by a boiler explosion, which occurred near Sistersville, W. Va.

(86.) — The steamer *Artemus Lamb* was badly wrecked at Scotch Jimmy's Island, near Alton, Ill., on March 26th, by the explosion of one of her boilers. Fireman Edward Milliard was terribly scalded, and blown into the river. He was rescued from drowning, but he cannot live. Eli Lancaster was also painfully injured.

(87.) — On March 26th, a flue failed in Finney Bros'. mill at Brown Hill, near Meadville, Pa. It does not appear that any one was seriously injured.

(88.) — A boiler exploded, on March 28th, in John Blair's saw-mill at Swanville, near Little Falls, Minn. The mill was badly damaged, but fortunately nobody was killed.

(89.) — The steam tug *Isabelle* was wrecked by the explosion of her boiler, on March 30th, near Moss Point, Mich. Samuel Taylor and Giles Broom were seriously burned and scalded. The *Isabelle* was torn to pieces, and sank immediately. The property loss was about $5,000.

(90.) — On March 31st, a boiler exploded in J. C. Conley's mill, near Daingerfield, Morris county, Texas. Granville W. Porter was instantly killed, and Robert Banks, Thomas Sowells, and B. J. Curry were seriously injured. Sowells may die. Several other men were slightly injured. The mill was completely wrecked.

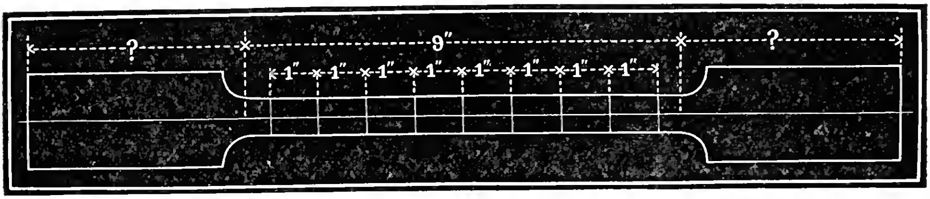
U. S. Government Tests of Steel Plate.

At the regular meeting at Washington, in January, 1896, amendments were made to certain of the Rules and Regulations of the Board of Supervising Inspectors of Steam Vessels. We present, herewith, such parts as relate to the testing of steel plate:

"To ascertain the tensile strength and other qualities of steel plate, there shall be taken from each sheet to be used in shell or other parts of boiler which are subject to tensile strain, a test piece prepared in form according to" the diagram given and described below. "The straight part shall be nine inches in length and one inch in width, marked with light prick punch marks at distances one inch apart, as shown, spaced so as to give eight inches in length." The curved parts shown are to be of one inch radius, and the ends for securing the piece in the testing machine are to be from 3 to 6 inches long (*i. e.* the dimension marked "?"), and 1½ to 2 inches wide. "The sample must show, when tested, an elongation of at least 25 per cent. in a length of 2 inches, for thicknesses up to ¼ inch, inclusive; and in a length of 4 inches, for over ¼ to $\frac{7}{16}$, inclusive; in a length of 8 inches, for over $\frac{7}{16}$ to 1 inch, inclusive; and in a length of 6 inches, for all thicknesses over 1 inch. The reduction of area shall be the same as called for by the rules of the Board." [The rules here referred to are as follows: "All steel plate of one-half inch thickness and under shall show a contraction of area of not less than fifty per cent. Steel plate over one-half inch in thickness, up to three-quarters inch in thickness, shall show a reduction of not less than forty-five per cent. All steel plate over three-fourths inch thickness shall show a reduction of not less than forty per cent.; *provided*, however, that steel plate required for repairs to boilers built previous to April 1, 1886, may be used for such repairs when showing a contraction of area of not less than forty per cent."]

"No plate shall contain more than .06 per cent. of phosphorus, and .04 per cent. of sulphur, to be determined by analysis by the manufacturers, verified by them, and copy furnished the inspector for each order tested; which analysis shall, if deemed expedient by the Supervising Inspector-General, be verified by an outside test at the expense of the manufacturer of the plate.

"*It being further provided* that said manufacturer shall also furnish a certificate with each order of steel to be tested, stating the technical process by which said steel was manufactured. It being further provided that steel manufactured by what is known as



FORM OF TEST PIECE REQUIRED FOR STEEL PLATE TESTS.

the Bessemer process shall not be allowed to be used in the construction of marine boilers. Plates over 1 inch in thickness may be reduced to 1 inch in the straight part for testing, in cases where the testing apparatus is not of sufficient capacity to test the full thickness of plate. The reduction of area and elongation must be equal to the requirement of full thickness of metal.

"Provided, however, that where contracts for boilers for ocean-going steamers require a test of material in compliance with the British Board of Trade, British Lloyds, or Bureau Veritas rules for testing, the inspectors shall make the tests in compliance with the above rules. The samples shall also be capable of being bent to a curve of which the inner radius is not greater than one and a half times the thickness of the plates, after having been heated uniformly to a low cherry red, and quenched in water of 82 degrees Fahrenheit."

ON March 11th a boiler exploded in a steel foundry near Athus, in Southern Belgium Twelve persons were killed and many others were injured.

The boilers of the tug-boat *Virginie*, plying between Ghent and Antwerp, Holland, exploded on April 5th, between the villages of Moerseke and Baerrode, on the Scheldt. The captain escaped, but the four men composing the crew were killed. The explosion caused the sinking of a barge, and the drowning of eight persons who were aboard of it.

A very similar accident occurred on May 20th, at Bingenbruck, near Bingen-on-the-Rhine, Germany. A tug-boat boiler exploded, sinking two barges, killing eight people, and injuring many others.

The Chilian iron-clad, *Huascar*, reached Valparaiso, Chile, on April 2d, fresh from the dry-dock in Talcahuano. She had scarcely cast anchor when the main steam pipe of her engine burst, killing eight of the crew, and seriously injuring nine others.

A converter exploded on April 17th, at the plant of the American Glucose Company, Peoria, Ill. William Burns and John Hoey were instantly killed, and John Wilson, Matthew Connelly, John Dooley, and John Schultz were badly scalded. The converter was supposed to be in good condition.

The Locomotive.

HARTFORD, JUNE 15, 1896.

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

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

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

A RECENT issue of the *Railway Review* contains an interesting contribution from Mr. Charles W. Whitney, on the "Serve tube," as applied to locomotive boilers. The Serve tube, as our readers very likely know, differs from the ordinary boiler tube in having a number of ribs on its inner surface, which run lengthwise of the tube, and are supposed to increase its efficiency by providing a larger surface for heat absorption. Mr. Whitney undertakes to show that if all the 20,000 freight engines in the United States were refitted with Serve tubes, the initial outlay would be about $29,000,000, while the *annual* saving to the railroad companies would be something like $100,000,000. We do not say that he succeeds in establishing this proposition; but his letter is certainly worthy of careful perusal. We are not prepared to give an opinion concerning the Serve tube, because it is a comparatively new thing in this country. We observe, too, that even where it has been used for some time, engineers are by no means unanimous in their judgments. Some pronounce it to be an excellent thing, while others appear to feel that it is of doubtful value. Those of our readers who may wish to know something of both sides of the question will do well to consult the files of *Engineering* (London). Many letters on this subject, from engineers, have appeared in that journal during the past few months.

A CORRESPONDENT points out that in computing the heating surface of a boiler we used the *inner* surface of the tubes in our issue for September, 1884, whereas in our issue for December, 1895, we used the *outer* surface. His statement is correct. The fiercest fires of criticism could not budge him, for he stands upon a rock; and we acknowledge the keenness of his eye as cheerfully as may be. But he appears to infer, from what he has observed, that the jewel consistency does not shine within our editorial inner self, with its accustomed effulgence; and that is where we can't agree with him. We beg to assure him that the precious gem is still shining at the old stand, with all its former brilliance; but we never let it interfere with the inalienable right, that inheres in every man, to change his opinion when he thinks it is time to do so. In the eleven years that have elapsed since our first article, we have had a corresponding amount of experience; and we should be dull scholars indeed if we had not learned something from it. A college course requires but *four* years. One of the things that we learned is, that a well-designed horizontal tubular boiler, properly set and properly cared for, can evaporate considerably more than 2½ pounds of water, per square foot of *inside* tube surface, per hour; and we felt called upon, therefore, either to adopt an evaporation constant *greater* than $2\frac{1}{2}$, or (which is pretty much the same thing) to use the *outer* surface of the tubes in computing the heating surface. We adopted the latter alternative, partly because it makes the "nominal" horse-power of a boiler, as computed by the centennial rule, come nearer the *actual* horse-power. Anyhow, we plead that the rule given in our December issue agrees pretty well with the actual facts; and we conceive this to be the final test, from which there is no appeal.

Every Man His Own Inspector.

There are times when certain people can learn various things in one way, better than they can in some other way. This generalization was reached only after prolonged meditation. There may be some who cannot take it in, in its full breadth, and so perhaps we had better tell what called it forth.

It was this way: We had insured a boiler — we won't say just where it was, except that it was near the spot where the Mississippi watershed crosses the North Temperate Zone,— and after carrying it for some years, and watching it carefully, we came to the conclusion that it had outlived most of its usefulness; so we told the owners that we couldn't allow them to carry more than 70 pounds pressure on it. These gentlemen were more than mildly surprised, and thinking, doubtless, that our business interests had led us to demand the reduction, simply on the general principle that our risk would be less if they ran at a very low pressure, they intimated that they would prefer to do their own inspecting in the future, and suggested that we relieve our corporate conscience of the load that their boiler had laid upon it. We did so. The policy was canceled. Our method of inspection passed away, and the self-acting system took its place.

This wasn't so very long ago, and yet it is not likely that the new kind of inspections will be further exploited. They were interesting enough,— lively, you know, and full of fireworks, and that sort of thing,— but somehow they seemed to pall on the spectators after a time. The last one, we believe, was carried out on April 23d. It was watched (at a respectful distance) by all the workmen. According to a local paper. "The men were ordered to leave the factory, and John Channel, the engineer, began to fire up. The weight on the safety-valve was moved out so as to prevent it from blowing off. There were 90 pounds on *when the engineer took the last peep* (!) He had just decided that the boiler was all right, and told the men to return," when the head of the dome blew out, passing straight upwards into the air, and knocking a four-foot hole through the roof of the building.

"For some unknown reason," adds the paper, "the police were called." Might we suggest that somebody, in a moment of temporary aberration, had perhaps thought of handing the engineer over to them?

When we consider the widespread interest that Dr. Roentgen's discovery aroused, and the great activity in scientific circles that it produced, it is strange that further discoveries of fundamental importance have not been made. We do not yet know the nature of the "X-rays," although among competent physicists there appears to be a growing conviction that they are merely light-rays in which the vibrations are extraordinarily rapid. Nothing is yet certain about them, however, and there is still a chance for any imaginative student, who has laboratory facilities at hand, to make himself forever famous.

Explosion of a Brass Casting.

A peculiar accident, resulting in the serious wounding of two men, occurred on June 8th in the South Brooklyn Steam Engine Works, on Van Brunt and Summit streets. Among the discarded castings in the works was a brass plunger, which had been taken from the pump cylinder of a steamship. It was 2 feet long, 6″ in diameter, and $\frac{5}{8}$″ in thickness. Patrick Smith and John Higgins, old employes in the works, were assigned to the job of breaking up the old brass plunger, and preparatory to doing this they heated it red-hot, so as to make it break more readily. Higgins removed it from the oven with a pair of tongs when it had been heated almost to the melting point, and dropped it on the floor. Smith raised his big sledge hammer and brought it down on the plunger with all his force. The plunger went to pieces with a report like that of a cannon. Two of the pieces flew upward and passed through the roof of the one-story building. When the score or more of other workmen, who had fled panic-stricken from the building, returned, they found Higgins and Smith lying unconscious on the floor and badly wounded. Higgins's right leg was nearly cut off and his left leg was broken in two places, and he was otherwise severely injured. When the ambulance surgeons arrived from the Seney and Long Island College hospitals the right leg was amputated and the victim removed to the former hospital. Smith, who received a compound fracture of both legs, was taken to the Long Island Hospital, where both his legs were amputated. Both men are suffering from severe shock, and the doctors fear that Higgins will not survive. Mr. J. H. Taylor, the manager of the works, said that the brass plunger had evidently absorbed moisture, and the heating process produced a condition which caused the explosion. The men, he said, had been warned not to use their hammers until the plunger had cooled off. He was surprised that they did not take this precaution, as they had been engaged in such work for several years. Both the injured men are married and have large families. — *New York Sun.*

[There was probably a cavity in the casting, which had filled with water during the long service of the plunger on board ship; and heating the casting red-hot would transform the water into steam at an enormous pressure.]

The Sellers System of Screw Threads.

Until the "sixties," there was a considerable variety in the shapes and pitches of the screw threads that were in use by different manufacturers in the country; and in the hope of securing a more uniform practice Mr. William Sellers introduced the system that bears his name, and which we propose to briefly describe. Mr. Sellers' views were presented on April 21, 1864, in a paper that he read before the Franklin Institute, of which he was then president.

His paper began as follows: "The importance of a uniform system of screw threads and nuts is so generally acknowledged by the engineering profession, that it needs no argument to set forth its advantages; and in offering any plan for their acceptance, it remains only to demonstrate its practicability and its superiority over any of the numerous special proportions now used by the different manufacturers. In this country no organized attempt has as yet been made to establish any system, each manufacturer having adopted whatever his judgment may have dictated as the best, or as most convenient for himself; but the importance of the works now in progress, and the extent to which manufacturing has attained, admonish us that so radical a defect should be allowed to exist no longer. The importance of this subject was long ago recognized in

England, and the engineers of that country, by mutual agreement, adopted the proportions now in universal use there. Our standard of length being the same as theirs, it would seem desirable that the system which they have adopted should also be employed by us, unless grave objections can be urged against it, and a better one substituted."

Mr. Sellers then proceeded to examine the English system in detail, beginning with the number of threads per inch. He found that the English practice could be represented, approximately, by the following formula, in which d is the diameter of the screw, over all, in sixteenths of an inch:

$$\textit{Threads per inch} = \frac{16.64}{\sqrt{d+10} - 2.909}.$$

Thus if the outside diameter of the thread were $1\frac{1}{8}''$, we have $d = 18$, and $d + 10 = 28$. The square root of 28 is 5.29, and $5.29 - 2.909 = 2.381$. Dividing 16.64 by 2.38 we have

$$\textit{Threads per inch} = 16.64 \div 2.38 = 6.99,$$

the nearest convenient number to this being 7. In the same way the number of threads per inch was computed for each diameter of screw. The results given by the formula usually contained incommensurable decimals, and in such cases the nearest convenient pitch was adopted, as illustrated in the foregoing example. The standard pitches so obtained are given in the second column of Table I.

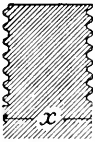
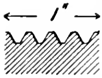
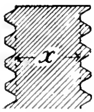
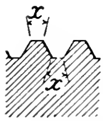
Mr. Sellers next took up the *shape* of the standard English thread, and pointed out its few advantages, and its numerous disadvantages. The angle of the English thread is 55°; and owing to the difficulty of verifying this particular angle, and of making gauges to fit it accurately, Mr. Sellers recommended that the angle of our standard thread be made 60°. To prevent injury to the top of the thread, it is customary, in England, to dress the top of the *V* into a rounded shape, for which certain standard proportions are given. The production of the rounded thread involves mechanical difficulties, however, which had led our own manufacturers to substitute a *flat* surface for the rounded one. This change was commended, and in order to secure uniformity in the various shops, it was suggested that the simple *V* thread be modified as follows: "Divide the pitch, or, which is the same thing, the side of the thread, into eight equal parts, and take off one of these parts from the top, and fill in one of them in the bottom of the thread. Then the width of the flat top and bottom will equal one-eighth of the pitch, and the wearing surface will be three-quarters of the pitch." The diameter of the screw at the root of the thread will then be given by the formula —

$$\textit{Diameter at root of thread} = \textit{outside diameter of actual thread} - \frac{1.299}{n},$$

where n is the number of threads per inch. These proportions give almost precisely the same depth of thread as is used in English practice, while they increase the actual available bearing surface by about 36 per cent. The proportions of the Sellers thread are shown in Fig. 1, where h represents the depth of the unmodified *V* thread, and f, which is the flat surface at the top and bottom, is equal to one-eighth of the pitch.

Fig. 2 is given to make the significance of the table clearer. In this cut, f is the "width of flat top and bottom," while a is the "diameter at root of thread," and the cross-section which is indicated by A is the "area at root of thread." In the tables the first column calls for a little explanation. The expression, "diameter of bolt," is used for the sake of brevity, instead of the more accurate one, "diameter of the thread over all." In some cases the shank of the bolt is larger than the outside diameter of the thread, and when it is so, care must be taken to base the calculation, not on the diameter of the *actual* bolt, but on the diameter of the smallest bolt from which the desired thread could be cut. This same caution must be exercised when using the section headed "area of bolt body in square inches"; for this column only gives the sectional area of a bolt whose diameter is equal to the *outside diameter of the thread.*

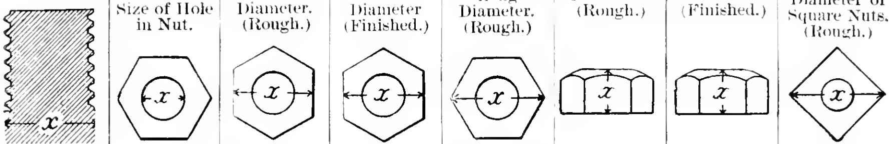
TABLE I.— SELLERS STANDARD THREADS.

Diameter of Bolt.* 	Threads per Inch. 	Diameter at Root of Thread. 	Width of Flat, Top and Bottom. 	Area of Body of Bolt in Square Inches.*	Area at Root of Thread in Square Inches.
″		″	″		
1/4	20	.185	.0062	.049	.027
5/16	18	.240	.0069	.077	.045
3/8	16	.294	.0078	.110	.068
7/16	14	.344	.0089	.150	.093
1/2	13	.400	.0096	.196	.126
9/16	12	.454	.0104	.249	.162
5/8	11	.507	.0113	.307	.202
3/4	10	.620	.0125	.442	.302
7/8	9	.731	.0139	.601	.420
1	8	.837	.0156	.785	.550
1 1/8	7	.940	.0179	.994	.694
1 1/4	7	1.065	.0179	1.227	.893
1 3/8	6	1.160	.0208	1.485	1.057
1 1/2	6	1.284	.0208	1.767	1.295
1 5/8	5 1/2	1.389	.0227	2.074	1.515
1 3/4	5	1.490	.0250	2.405	1.746
1 7/8	5	1.615	.0250	2.761	2.051
2	4 1/2	1.712	.0278	3.142	2.302
2 1/4	4 1/2	1.962	.0278	3.976	3.023
2 1/2	4	2.175	.0312	4.909	3.719
2 3/4	4	2.425	.0312	5.940	4.620
3	3 1/2	2.628	.0357	7.069	5.428
3 1/4	3 1/2	2.878	.0357	8.296	6.510
3 1/2	3 1/4	3.100	.0384	9.621	7.548
3 3/4	3	3.317	.0417	11.045	8.641
4	3	3.566	.0417	12.566	9.963
4 1/4	2 7/8	3.798	.0435	14.186	11.329
4 1/2	2 3/4	4.027	.0455	15.904	12.753
4 3/4	2 5/8	4.255	.0476	17.728	14.226
5	2 1/2	4.480	.0500	19.635	15.763
5 1/4	2 1/2	4.730	.0500	21.648	17.572
5 1/2	2 3/8	4.953	.0526	23.758	19.267
5 3/4	2 3/8	5.203	.0526	25.967	21.262
6	2 1/4	5.423	.0555	28.274	23.098

* The "diameter of the bolt" is assumed to be the same as the outside diameter of the screw.

Table II gives the dimensions of bolt-heads or nuts, as recommended by Mr. Sellers in his paper. The "size of hole in nut" is the same as the diameter of the bolt at the root of the thread, whether the nut be square or hexagonal. The thickness of both kinds of nuts, in the rough, is equal to the diameter of the bolt; and the *finished* nut is

TABLE II. — SELLERS STANDARD NUTS AND BOLT HEADS.



Diameter of Bolt.*	Size of Hole in Nut.	Hexagonal Nuts and Heads. Short Diameter. (Rough.)	Short Diameter (Finished.)	Long Diameter. (Rough.)	Thickness. (Rough.)	Thickness. (Finished.)	Long Diameter of Square Nuts. (Rough.)
″	″	″	″	″	″	″	″
1/4	.185	1/2	7/16	37/64	1/4	3/16	7/10
5/16	.240	19/32	17/32	11/16	5/16	1/4	10/12
3/8	.294	11/16	5/8	51/64	3/8	5/16	31/32
7/16	.344	25/32	23/32	9/10	7/16	3/8	1 7/64
1/2	.400	7/8	13/16	1	1/2	7/16	1 15/64
9/16	.454	31/32	29/32	1 1/8	9/16	1/2	1 3/8
5/8	.507	1 1/16	1	1 7/32	5/8	9/16	1 1/2
3/4	.620	1 1/4	1 3/16	1 7/16	3/4	11/16	1 49/64
7/8	.731	1 7/16	1 3/8	1 21/32	7/8	13/16	2 1/32
1	.837	1 5/8	1 9/16	1 7/8	1	15/16	2 19/64
1 1/8	.940	1 13/16	1 3/4	2 3/32	1 1/8	1 1/16	2 9/16
1 1/4	1.065	2	1 15/16	2 5/16	1 1/4	1 3/16	2 53/64
1 3/8	1.160	2 3/16	2 1/8	2 17/32	1 3/8	1 5/16	3 3/32
1 1/2	1.284	2 3/8	2 5/16	2 3/4	1 1/2	1 7/16	3 23/64
1 5/8	1.389	2 9/16	2 1/2	2 31/32	1 5/8	1 9/16	3 5/8
1 3/4	1.490	2 3/4	2 11/16	3 3/16	1 3/4	1 11/16	3 57/64
1 7/8	1.615	2 15/16	2 7/8	3 13/32	1 7/8	1 13/16	4 5/32
2	1.712	3 1/8	3 1/16	3 5/8	2	1 15/16	4 27/64
2 1/4	1.962	3 1/2	3 7/16	4 1/16	2 1/4	2 3/16	4 61/64
2 1/2	2.175	3 7/8	3 13/16	4 1/2	2 1/2	2 7/16	5 31/64
2 3/4	2.425	4 1/4	4 3/16	4 29/32	2 3/4	2 11/16	6
3	2.628	4 5/8	4 9/16	5 3/8	3	2 15/16	6 17/32
3 1/4	2.878	5	4 15/16	5 13/16	3 1/4	3 3/16	7 1/16
3 1/2	3.100	5 3/8	5 5/16	6 7/64	3 1/2	3 7/16	7 19/32
3 3/4	3.317	5 3/4	5 11/16	6 21/32	3 3/4	3 11/16	8 1/8
4	3.566	6 1/8	6 1/16	7 3/32	4	3 15/16	8 21/32
4 1/4	3.798	6 1/2	6 7/16	7 9/16	4 1/4	4 3/16	9 3/16
4 1/2	4.027	6 7/8	6 13/16	7 31/32	4 1/2	4 7/16	9 23/32
4 3/4	4.255	7 1/4	7 3/16	8 13/32	4 3/4	4 11/16	10 1/4
5	4.480	7 5/8	7 9/16	8 27/32	5	4 15/16	10 25/32
5 1/4	4.730	8	7 15/16	9 9/32	5 1/4	5 3/16	11 5/16
5 1/2	4.953	8 3/8	8 5/16	9 23/32	5 1/2	5 7/16	11 7/8
5 3/4	5.203	8 3/4	8 11/16	10 5/32	5 3/4	5 11/16	12 3/8
6	5.423	9 1/8	9 1/16	10 19/32	6	5 15/16	12 15/16

* See the note under Table I.

thinner by $\frac{1}{16}''$. The short diameter of a rough hexagonal or square nut is to be equal to $1\frac{1}{2}$ times the diameter of the screw, plus $\frac{1}{8}''$. The short diameter of the *finished* nut is less than this by $\frac{1}{16}''$. The long diameter of a hexagonal nut, whether rough or finished, is found by multiplying the corresponding short diameter by 1.155; and the long diameter of a square nut is similarly to be found by multiplying the corresponding

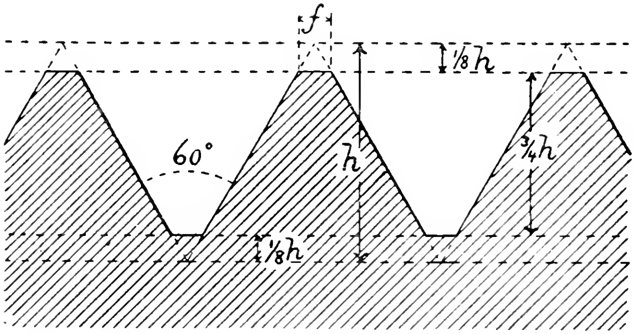


FIG. 1. — DIAGRAM OF THE SELLERS THREAD.

short diameter by 1.414. The exact results that are obtained by the application of these rules for the "long diameters," contain unwieldly decimals. Mr. Sellers gave the values of these decimals to the nearest thirty-second; but we have followed Kent, in giving them to the nearest sixty-fourth. (A few mistakes which occur in Kent's *Pocket-Book* in the last column, have here been corrected.)

In conclusion we may add that the system of screw-threads devised by Mr. Sellers and explained above was recommended and adopted by a committee of the Franklin

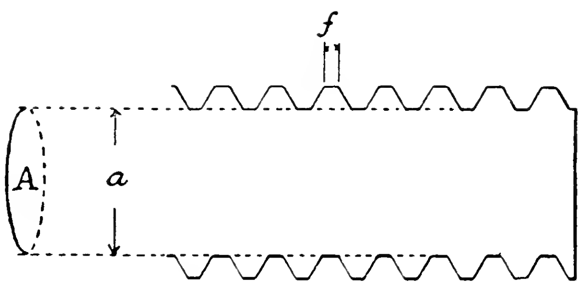


FIG. 2. — ILLUSTRATING "DIAMETER AT ROOT OF THREAD," ETC.

Institute on December 15, 1864, and by the United States Government in May, 1868. It has also been adopted by the Master Mechanics' and Master Car Builders' Associations; so that it is fairly entitled to its name of the "United States Standard System." The Sellers (or Franklin Institute) system of *bolt-heads* and *nuts*, however, has not met with such general acceptance. The United States Government decided that in its own work, the rough and finished nuts must be of the same size, so that the same wrench could be used on either; and they adopted the "rough" sizes of the foregoing table as their standards. Improved methods of manufacture have also interfered with the adoption of the Sellers' standard, because many of the "rough" nuts that are turned out to-day are as good as the "finished" nuts of 1864. The Sellers sizes for nuts and heads also require odd sizes of iron in their manufacture; and while this would not be objectionable to a firm who manufactured them on a grand scale, it is a matter of some importance to the smaller manufacturers, and has doubtless had much influence in preventing the more general adoption of the system.

The Spelling of "Muhammad."

There is much confusion, even in literary circles, about the spelling of the name of Arabia's great Prophet. The following communication, which was signed by Thomas P. Hughes and published in the *New York Sun*, ought to dispel the uncertainty, we should think :

"It is a curious circumstance that, notwithstanding the many efforts made by the compilers of dictionaries to transliterate the spelling of this name correctly, they have, up to the present time, failed. There can only be one way of transliterating an Arabic word, as every Arabic scholar knows. There are Arabian provincialisms, but they have nothing to do with the phonetic spelling of the language.

"The only correct way of spelling the word under consideration is 'Muhammad.' And I will endeavor to explain why. In the name there are four consonants, M, H, M, D, but the second M is what is called in Arabic a *tashdeed*. That is, it is duplicated. Then the consonants M and H are moved by the vowel point *Damma*, the sound of which is the English u. The H and M are moved by the vowel point *Fatha*, the sound of which is our English letter a. The M is duplicated by the *tashdeed*. The M and D are also moved by a *Fatha*. Consequently we have the consonants and the vowel points giving us the word "Muhammad." If the word were "Mohammed," as it is often spelled, then it would be spelled with the Arabic letters Meem or M and Vaw or O, the Vaw here being the consonant O and not the vowel. Of course, in the provincial Arabic of Turkey and Syria the word may be otherwise pronounced, but the only Arabic with which I am acquainted is that of Arabic scholars, and my 'Dictionary of Islam,' to which you so kindly refer, was revised and prepared for the press by the eminent Arabic scholar, Dr. F. Steingass of the University of Munich, the author of an Arabic-English dictionary of great value to scholars.

"I shall be glad if you can find room for the insertion of this letter, because the present spelling of the name of the Arabian Prophet, as we find it in our English dictionaries, is a literary curiosity. For example, if the word is spelled Mohammed, you have the *Fatha* vowel sound rendered correctly by an *a* in the first instance, and incorrectly by an *e* in the second. In writing for the press I very often use the incorrect spelling, just as Sir William Muir uses the word Mahomet in his life of the Prophet of Arabia, because it is more familiar. But I venture to maintain that there can only be one *correct* way of transliterating it."

"I thought you had a good girl, Mrs. Bloom?"

"I had."

"What became of her?"

"I told her to get up early and dust."

"Well?"

"She got up and dusted." — *Detroit Free Press.*

The Locomotive.

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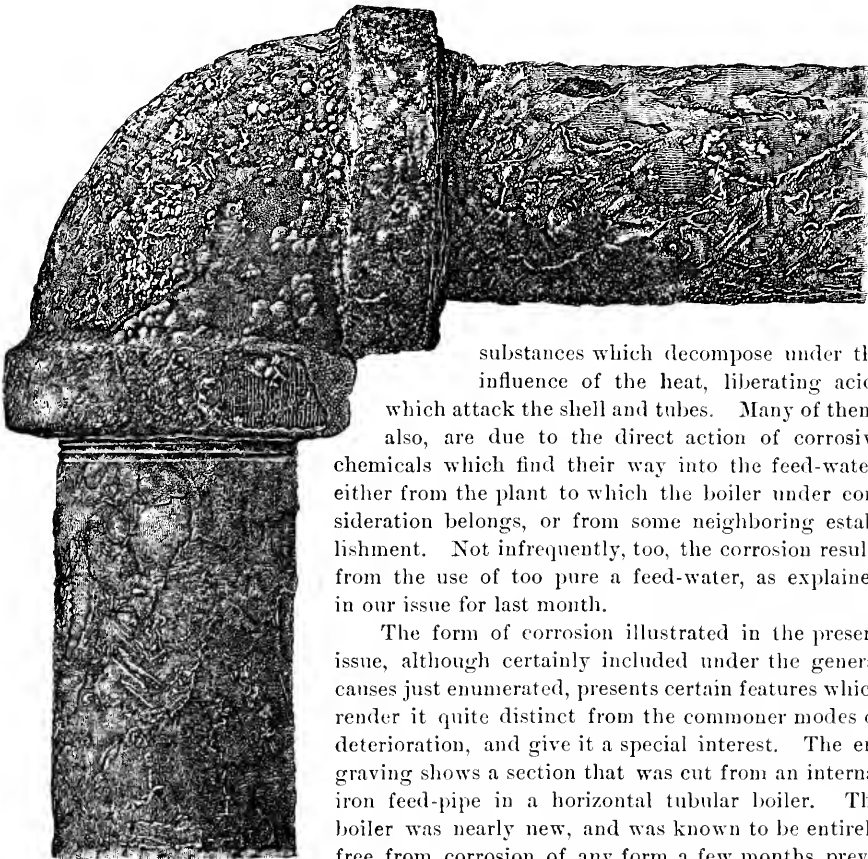
Corrosion from Dissolved Copper.

From time to time, in these pages, we have discussed and illustrated the various forms of corrosion that we find in steam boilers in our work of inspection. Many of these cases of corrosion are due to the contamination of the feed-water with organic



Iron Feed-Pipe — Corroded by Dissolved Copper.

substances which decompose under the influence of the heat, liberating acids which attack the shell and tubes. Many of them, also, are due to the direct action of corrosive chemicals which find their way into the feed-water, either from the plant to which the boiler under consideration belongs, or from some neighboring establishment. Not infrequently, too, the corrosion results from the use of too pure a feed-water, as explained in our issue for last month.

The form of corrosion illustrated in the present issue, although certainly included under the general causes just enumerated, presents certain features which render it quite distinct from the commoner modes of deterioration, and give it a special interest. The engraving shows a section that was cut from an internal iron feed-pipe in a horizontal tubular boiler. The boiler was nearly new, and was known to be entirely free from corrosion of any form a few months previous to the time of making the internal examination which disclosed the corrosion shown. The pipe entered the front head about four inches above the tubes, and extended nearly the whole length of the boiler, being entirely submerged in water. The entire steam plant is of modern construction, and is well cared for in all details. The setting walls closed in against the boiler shell at the center, cutting off the heat from the furnace at that point. The water level was about ten inches higher,— that is, it was ten inches above the center line of the boiler. The boiler under consideration had been run in connection with several others; but about two months previous to the last inspection it had been cut off from the rest of the battery, and had been used for furnishing the steam required for heating a series of large copper vacuum kettles. The water of condensation returned from the kettles by gravity, and as the leakage or waste was quite small, the boiler required very little fresh water.

Upon entering the boiler, after it had been running for two months under these conditions, the inspector observed a serious corrosion along the feed-pipe, and on that part of the shell which lay below the water line and above the fire line. The general appearance of the affected parts was much the same as in other forms of corrosion, except that the action is not usually so strongly localized. They were covered with large blisters and discolored blotches. Upon slightly burnishing the blotches or blisters, they were found to consist of metallic copper, overlying a thick deposit of iron oxide. The iron oxide was very heavy on the feed-pipe, and the pipe itself was correspondingly cut and pitted, so that it was nearly all destroyed. The action on the shell was of the same nature, but not so severe.

It is not hard to understand the general cause of this form of corrosion, although there are some points about it that could be cleared up only by an extended and careful series of experiments. The general fact seems to be, that the distilled water resulting from the condensation of steam in the vacuum kettles dissolves more or less of the copper of which these kettles are composed, and carries it in solution back to the boiler. We do not know the precise chemical *form* of the dissolved copper. Copper itself is not soluble in water, and copper oxide is so slightly soluble that it could hardly be taken up fast enough to produce the observed effects. It is possible that some kind of a *hydrate* is formed by direct union of the metal with water; but a more likely hypothesis is, that grease or oil finds its way into the kettles, somehow, the result being that a stearate or oleate of copper is formed. An organic compound of this nature might dissolve readily enough, and be returned to the boiler with the drip.

Whatever may be the form in which the copper is taken up, it is certain that *some* compound of that metal finds its way back into the boiler, so that the water in the boiler becomes a dilute solution of copper hydrate, or oleate, or stearate, or something of the sort. Now it is a well-known fact that copper, in nearly all of its compounds, is readily replaced by iron. A familiar experiment illustrating this fact consists in placing a clean iron nail in a solution containing copper, and noting that the copper is gradually deposited on the nail, an equivalent amount of iron being dissolved away, to take its place. The action in the boiler is doubtless the same. The copper held in solution is replaced by the iron of the boiler, the result being that metallic copper is deposited, and a corresponding amount of iron is dissolved away. A new boiler would be more liable to this form of corrosion than an old one, because the new one would be comparatively clean, while in an older one the shell and feed-pipe and tubes would be likely to be coated to a certain extent with a protective covering of scale or other similar matter.

An obvious method of preventing the injurious action of copper, in cases like this, is to cause the drip, as it returns from the kettles, to percolate slowly through a large mass of clean iron-turnings, from which all grease or other oily matter has been removed. The copper will then be deposited upon the iron scraps in the percolator, and the boiler will be effectively protected.

Inspectors' Report.

May, 1896.

During this month our inspectors made 7,947 inspection trips, visited 15,877 boilers, inspected 7,047 both internally and externally, and subjected 677 to hydrostatic pressure. The whole number of defects reported reached 12,641, of which 1,170 were considered dangerous; 83 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,070	49
Cases of incrustation and scale,	2,354	66
Cases of internal grooving,	124	21
Cases of internal corrosion,	777	30
Cases of external corrosion,	810	50
Broken and loose braces and stays,	159	64
Settings defective,	426	36
Furnaces out of shape,	477	25
Fractured plates,	350	65
Burned plates,	288	30
Blistered plates,	223	8
Cases of defective riveting,	1,049	30
Defective heads,	164	26
Serious leakage around tube ends,	2,312	366
Serious leakage at seams,	539	50
Defective water gauges,	368	74
Defective blow-offs,	187	50
Cases of deficiency of water,	19	16
Safety-valves overloaded,	74	33
Safety-valves defective in construction,	145	45
Pressure gauges defective,	607	33
Boilers without pressure gauges,	2	2
Unclassified defects,	117	1
Total,	12,641	1,170

A large driving belt has just been completed by the Chicago Belting Company, of Chicago, for the engine-room of the Louisiana Electric Light Company, of New Orleans. It is 150 feet in length, 7 feet wide, $\frac{7}{8}$-inch thick, and weighs 3,300 pounds. Selected portions of 450 oak-tanned hides, specially chosen from some 5,000 skins, were employed in its construction. There is not a stitch or a rivet in it from one end to the other, the hides being pasted together with boiling glue and then subjected to a hydraulic pressure of about 220 tons. The belt is to run from a 28-foot driving wheel, and will be capable of transmitting about 3,000 horse power.— *Practical Engineer.*

The Charleston, S. C., Board of Underwriters, at its regular monthly meeting on June 16th, presented a loving cup to Mr. William S. Hastie, general agent of the Hartford Steam Boiler Inspection and Insurance Company, who then retired from office as president of the board, after six years of service in that capacity. President Johnson made the formal presentation address, and Mr. Hastie replied with a short but felicitous speech.

Boiler Explosions.

APRIL, 1896.

(91.)— On April 1st two boilers exploded at the works of the Planters' Cotton Seed and Crushing Association, Greenville, Miss. Edgar Humphreys, Horace Wilkinson, Isam Freeman, John Henry Williams, Edward Strasack, and Harry Calhoun were killed, and Columbus Washington was fatally injured. Frank Wolfenden, Thomas Brown, W. E. B. Freeman, Alexander Hughes, and Freeman Pendleton were also severely injured. The boiler and engine rooms were demolished, and a considerable part of the main building was wrecked. The loss was about $12,000. The plant was one of the most complete of its kind in the South. It was destroyed by fire last summer, but was rebuilt and ready for work in the fall.

(92.)— A boiler belonging to Frederick Groves exploded, on April 1st, at Eleanor, near Milford, Ohio. Ernest Martin and W. R. Fitzwater were instantly killed, and Frederick Groves was fatally injured. Hiram Fitzwater and Aquilla Fitzwater also received severe injuries. The boiler and engine were completely wrecked, only a hole in the ground showing where they formerly stood. The mill was also totally destroyed.

(93.)—A boiler exploded, on April 1st, at the Etna Coal Company's mines at Whiteside, near Chattanooga, Tenn. Joseph Anderson was instantly killed and Robert Alexander was fearfully scalded about the head, face, and body. The building in which the boiler stood was entirely demolished. We have seen no estimate of the property loss.

(94.)— On April 2d a boiler exploded in Eastland Bros.' mill at Lloyd, near Richland Center, Wis. Charles Eastland and William Keith were killed, and Leon Eastland, Alfred Minard, and Fred Minard were severely injured. The mill was destroyed.

(95.)— The Pennsylvania tug *Delaware*, with a laden carfloat in tow, blew out a sheet of her boiler, on April 3d, while towing her charge from Williamsburg to the company's docks in Jersey City, N. J. The disabled tug and her tow drifted helplessly, and were in danger of being carried on Governor's Island, when two other tugs of the Pennsylvania Company came to their assistance. No one was hurt by the explosion.

(96.)— A boiler exploded with terrific force, on April 3d, at one of the Forest Oil Company's wells, on the David Thornburg farm, in Robinson Township, five miles from Pittsburgh, Pa. W. S. Thomas, a tool dresser, was badly cut and scalded, and died from his injuries shortly afterwards. John B. Beck was also seriously injured, but will recover. Scarcely a square foot of the boiler could be found after the explosion. The engine house was torn to atoms, and the "bull wheel" was thrown a considerable distance over a hill.

(97.)— On April 6th a boiler exploded in a wood-working mill belonging to Messrs. Watson Brothers, of Ridgetown, Ont., a few minutes after the works had been started for the day. The mill was completely wrecked, together with the machinery it contained, some of which was thrown several blocks away. Daniel Leitch and William Cunningham were killed, their bodies being found in the ruins. Jonathan T. Buller was also fatally injured, so that he died next day. William Watson and Thomas Shea were seriously injured, and it is almost certain that one of them will die. Three other men were also injured to a lesser extent. The explosion has destroyed Ridgetown's most important industry and thrown a large number of men out of work. We understand that the exploded boiler was considered to be in good order and that it appears to have been well cared for. The property loss will amount to some thousands of dollars.

(98.)—A boiler exploded, on April 6th, at the Murphy Varnish Works, on Twenty-second street, Chicago, Ill. John Laaten, Jr., was killed, and his father, John Laaten, Sr., was badly burned. The damage to the factory was about $1,000.

(99.)—A boiler in the W. P. Orr Linseed Oil Company's mill, at Piqua, Ohio, exploded April 5th. Although the explosion was extremely violent, nobody was killed. Samuel Jones, John Whitby, and George Fine were slightly injured. The entire east wing of the four-story building was completely wrecked, and the machinery (with the exception of the heavy presses) was likewise ruined. Two railroad bridges on the south side of the plant were destroyed, and a part of R. Slauson & Son's grain elevator was torn away. A freight car was blown into a canal, and the walls of the building that were left standing were damaged so badly that it is likely that they will have to be taken down. The property loss is variously estimated at from $50,000 to $70,000.

(100.)—A boiler exploded, on April 8th, in Dennis Boyd's mill, at North Mountain, near Newville, Pa. John Boyd was instantly killed, and George Oyler died in a few minutes. Four other persons were injured, three of them quite seriously. The mill was destroyed. The engine was blown into such small fragments that two men could lift the largest of them. Very few parts of the boiler can be found.

(101.)—A new boiler, recently put in at the Hudson Coal Company's new shaft at Deerfield, near Alliance, Ohio, exploded with terrible force on April 13th, wrecking the engine room and boiler-house. The engineer and fireman were about fifty feet away at the time, and escaped injury. The loss was about $3,000, and the mine, which employs fifty men, was forced to remain idle for a considerable time.

(102.)—One of the boilers in George B. Breen's saw-mill, on Queen's Run, near Williamsport, Pa., exploded on April 16th. The explosion occurred one hour after the fires had been banked for the night, and the only person about the place was night watchman C. L. Reeder, who fortunately escaped injury. The boiler was blown into pieces, but the mill was not badly wrecked. The loss is about $1,200.

(103.)—On April 17th, a big boiler, used for converting starch into glucose, exploded in the American Glucose Company's works, at Peoria, Ill. Steam could not be shut off from the converter, and fully an hour elapsed from the time the fires were drawn in the boiler house, before the converter room could be entered. William Burns and John Hoey were killed, and Burns's body was blown through a window to the ground. John Dooley, Matthew Connelly, and John Wilson were seriously scalded. The converter was made of copper, and was originally three-eighths of an inch thick. According to the Peoria *Journal*, Coroner Hoefer had a piece of the metal cut out for examination, and found that it had wasted away, under the corrosive action of the starch, until it was reduced to one-third of the original thickness.

(104.)—A small boiler exploded, on April 18th, in Lewis Schreder's machine shop, on North Fourth street, Philadelphia, Pa. Mr. Schreder was severely scalded about the feet and ankles.

(105.)—A small boiler, used in the manufacture of ice-cream in J. H. Stockton's restaurant at Lambertville, N. J., exploded with a terrific report on April 20th. Mr. Stockton and his assistant, having just left the neighborhood of the boiler, escaped injury. The machinery was blown to pieces, the boiler passing entirely through the building. The sides of the building were blown out. The explosion was heard all over the town, and many persons took it to be a heavy blast in the quarries.

(106.) — Fireman John Elliott was scalded to death, on April 21st, by the explosion of a boiler in the Jefferson Iron Works, at Steubenville, Ohio.

(107.) — A boiler exploded, on April 23d, in Hess, Crotty & Williams' factory, at Ottawa, Ill. The explosion consisted in the blowing out of the head of the dome. The dome head passed upward through the roof, making an opening some four feet square. Nobody was injured.

(108.) — A boiler exploded in Noah Mumpher's saw-mill, three miles from Lewiston, Pa., on April 23d, demolishing the mill. B. Evans was seriously hurt about the side and arms, and another man, whose name we did not learn, received injuries about the feet and legs.

(109.) — On April 23d a boiler exploded in Adam Hirsch's furniture factory, at Winchester, Ind. Nobody was near the boiler at the time. The damage was small.

(110.) — A boiler exploded, on April 25th, in Ellis Stockwell's big saw-mill, at Greene, near Warren, Ohio. Mr. Stockwell and Charles Manes received serious injuries, and Stockwell may not recover. Charles Wolcott and George Fink were also injured. The mill was reduced to a pile of ruins.

(111.) — On April 25th a boiler exploded at Flynnton, Cambria county, Pa. Frank Gates, Demetrius McGough, and Henry Burgoon, were killed, and Isaiah Gates was painfully injured. The building in which the boiler stood was completely wrecked, so that nothing remains of it but a few blackened ruins.

(112.) — On April 25th a boiler exploded in a rice mill at Oberlin, La. The miller (an elderly man named Schufelt) was terribly burned about the face, neck, and arms, and will probably die. The engineer and a boy were also injured, in a lesser degree.

(113.) — A boiler exploded at Grapevine, Texas, on April 30th. A little boy was blown sixty feet, but was not seriously injured.

Prof. Joule's Method of Testing Boilers.

We note, in the first volume of *The Scientific Papers of James Prescott Joule*, on page 480, a paper on the testing of boilers, which is short enough, and remarkable enough, to be reproduced in this place.

"In the course of my experiments on steam," he says, "I had to employ pressures which I did not consider absolutely safe unless the boiler was previously tested. The means I adopted being simple, inexpensive, and efficacious, may, I think, be recommended for general adoption. My plan is as follows: — The boiler is to be first entirely filled with water, care being taken to close all passages leading therefrom. A brisk fire must then be made under it, and after the water has been moderately heated, say to 90° Fahr., the safety-valve must be loaded to the pressure up to which the boiler is intended to be tried. Bourdon's circular gauge, or other pressure-indicator, is then to be constantly observed; and if the pressure arising from the expansion of the water goes on increasing continuously, without sudden decrease or stoppage, until the testing pressure is attained, it may be inferred that the boiler has sustained it without having suffered strain.

"In testing my own boiler," he continues, "the pressure ran up from zero to sixty-two pounds on the inch in five minutes. It rose more rapidly at the commencement than towards the termination of the trial, owing to leakage, which was considerable, and of course increased with the pressure. But as there was no sudden alteration or discontinuity in the rise of pressure, it was evident that no permanent alteration of figure or incipient rupture had taken place.

"In the so-called testing by steam-pressure it is impossible to be sure that a boiler has not thereby suffered strain, and there is therefore no guarantee that it will not burst if subsequently worked at the same or even a somewhat lower pressure. It is to be hoped that this practice, objectionable on account of its uselessness as well as its danger, will be immediately abandoned. In the ordinary hydraulic test the water is introduced discontinuously, and therefore the pressure increases by successive additions, rendering it difficult to be sure that strain is not taking place. This system also requires the use of a special apparatus. The plan I recommend is free from the objections that belong to the others; and the facility with which it may be employed will probably induce owners to subject their boilers to those periodical tests the necessity for which fatal experience has so abundantly demonstrated."

In a word, Professor Joule's proposition is, to obtain the pressure required for the test, by making use of the expansion that water undergoes when heated. If his plan is carried out precisely as he intended it to be, it might not be particularly dangerous. It will be observed that he says that the boiler is to be *entirely filled*, so that no air space is left; and his evident intention is, to obtain the desired pressure, not by the formation of steam, but by the direct expansion of the water itself, as already noted. In one of the two experiments whose results he appends to the paper here quoted, it appears that the safety-valve was closed when the temperature of the water in the boiler was 97° Fahr. In 19 minutes the temperature of the water had risen to 126° Fahr., the water meanwhile expanding so that the observed pressure at the end of the test was 63 pounds per square inch. It is easy to see that the boiler had enlarged somewhat, from the combined application of the heat and pressure; because a simple calculation shows that when water is heated from 97° to 126°, it increases in volume (unless prevented from doing so by pressure) by about $\frac{1}{150}$th of its own volume. We do not know the size of Professor Joule's boiler, but we shall assume, for the sake of illustration, that it contained only 150 cubic feet of water, when entirely filled. Raising the temperature from 97° to 126° would therefore tend to cause the water to expand by about one cubic foot. To prevent this expansion a pressure of about 2,900 pounds per square inch would have to be applied; and as the pressure actually observed by Professor Joule was only 63 pounds, we infer that the boiler yielded by a notable amount. The theory underlying the method is, that if there had been any structural weakness in the boiler, there would have been a *sudden* fall of pressure at some point; and since there was no such sudden change, we are supposed to infer that the boiler was safe at 63 pounds pressure.

We cannot admit the soundness of this conclusion, for although the boiler may have yielded gradually enough up to the 63 pound limit, we cannot see how it follows that it was not *on the point* of rupturing,— or, at least, of being somewhere strained beyond its elastic limit. We therefore cannot give our approval to this method of testing, and we should not have dwelt upon it at such length, had it not proceeded from so eminent an authority. The man whose famous "772" has been in all our text-books for years, is entitled to a respectful hearing, even if we do not agree with him. But the chief reason why we object to this method of testing is, that it is liable to lead to disastrous results. For although Joule was doubtless careful to fill his own boiler so that it was indeed perfectly *full*, we are much afraid that in the ordinary run of tests, the man in charge might grow a little careless at times, and perhaps neglect to see that all the connections were filled with water, as well as the boiler itself. If this precaution were neglected, and a little air were allowed to remain in the boiler — trapped, perhaps, in the main steam pipe, or in the upper part of the boiler itself if it were not perfectly level — the force of the expanding water would not make itself felt, and the pressure gauge would not reach the desired point until the boiler was under steam. We feel that this danger is a real one, and we believe that it has only to be pointed out, to be generally admitted. A test by direct steam pressure certainly would not be countenanced by any competent engineer. It is too much like the famous way of testing fungi by eating them — if they kill you, they were toadstools; and if they don't, they were mushrooms. Of course we know quite well that the formation of steam may be detected by opening a try-cock, or by using a thermometer; but the man who is carrying out Joule's method isn't going to open the try-cocks, because that would interfere with the regular increase in the pressure, which is the central idea of the test. Joule himself used a thermometer, and the two tests that he quotes were completed at 126° Fahr. and 139° Fahr., respectively — both of these temperatures being far below the boiling point. The same plan might be followed by others; but it could not be put into practice without a special form of thermometer, adapted to this particular kind of work, and attached to the boiler in a proper manner. This appears to us to involve as much "special apparatus" as the ordinary hydrostatic test, which calls for but little except a force-pump and a length of stout hose.

Last Winter's Heat in Australia.

Of course our readers all know that it is summer in Australia, when it is winter here; and yet it was a little odd, about New Year's time, to read in the papers of the fearful spell of hot weather that was then prostrating the inhabitants of that distant region by hundreds. The *New York Tribune* recently gave some particulars of the weather that prevailed in Australia at that time. "An accurate record of Fahrenheit readings observed in the shade on a veranda overlooking the Darling River, in New South Wales in January last," it says, "is as follows: On New Year's Day, 112°; on January 2d, 107°; then steadily rising to 123° on January 7th; falling to 114° on the 10th, only to rise to 124° on the 11th; and then, with some fluctuations as low as 117°, but not lower, the thermometer registered 128° on the 15th and 16th, and 129° on the 18th. Such temperatures in the shade seem incredible, and yet the record is true. From January 1st to January 19th, the range of heat (in the shade) was from 107° (the lowest point) up to 129°. What it was in the sun, one hesitates to think. At Adelaide, on January 23d, the mercury registered, in the sun, the appalling height of 172° (within 40° of the boiling-point!) Nor was there any appreciable relief from the heat at night. For the first three weeks of January the mercury did not fall below 100° at any time in the twenty-four hours, and in many places 105° was the lowest point recorded. . . . Whatever the cause of this hot wave may have been, its results are scarcely to be described. People died by thousands. Birds dropped dead from the trees. Rabbits and other animals, though hidden in the shadiest recesses of the forests, perished wholesale. Those that survived were dazed and stupefied, so that the wildest and shyest could be anywhere approached and picked up. Even insect life succumbed, and perhaps the most impressive record of all was that furnished from a place called Nyngan, to the effect that 'mosquitoes are being killed by the heat.' And all this, it must be remembered, was in a so-called temperate zone, in latitute 30° to 35° south, corresponding in situation with South Carolina and Georgia. Surely, in the face of such a record, when the mercury is only in the nineties we may keep cool and take courage."

Ants Used by Surgeons.

In the Levant the Greek surgeons find the ant a valuable aid in their operations, and almost universally employ the busy little creatures. The ant they use is a big, strong fellow, much larger and stronger than the ants we are accustomed to seeing here. They have particularly large and strong mandibles, which make them of value to the surgeons, who use them in holding together the sides of an incised wound.

The Levantine surgeon never goes out to attend an ordinary case without having a few ants tucked away snugly in some safe place about his person. He produces his knife and his ants at the same time, and the patient regards the knife with horror and the ants with satisfaction. Having made the cut, the surgeon next selects an ant from his collection. These ants are vicious fellows and are fierce fighters among their kind. For that reason the surgeon handles them with a pair of forceps. When the forceps close over the ant he begins to struggle at once.

As he fights with his mandibles they are thrown wide open. The ant will close them on the first object with which he comes in contact. With his disengaged hand the surgeon draws the edges of the wound together. When they have been properly arranged he places the ant near the cut. The ant, eager for fight, is ready to seize anything. The surgeon holds it down close to the edges of the wound and the powerful mandibles grip it on either side.

The surgeon holds the ant thus for a couple of minutes, while the insect, having at last found something upon which to vent his anger, gets a firmer grip. When it has secured a good, strong hold it gives up its life for science, because the surgeon very promptly cuts off its head. When the head of the ant is removed the mandibles do not relax the grip they secured in the edges of the wound before death. Wounds so treated heal rapidly and without any further difficulty to either patient or surgeon. — *Chicago Chronicle.*

We have received a copy of *Textile Calculations*, a work written and published by Mr. E. A. Posselt, editor of the *Textile Record.* It is intended, as its title page states, as "a guide to calculations relating to the construction of all kinds of yarns and fabrics." It is divided into four general sections, the first of which is devoted to "Yarn and Cloth Calculations." Here we find rules given for nearly every kind of calculation that can come up, together with a large number of illustrative examples, worked out in full. The second section considers the "Structure of Textile Fabrics," and here also the treatment is both full and lucid. The third section of the book treats of the analysis of yarns and fabrics, and gives numerous tests, both microscopic and chemical, for the recognition of the various substances that are likely to occur in them. The remaining portion of the volume contains various rules concerning gears, belts, and other matters relating to the generation and transmission of power, and concludes with a somewhat extensive section on arithmetic, in which the principles of that science are explained. We are inclined to question the utility of the last 30 pages of the book; for if the reader is not familiar with the ordinary rules of arithmetic, he had better study them by the aid of a text-book devoted solely to that subject. The earlier parts of Mr. Posselt's volume, however, appear to be replete with information that should prove serviceable to all who have to deal with the vexing numerical problems about yarns and fabrics, that are coming up all the time in textile manufactories. (E. A. Posselt, publisher, 2152 N. Twenty-first Street, Philadelphia.)

The Locomotive.

HARTFORD, JULY 15, 1896.

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

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

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

"ENGINEERS all over the country," says *The Digest of Physical Tests,* "will be interested in learning of the discovery of a new method of conducting tests when the strength of the specimen to be tested exceeds the capacity of an available machine." This most remarkable method, it appears, "was recently evolved by a nineteenth-century engineer and inspector in the employ of one of the prominent English steamship insurance companies, who, having occasion to test the tensile strength of a 1¾-inch chain cable, when the largest available testing machine would only pull 1½ inch diameter, first broke a one-inch chain and then a three-quarter-inch chain, added the results together, and handed in his report!"

WE can heartily commend Mr. Oberlin Smith's delightful book entitled *Press-Working of Metals.* It is the outcome of many years of experience in this kind of work, and it ought to be warmly welcomed by every person who has to do with the shaping of metals by dies or presses. Cut, pressed, stamped, and drawn articles, as Mr. Smith says in his preface, "are found in all departments of our modern civilized life. often forming integral parts even of the cradle and the coffin — not to speak of the wedding ring between;" and hence the importance of a book like this, which seeks to impart information that the author has often had to coax from Dame Nature by the far rougher process of guess and trial. The book contains 276 pages and over 400 illustrations. and is written in a charming style. (John Wiley & Sons, 53 East Tenth St., New York. Cloth, $3.00.)

THE late Shah of Persia made the eighteenth sovereign, or head of a nation, assassinated during the present century. The Emperor Paul of Russia, in 1801, was murdered by palace conspirators; Sultan Selim was assassinated in 1808; Capo D'Istria. President of the Provisional Government of the Hellenes, was dispatched by a blow from a yataghan at Nauplia in 1831; the Duke of Parma was assassinated in 1854, and the President of Hayti in 1859; the assassination of President Lincoln occurred in 1865: the shooting and killing of Colonel Balta, President of Peru, happened seven years later; Moreno, President of Ecuador, was likewise killed in the same year, and his successor, Guthirez, in 1873; Abdul Aziz was killed with scissors in a warm bath in 1874; President Garfield was shot in 1880; Alexander II of Russia was blown up in 1881, and President Carnot was recently stabbed at Lyons. The last before the Shah was the Queen of Korea. — *The Independent.*

How Not to Steam Crabs.

The fact that high-pressure steam, if dry, may be allowed to blow against the hand without any serious consequences, has long been known. We have seen the fact exemplified a great many times. We do not know who first discovered it, but it was certainly known as long ago as 1850, since it is explicitly mentioned in a letter that was written by William Thomson to Mr. Joule, at that time. (The letter in question will be found in the *Philosophical Magazine* for November, 1850.)

A correspondent has sent us an amusing experience that illustrates this peculiarity of steam. "About thirty years ago," he says, "just after the war, I was carrying a small steamer from Troy, N. Y., to Savannah, and owing to stress of weather I was obliged to go through the 'inside passage' from Charleston to Savannah. When about half way through, the boat was left aground by the receding tide, and we were obliged to wait for it to return. The bayou had numerous holes in it, which were filled with a mixture of water and crabs, — the crabs predominating. An idea struck me, and I took a landing net and filled a bucket with the little creatures in three or four minutes. I hung this bucket under one of the gauge cocks on the boiler, and opened the cock so that the steam should blow down into it. I had expectations of a fine dinner ; but upon returning in about twenty minutes to find out if the crabs were cooked, I was amazed to find them as lively as ever. There was 80 pounds pressure on the boiler at the time, and I could not make out, until years afterwards, why those crabs were not boiled."

Lord Kelvin's Jubilee.

Lord Kelvin (better known, to many of us, by his old name, "Sir William Thomson,") is a unique figure in the scientific world, in many ways. Possessing great abilities, he would certainly make his mark in any age; but as it happened, he had the good fortune to come to maturity at a time when several great discoveries, especially in connection with heat and electricity, were already in the air. Of prime importance among these discoveries was the great law of nature known as the "conservation of energy," which had long been known in its narrower, mechanical applications, but which was not known to be applicable to *all* the phenomena of nature until the advent of Mayer, Colding, and Joule, in the first half of the present century. The law itself, indeed, originated in other minds; but Kelvin did much to place it upon a firm foundation. His fertile mind appreciated the tremendous importance of the new doctrine, and he applied it, with great ingenuity, to a host of problems, discovering new facts at every turn. The science of electricity is also deeply indebted to him. When it first engaged his attention, it was in its infancy. He has grown up with it, laboring earnestly and continuously, and with much success, to realize the possibilities that it offers; and in the practical applications of this science to our daily wants, his touch is to be felt at every turn.

Lord Kelvin has now been a professor at the University of Glasgow for fifty years; and a celebration, lasting through several days, has just been held, at that place, in his honor. Something of the importance of his life and work may be gathered from the following editorial which we take from *Engineering:*

"It is given to but few men to celebrate the fiftieth year of the occupancy of one professorial chair, and Lord Kelvin's jubilee is probably unique in respect that he is but 72 years of age, and has, so far as evidence goes, many years still to add to the long 'record of persevering endeavor to see below the surface of matter.' This early attainment of a jubilee is only one result of that hereditary genius which enabled him to start his university career with his elder brother James, when he was but 10 years and five months old, under his father, who was noted specially for his power of exciting in his students his own enthusiasm for mathematics. At the age of 17 Thomson went to Cambridge, where, while he engaged in all the sports, he graduated B.A. at 21, being second wrangler, but Smith prizeman. A year was spent in Paris on experimental work with Biot and Regnault, and then, in 1846, he returned to Glasgow as Professor of Natural Philosophy. At 22 he attained this high position on his merits, for his father wrote that from the electors he wished no pledge or promise in his favor. Thus it comes that a professional jubilee comes to be celebrated, while yet Lord Kelvin is full of vigor.

"Of the work that has been crowded into these 50 years it were idle to write in detail. Lord Kelvin was peculiarly endowed, for while he had that excellent mathematical training which was not possessed by Faraday, he had larger gifts in the direction of experimental work than Clerk-Maxwell: and it were difficult to closely apportion the influence of these advantages in the fulfilment of his many services to science. We recall his contributions, as a youth, to the *Cambridge and Dublin Mathematical Journal* (which he edited) on Fourier, and on heat and electricity: also his meeting with Joule, with its immense results, and his strong recommendation to Clerk-Maxwell to master Faraday's *Experimental Researches on Electricity*, with the supremely important consequences resulting: but the man in the street does not appreciate such far-reaching studies on thermodynamics and electricity so highly as he does the immediately practical results which flowed therefrom. Every one can appreciate the services rendered in the laying of the first Atlantic cable, together with the invention of the mirror galvanometer, and, subsequently, of the syphon recorder: and it was appropriate that cablegrams should come this week from every corner of the globe, from the United States, India, Africa, even from Bulawayo and the Antipodes, with congratulations to Lord Kelvin.

"It is only characteristic, too, of his association of recreation with science, that when enjoying the leisure of vacation with his large yacht, the *Lalla Rookh*, he invented the form of compass now universally used, and also a method of taking deep sea soundings without the ship easing in speed. Amongst other nautical instruments of his invention we must mention the tide gauge, the tide predicter, and the harmonic analyzer. His many papers on these subjects have also greatly helped others. But it is in electrical instruments that Sir William Thomson (to give him his best known title) found his widest field for energy — balances, voltmeters, ammeters, watt-meters, and many others, — and the notable fact is, that although some of these have been in use many years, they are still among the most perfect obtainable; a testimony at once to the great skill and foresight involved in their original design. To Lord Kelvin's practical treatises before scientific and technical societies it is not necessary to refer; it were easy to quote a few titles sufficient in abstruseness to stagger any reader, and to abundantly prove great skill and ingenuity in their composition.

"Glasgow is naturally proud in having retained for so long the services of such a distinguished *savant*, and that feeling is reciprocated: — he said, at one of the many functions in connection with the jubilee, that since 1832, when he came to Glasgow, he had enjoyed the primary essential of happiness, living amongst encouraging friends, and he referred to the liberality with which the beautiful university was endowed with all that a scientist could wish. But peculiarly enough, Lord Kelvin only this week got his first degree from the Glasgow University — that of Doctor of Law and Logic, — although nearly every other university of note, here and abroad, has long since delighted to honor him. The week, however, has been full of honors. Congratulations have been made personally or otherwise by many scientific and technical organizations, and from many individuals who take an interest in scientific research, from the Queen and the Prince of Wales downwards. The corporation have held a dinner in his honor, the university a reception with an exhibition of his productions and medals, to which the Arago medal of the Institute of France has just been added, and altogether the Jubilee celebration has partaken of such an international character that Her Majesty, in offering sincere congratulations and hope for many years of health and prosperity for Lord and Lady Kelvin, gives expression to the views of her people in saying that she is 'particularly gratified at the presence of so many eminent representatives from all countries of the world,' who had come to do honor to Glasgow's distinguished guest. Lord Kelvin himself, with characteristic felicity of speech, called them comrade day-laborers in science."

Strange as it may appear, Lord Kelvin is by no means satisfied with the successes he has achieved. He has had high ideals constantly before him, and he feels a touch of disappointment that in the half century of his activity, he has not learned more about the real nature of electricity and matter. In the course of a speech that he made in reply to the congratulations offered him at the jubilee, he used these melancholy words: "One word characterizes the most strenuous of the efforts for advancement of science that I have made perseveringly through fifty-five years. *That word is failure.* I know no more of electric and magnetic force, nor of the relations between ether, electricity, and ponderable matter, nor of chemical affinity, than I knew and tried to teach my students of natural philosophy fifty years ago, in my first session as professor." The New York *Sun*, in commenting on this passage, says that "Lord Kelvin is not the first great man to whom his own work, highly as it was esteemed by others, has been insufficient to content himself. His self-depreciation recalls the well-known saying of Sir Isaac Newton: 'I do not know what I may appear to the world; but to myself I seem to have been only a boy playing on the seashore and diverting myself in finding now and then a smoother pebble or a prettier shell than ordinary, whilst the great ocean of truth lay all undiscovered before me.' Indeed, no man with lofty ideals ever attains them to his own satisfaction, and it may comfort less eminent laborers in the field of human effort, who are despondent at their apparent want of success, to reflect that the greatest of their fellow laborers have been oppressed by the same sense of failure."

Fitting Out an Ocean Steamship.

A recent issue of the New York *Sun* contains an interesting article on this subject. The article is too long to be reproduced entire, but we take the following facts from it:

The task of fitting out a vessel like the *St. Louis* or *St. Paul* is enormous. No less than 100,000 articles must be purchased and put in place. It takes months of study in prices, and texture of wares. Elaborate schedules of the articles needed for each department of the ship are prepared, and then a lot of shopping and correspondence follow. Like the furnishing of a house or a hotel, there are two ways of going about it. One is to set aside a certain sum and strike a certain average of quality and quantity of articles purchased, so as to bring the cost of the fittings within the sum set aside. The other is to decide what is needed and of what quality, and to purchase the supplies as reasonably as possible. It is this plan practically which must be adopted by a steamship company. For not only must the fittings be suited in quality and quantity to the size and character of the vessel, but they must be as good as the fittings of any other vessel of a corresponding size afloat, and if possible better.

Here are some of the articles and the quantity required in a general way for such a ship as one of the new American liners. For the first cabin alone there must be 3,000 spoons, 2,000 forks, 1,000 napkin rings, 3,000 knives, 500 finger bowls, 300 salt-cellars, 2,000 tumblers, 1,000 cups and 1,000 saucers, 6,000 plates of various kinds, 12,000 napkins. In the outfit of the staterooms there will be required at least 2,000 blankets, 1,000 counterpanes, 500 mattresses, 800 pillows, 7,000 sheets, 1,000 bath towels, 10,000 other towels. It will surprise many to know that about 35,000 yards of carpet are necessary to fit out the ship. When one considers that the second cabin requires from one-half to two-thirds as many articles as the first cabin, and that in these days there is very little difference in the quality of the articles used in the two cabins, one can see the addition there must be to cost and quantity in the furnishing of the second cabin.

But the supplies do not stop with the cabins.

The kitchen and pantry supplies and fittings are more elaborate than any hotel requires. The list of implements required in these departments contains hundreds of items. Every variety of cooking utensil is supplied. Every kind of household article of known utility is purchased. In addition to all these every ship contains two kinds of supplies that no hotel ever has. One of these kinds is the outfit for a hospital, and the other is the outfit for an apothecary shop. The list of surgical instruments alone occupies several pages of the outfitting schedule of a ship. The same is true as regards the apothecary outfit.

A ship like one of the new liners frequently carries 1,500 persons across the ocean. There is probably no hotel in the world that frequently has any such number of guests for a week at a time. Almost every article that can be imagined to be of use in a hotel or private house is included in the list of supplies. The list ranges from beer mallets to pianos, from cheese scoops to "paste jiggers," from dish-washing machines to dice boxes, from dark lanterns to costly stationery, and from a printing-press to a fireproof safe.

When it comes to food and drink the ingenuity of the port steward of the line and the steward of the ship is exercised. It is customary on all ocean steamships for the steward to keep an accurate account of all articles used from day to day. When a ship reaches port the steward has a report in tabular form showing the amount and kinds of food used every day, and also showing how much there is in store. A day or two before the ship leaves port again the number of passengers that will probably sail on the ship is figured up and the ship's steward makes requisition on the port steward for supplies for the trip. Few persons realize the variety of the food supplies required. For example, no less than fifteen kinds of cheese are used. Fish in fully a hundred grades and forms is stowed away. In the list of fruits, dried, fresh, and canned, there are at least 125 varieties. The same is true of vegetables.

Here is part of what is required in the way of supplies when a ship like the *St. Louis* is crowded: — 25,000 to 30,000 pounds of beef, 5,000 pounds of mutton, 2,600 pounds of veal, pork, and corned beef; 8,000 pounds of sausage, tripe, liver, calves' head, calves' feet, sweetbreads, and kidneys; 2,000 pounds of fresh fish, 10,000 clams and oysters, 250 tins of preserved fruit, 200 tins of jam and marmalade, 100 large bottles of pickles and sauces, 500 pounds of coffee, 250 pounds of tea, 250 pounds of potted fish, 300 fresh lobsters, 3,000 pounds of moist sugar, 600 pounds of lump sugar, 500 quarts of ice cream, 3,000 pounds of butter of various grades, 16 tons of potatoes, 5 tons of other vegetables, 15,000 eggs, 1,000 chickens and ducks, and 2,000 birds of different kinds. Lard by the ton is used, and frequently as many as 140 barrels of flour are consumed.

Several years ago there was published the record of the amount of food consumed on the entire Cunard fleet for one year. The record is probably as large, but not much larger, at the present time. In one year it was shown that the passengers on the Cunard boats consumed these items of food: 4,656 sheep, 1,800 lambs, 2,474 oxen, the total being equivalent to more than two million pounds of fresh meat. There were also used 53 tons of ham, 20 tons of bacon, 25,000 chickens, 4,500 ducks, 2,000 turkeys, and 2,000 geese. The number of eggs used in one year on the fleet was nearly 850,000. The supply of tea amounted to 21,000 pounds. The amount of coffee used was nearly 72,000 pounds. The pounds of sugar consumed reached nearly 300,000. In the matter of spices the figures reached 30,000 pounds of mustard and 35,000 pounds of pepper. There were also used more than 7,000 bottles of pickles, 8,000 tins of sardines, 30,000 pounds of salt fish, 4,000 jars of jam, and 15,000 tins of marmalade. The consumption of raisins, currants, and figs amounted to about 22 tons. In the consumption of pearl barley 15 tons were used, and other figures follow: split peas, 18 tons; rice, 17 tons; oatmeal, 34 tons; flour, 460 tons; salt, 33 tons. There were also used nearly 50,000 loaves of bread, 15 tons of cheese, and 930 tons of potatoes. The consumption of wines and other liquors aggregated: Champagne, 16,000 quarts; claret, 16,000 quarts; other wines, 9,000 quarts; mineral waters, 175,000 quarts; ale and porter, 240,000 quarts. Nearly 35,000 pounds of tobacco were used, and 64,000 cigars were sold to passengers.

Miscellaneous Accidents Due to Steam.

In the issue of the *Scientific American* for June 27th there is an illustrated account of the explosion of a locomotive boiler, which occurred on April 8th, at Barranco, Peru, on the Lima & Chorrillos Railway. The explosion took place as the train was leaving the Barranco station, the initial fracture being apparently longitudinal. The entire shell, forward of the fire-box, was torn loose, and the locomotive was left standing on the track with the front head still united to the fire-box by the tubes. Although the accident occurred in one of the streets of the town, only two or three persons were injured. The fireman and engineer escaped with a few scalds. The shock of the explosion was felt three miles away.

On May 1st the bonnet blew off of a steam chest in the basement of the new fifteen-story Lord's Court building, at William street and Exchange place, New York city. Thirty or forty men were at work about the place at the time, but all escaped without injury except James Smith, a telegraph lineman, who was severely scalded about the head, arms, and back.

During the official trial of the new French ironclad, *Jauréguiberry*, at Toulon, France, on June 10th, one of her boilers exploded. Nine men were injured.

The French admiralty officials, who have been examining the scene of the wreck of the *Drummond Castle*, near Brest, France, have concluded that she was broken up by the explosion of her boilers, after she began to founder. M. Bertillon, who devised the system of identifying persons by measurement, which is known by his name and is in use by the French army and police, has been sent by the government to measure the dead for the purpose of identification.

The Locomotive.

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Man-Hole Frames.

It is universally admitted, we believe, that every boiler that is large enough to admit a man should be provided with at least one man-hole. In boilers that are too small to be entered, the man-hole is not so useful; but in these cases it should be replaced by a number of hand-holes, judiciously placed, through which the interior of the boiler may be examined, and scale-matter and other deposits removed.

A man-hole is not intended for ornament, but for use; and hence it should be convenient of access, and large enough to admit a man of ordinary size. Too often we find boilers set in such a way that the roof or floor above them comes so close to the

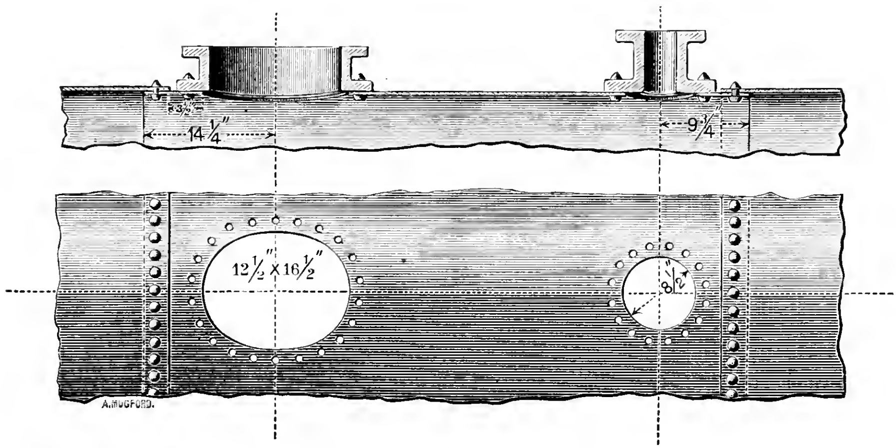

Fig. 1. — Faulty Location of a Man-hole.

setting that the inspector has to crawl a considerable distance, flat on his face, before he can reach the man-hole; and when he *has* reached it, the difficulty has perhaps only just begun, for it is by no means easy to get into a man-hole in such close quarters. There seems to be no excuse for construction of this kind. If it is really necessary to economize space to such an extent, a trap door should be cut through the floor over the man-hole, so that access to the interior of the boiler may be as easy as possible. We speak feelingly about the inspector, because we have frequently seen the difficulty from his point of view. He is not the only one to be considered, however, for it stands to reason that your own engineer, unless he is a gymnast or a contortionist, will not open up your boiler and clean it out any oftener than he has to, if you handicap him so. Even when the space above the boiler is ample, it is not uncommon to find the main steam-pipe, or a stop-valve, or some other device, right over the man-hole and only a few inches above it, when it might just as well be somewhere else. The thoughtful owner, who wants his boiler properly cared for, will see to it that the man-hole can be conveniently reached, and that it is of comfortable size — not smaller than 11″ × 15″.

Although it is important to have a man-hole *convenient*, it is much more important to have it *safe*. A large hole in the shell of a boiler is certain to be a source of weakness, unless it is properly re-enforced, and the man-hole of a boiler should therefore receive the most careful attention.

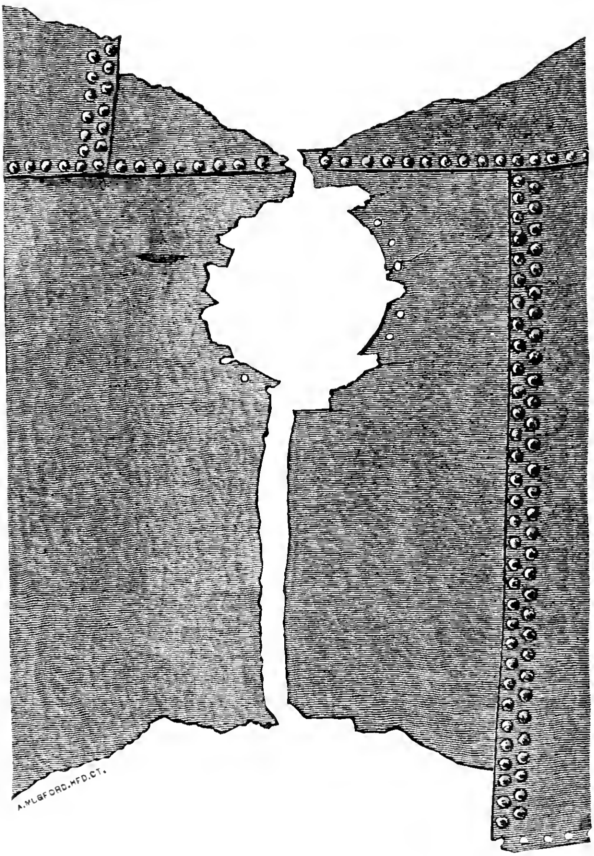

FIG. 2.— THE INITIAL RUPTURE THROUGH THE MAN-HOLE.

In the first place, we should remember that the strain on a boiler-shell is not the same in all directions. It is twice as great, girthwise, as it is lengthwise. That is why we give the longitudinal joints two or more rows of rivets, while the girth joints have but one. The boiler being more likely to fracture lengthwise than in any other direction, it is important that we should not cut away the metal of the shell in that direction any more than we have to, in making the man-hole opening.* In other words, the *length* of the man-hole ought not to lie in the direction of the length of the boiler, but ought to run *girthwise*. A man-hole placed in this way also has the minor advantage of being easier to get into.

Fig. 1 shows a badly arranged man-hole opening. Its length was lengthwise of the boiler, as shown; and the result was, that the shell was cut away along the line of its greatest weakness, 4″ more than it would have been if the hole had been turned the other way. The engraving serves to illustrate several other errors in design that should be avoided. The man-hole, as will be seen, was placed close to one of the girth joints. This is bad practice. The man-hole should come in the middle of the sheet. Another point to be noted is that an $8\frac{1}{2}$″ opening was cut through this same sheet, for the steam-nozzle. It is a serious mistake to place the

* The relative strengths of a boiler shell, lengthwise and girthwise, were discussed in THE LOCOMOTIVE for November, 1891. See also the issue for February, 1892.

man-hole and steam-opening too near each other. They should come on different courses, so that no single course may be unduly weakened. The importance of this consideration will be evident, from the fact that in the case here given, no less than thirty-seven per cent. of the length of the sheet was cut away ; and while the castings that were riveted aronnd the openings were supposed to possess sufficient rigidity to make up for this loss of section in the plate, yet the strains resulting from such a disposition of the openings are not easily calculated, and it is evident that the failure of one or two rivets, either from imperfect workmanship or from undue stress, would alter the character of these strains materially, and might lead to serious results. The boiler from which this example was taken exploded with disastrous effect, killing over twenty persons, and causing an enormous property loss ; and while we do not say that the explosion was primarily caused by this particular arrangement of the man-hole and steam openings, it is significant that the initial line of rupture did pass through the centers of both of these openings, as shown in Fig. 2.

It being admitted that the man-hole should be in the middle of the sheet, and that its length should run girthwise of the boiler, we proceed to consider the various types of frames that are used to strengthen the shell around the edge of the opening. We strongly recommend the use of wrought-iron or steel for these frames, under all circumstances ; and we *insist* upon it where high pressures are used. Cast-iron is a notoriously uncertain material, especially when exposed to *tension*. It may do well enough, if sound, for pressures of 75 pounds or less, but we are uncompromisingly opposed to its use in boilers carrying pressures of 100 pounds or so, and our specifications for such boilers require the man-hole frame to be forged or pressed up, from wrought-iron or steel. With these facts clearly in mind, let us pass to the consideration of those types of cast-iron frame which may be used on low pressure boilers. We shall return, afterwards, to the wrought-iron frame.

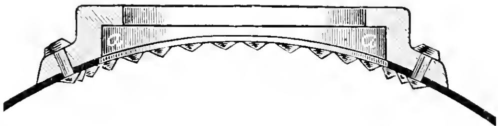

Fig. 3. — An "Outside Frame."

The form of cast-iron frame shown in Fig. 1 is very objectionable from many points of view. The cover to this frame consists simply in a flat (or ribbed) plate, which is bolted down to the upper flange. Every part of this construction is under tension, and the steam pressure tends to blow the cover off its seat, instead of pressing it more firmly against the gasket, as it should. Little or nothing can be said in favor of frames of this kind, and they ought not to be used.

The various styles of frame that are used may all be divided into two general classes, which are respectively known as the "outside" and "inside" types, according as they lie without or within the general contour of the shell. The frame already examined (Fig. 1) is of the outside type. A much better form of outside frame is that shown in Fig. 3. In this type the cover rests against the rabbet *a a*, the joint being made steam-tight by means of the usual rubber gasket. It will be noted that the pressure, in Fig. 3, tends to keep the joint tight, by forcing the cover more firmly against the gasket. The joint may therefore be said to remain tight *automatically*, and the bolt that secures the cover in place has very little strain

Fig. 4. — An "Inside Frame."

upon it when the boiler is under steam. (In the faulty form shown in Fig. 1, the entire pressure against the cover comes on the bolts that secure the cover to the upper flange.) The frame shown in Fig. 3, although far superior to that shown in Fig. 1, has certain disadvantages, however. For example, its weakest section is at the highest point of the shell; and it is at this very point that the tensile strain on the frame (due to the loss of material in the shell, where the opening has been cut,) is greatest. Again, the form of the frame is such that it is not easy to get a good even surface on the under side of the rabbet *a a*, for the gasket to bear against. Other objections could be urged, but it will not be necessary to consider them, since the expense of making the surface true along *a a* is an argument sufficiently potent with most boiler-makers to induce them to adopt a form of frame that is not only better, but easier to make.

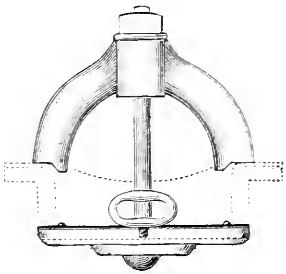

FIG. 5. — USUAL METHOD OF SECURING THE COVER PLATE.

This better form, which is illustrated in Fig. 4, is known as the "inside frame," because it lies wholly within the boiler. The seat, *c c*, against which the cover rests, can be planed true without the least difficulty. The sheet can be readily caulked along the edges indicated by the dotted lines; and the cross-section of the frame is greatest directly under the highest point of the shell, which is a most important advantage, because it is there that the frame is exposed to the greatest tensile strain, as already noted. The internal type of frame has been used and recommended by the Hartford Steam Boiler Inspection and Insurance Company for many years, and has given universal satisfaction. When the boiler is very small, so that the space above the tubes is more or less cramped, the internal frame is sometimes objectionable; but in all other cases it is decidedly superior to any other form.

Fig. 5 shows the usual method of securing the cover against the frame, by means of a yoke and bolt.

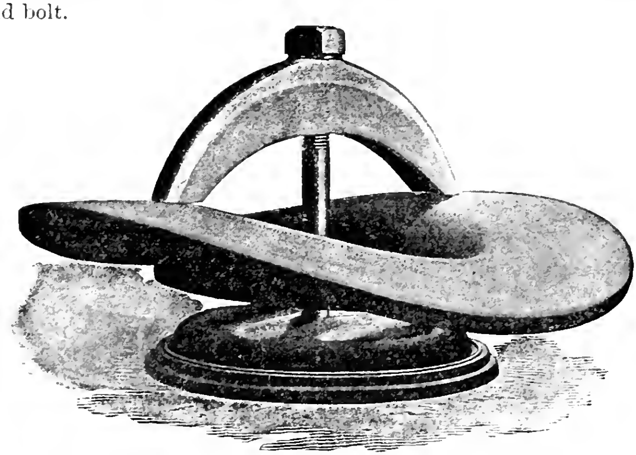

FIG. 6. — A MODERN FRAME OF WROUGHT IRON OR STEEL.

Thus far we have referred only to *cast* frames. Wrought frames may of course be made in the same way, but the expense of forging up frames of the forms described above has prevented the general use of wrought-iron for this purpose. Very good wrought-iron and steel frames, of the form shown in Fig. 6, can now be procured, however, at reasonable cost. These frames are made of $\frac{3}{4}''$ material, and are pressed into shape by special machinery. The cover plate is made in the same way, and has deep corrugations to give it the necessary stiffness. The bolt head does not pass through the cover, but is held by means of two of the corrugations, which are formed for the purpose somewhat as indicated in Fig. 7. The yoke is also pressed into shape from a piece of plate, and the whole device is secured to the boiler as shown in Fig. 7. This style of frame possesses all the good features of the form shown in Fig. 4, and has the added advantage of being made of a more reliable material. Lead gaskets are almost always used with this type of frame.

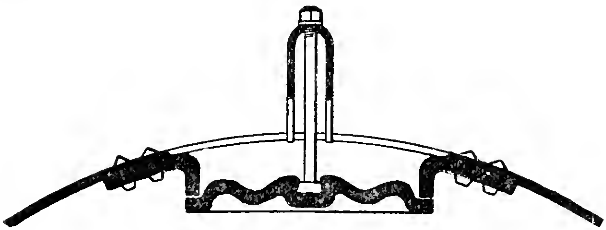

Fig. 7. — Section through the Frame shown in Fig. 6.

Whatever style of frame is used, it is important that its curvature should conform to the curve of the shell plates, where the two are riveted together. If this is not carefully attended to, the distribution of the strains, when the boiler is under steam, will be abnormal, and fractured rivets, or more serious results, will very likely follow.

Inspectors' Report.

June, 1896.

During this month our inspectors made 8,366 inspection trips, visited 15,840 boilers, inspected 7,200 both internally and externally, and subjected 795 to hydrostatic pressure. The whole number of defects reported reached 13,079, of which 1,105 were considered dangerous; 50 boilers were regarded unsafe for further use. Our usual summary is given below :

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,114	91
Cases of incrustation and scale,	2,124	83
Cases of internal grooving,	119	19
Cases of internal corrosion,	947	60
Cases of external corrosion,	778	49
Broken and loose braces and stays,	235	100
Settings defective,	403	37
Furnaces out of shape,	496	22
Fractured plates,	287	60
Burned plates,	278	30
Blistered plates,	283	13
Cases of defective riveting,	1,478	79
Defective heads,	171	44

Nature of Defects.	Whole Number.	Dangerous.
Serious leakage around tube ends,	2,203	222
Serious leakage at seams,	422	12
Defective water gauges,	391	47
Defective blow-offs,	213	46
Cases of deficiency of water,	12	6
Safety-valves overloaded,	89	18
Safety-valves defective in construction,	83	18
Pressure gauges defective,	675	45
Boilers without pressure gauges,	4	4
Unclassified defects,	274	0
Total,	13,079	1,105

Boiler Explosions.

May, 1896.

(114.) — Newman Segal's bath establishment on Pitt street, New York city, was badly wrecked by a boiler explosion on the morning of May 4th. The baths were empty at the time, and nobody was injured, but the macadamized floor of the place was torn up, and a great deal of glass was broken in the neighborhood.

(115.) — A boiler exploded, on May 8th, in a furniture factory owned by Conrey, Biroly & Co., of Shelbyville, Ind. Engineer John Delekamp was fatally scalded.

(116.) — The tow-boat *Harry Brown* was wrecked by the explosion of its boilers on May 10th, about 25 miles below Vicksburg, Miss. It was entirely destroyed, and sank in five minutes. Norman Dravo, G. W. Bardsley, William Dougherty, Annie Hess, Thomas Judge, William Wilson, William Fitzsimmons, Patrick Carniff, and William Kelly were killed outright. Frank Adrian and John Wagner could not be found, and at last accounts it was believed that they also perished. Captain John Kime, William Grimme, John Hardy, Dennis J. Lomey, and two deck hands whose names we have not learned, were seriously injured. Lomey cannot recover. The *Harry Brown* was one of the most powerful coal tow-boats on the Mississippi river. It was 210 feet long, 49 feet beam, and six feet deep in the hold. It had just gone down from Louisville with an immense coal-tow for plantations along the Louisiana coast, and was returning with empties. The property loss was about $50,000.

(117.) — A boiler, used for drilling an oil well, exploded on May 10th, on the Priest farm, near Corning, Ohio. S. E. Young was instantly killed, and John Moran was injured so seriously that it is doubtful if he can recover.

(118.) — On May 11th a boiler exploded in Edward J. Badgley's carpenter shop at Bellville, Ill. Mr. Badgley was fearfully scalded, but it is thought that he may recover.

(119.) — A boiler exploded, on May 12th, in the electric light plant at Easton, Pa. South Easton and Phillipsburg were left in darkness as a result, and half of the cars of the Easton Transit Company were stopped. We have not learned further particulars.

(120.) — An agricultural boiler exploded, on May 14th, in Manor Township, near Lancaster, Pa. Nathaniel Kauffman, who was in charge of the boiler at the time, was fearfully injured, so that he died about three hours later.

(121.) — A boiler exploded, on May 16th, in J. Shute & Sons' brickyard, at Monroe, N. C. George Bizzell and Henry White were instantly killed, and Ann Houston was injured so badly that she died next day.

(122.) — On May 16th a boiler exploded in the Strawsburg Lumber Company's mill at Hoffman, a small station on the Raleigh & Augusta Railroad, 79 miles from Raleigh, N. C. Robert McLaughlin and James Core were instantly killed. Herbert Williams was fatally injured, and died two days later.

(123.) — Rynders Bros.' grain elevator at Waverly, near Jacksonville, Ill., was destroyed by a boiler explosion on May 18th. Prentice Talkington, the engineer, was instantly killed. Some of the other workmen also received bruises.

(124). — A boiler explosion occurred, on May 19th, in the boiler-house of No. 6 Colliery of the Susquehanna Coal Company, at Nanticoke, near Wilkesbarre, Pa. Fireman Dennis Boyle was painfully scalded, but will recover. A breaker boy was also slightly injured by a flying brick. Boyle's escape from death was marvelously narrow. The explosion occurred while he was looking into the furnace. The front end of the boiler passed over him within a foot of his head, and went through a stone wall and lodged against the P. R. R. tracks beyond. The other end of the boiler passed through the end of the building, knocked down a tall stack outside, and demolished one side of the boiler-house.

(125.) — On May 20th a boiler exploded in Davidson Bros.' mill, at Marietta, Ind. Eunice Davidson, Thomas Davidson, and Frank Batram were fatally scalded and otherwise injured, and six other persons received serious injuries from which they are expected to recover.

(126.) — Eugene Morris and Sylvester Adams were killed, on May 20th, by the explosion of a boiler on Rocky Fork Creek, near Bluefield, W. Va. Several other men were seriously injured.

(127.) — On May 21st a boiler exploded in Moore's tile mill at Tipton, Ohio. Alexander Moore and his son, George Moore, were killed, and Frank Sunday, George Waldron, and Mrs. Riley Fay were injured. The mill was completely wrecked.

(128.) — A boiler exploded, on May 23d, in a saw-mill owned by Mr. Penn Sharp, at Augusta, Iowa. Benjamin Mayer, the fireman, was blown through a wall, and was supposed to be fatally injured, but late advices indicate that he is doing fairly well, and may recover. Mr. Sharp, the owner of the mill, was seriously cut about the head and face, but his injuries are not dangerous. One side of the mill was demolished, and the rest of the building was badly damaged. The boiler was carrying only forty pounds of steam at the time of the explosion.

(129.) — A flue failed, on May 23d, on the steamer *Rhoda Stewart*, when off Presque Isle, near Alpena, Mich. Second Engineer Henry Kesten, and Fireman Robert McNorton were killed, and Court Schrader received fatal injuries.

(130.) — On May 26th a locomotive boiler exploded in the shops of the Kickapoo Valley & Northern railroad, at Wauzeka, Wis., wrecking two other locomotives, and killing Steven E. Le Tellier, an expert machinist.

(131.) — A boiler exploded, on May 26th, in Stallings' mill, nine miles northeast of Shepherdsville, Ky. The mill was wrecked, and George Grant, the fireman was killed

(132.) — During the fearful tornado that visited St. Louis, Mo., on May 27th, the steamer *J. J. Odell* of the Illinois River packet line was blown against the second pier of the Eads bridge with such violence that she sank. Her boilers blew up before she disappeared. She had three passengers and a crew of twelve men besides her captain. Six of her crew succeeded in saving their lives. The remaining ten persons who were aboard perished.

(133.) — On May 27th a boiler exploded in S. H. Scudder's mill, near Clay City, Ill. Engineer Frank Evans was instantly killed, his body being blown across the Little Wabash river and buried in the opposite bank. S. H. Scudder, Otis Scudder, William Evans, John Wilson, and William Wilson were badly injured. The mill was completely wrecked.

(134.) — A boiler exploded, on May 27th, in the Atlantic Iron & Steel Company's rolling mill, at Greenville, Pa. Louis Rees, Bryan Nicholson, and two other persons, were badly scalded. A party of young women who were sight-seeing in the mill at the time were badly frightened, but escaped injury.

(135.) — The boiler of locomotive No. 142, on the Rio Grande Western railroad, exploded on May 27th, some 20 miles west of Green River, near Grand Junction, Colo. Matthew Campbell, conductor, and Henry Saulsbury, brakeman, were killed, and Engineer Konold and Fireman Thomas Rader were seriously injured.

(136.) — A boiler exploded, on May 30th, in the Jordan Lumber Company's new planing mill, at Mobile, Ala. Henry Williams and Minerva Williams were fatally injured, and Anna Young, Robert Anderson, Joseph Williams, John Crumpton, Peter Hogan, and Estelle Hogan were seriously injured. The boiler-house was demolished.

(137.) — On May 31st a boiler exploded at puddling furnace No. 16, in the Reeves Iron Company's rolling mills, at Canal Dover, Ohio. Augustus Berndt was fatally scalded, and John Loyd received painful injuries. The machinery in the building was wrecked, and the roof was blown off.

Why Men Need Change of Air.

It is notorious that men and women, of the Caucasian stock at all events, need change of air, but about the reason why they need it there is no agreement of opinion. A new theory upon the subject is advanced by Dr. Louis Robinson in the *National Review*. From the assumption, which in itself is plausible enough, that the original progenitors of the Indo-Germanic peoples were nomads or wanderers, is drawn the inference that an occasional removal from place to place is craved by a deep-seated hereditary instinct.

There is no doubt about the fact that a change of air is beneficial not only when the change is from bad to good, but from bad to bad of another kind. A resident in Rome, for instance, will often find his health improved by removal from the finest quarter of the city to the Ghetto, where, malodorous as the district is, the Roman fever seldom penetrates. Dr. Robinson cites the case of an English sufferer from asthma and bronchitis, whose home was in a healthy part of the suburban county, Surrey, but who obtained very great relief from a sojourn among the slums of Seven Dials. Many other examples might be given to show that mere change, irrespectively of the qualities of the atmospheres exchanged, gives a fillip to the system and increases its recuperative power. Equally established by experience is the effect of frequent removal from place to place on captured animals which are nomadic in their wild state. It has been observed in England that the wild beasts in traveling menageries, notwithstanding the rough and cramped accommodations to which they are condemned, are more healthy and live longer than those which have the advantage of scientific care in the Zoological Gardens. Especially significant is the fact that almost the first elephants to breed in captivity were those in Barnum's traveling show. There could be no stronger evidence that the circumstances under which these animals lived were more conducive to their general health than those amid which elephants are kept in Regent's Park, or even in the Government establishments in India. It is likewise alleged that race horses are more likely to become "stale" or to deteriorate in condition when they are kept on one track than when they travel about to different race meetings. On all these data Dr. Louis Robinson bases his explanation of the hygienic results of a change of place in the case of human beings. He points out that the epoch during which our progenitors were savage hunters, with no fixed abode, was so incalculably longer than the most extended estimate of historic time that it is impossible to ignore the influence of such a state of things on the constitution of Caucasian man as we find it to-day. That the primitive inhabitant of Europe was a wanderer on the face of the earth, like the red men of this continent, who got a precarious existence by hunting, is abundantly proved. With the change of the seasons, or as game became scarce in the neighborhood of his cave dwelling, he was compelled to migrate from place to place in search of a bare subsistence. That such habits, prevalent through so long a period, would be likely to leave a lasting impress on every cell and fibre of the human frame is pronounced more than probable. Moreover, if these were the prevailing conditions of environment during the manufacture of the human constitution, it would seem reasonable to infer *a priori* that somewhat similar conditions would be favorable to the smooth working of the physical machinery in modern times. It is certain that if a race of nomads, to whom vagrant habits have become a second nature, are compelled to remain permanently in one spot, evil consequences ensue, and these are especially likely to show themselves when the general vitality has been lowered by disease. Is it not a fair deduction that a renewal of the conditions to which the constitution of man originally was adapted would contribute to the recovery of a normal state of health?

Such is Dr. Robinson's attempt to account on theoretical grounds for the instinctive desire, periodically experienced, for a change of scene and air, and for the beneficial results which are found in practice to follow a gratification of the instinct. — *New York Sun.*

Now that people are discovering that there are men of high skill and intelligence in certain lines who cannot make a figure in an examination on the three R's, the following extracts from advertisements that a Puget Sound doctor prints, on a private press, are not without interest: "Legs and arms sawed off while you wate, without pane. No odds asked in measles, hooping coff or mumps: tumors a specialty. bunions, corns and ingrowing tow nails treated scientifically: cramps and worms nailed on sight: moles and cross-eye cured in one treatment or no pay. P. S. Terms — Cash invariably in advance. No cure, no pay. — P. S. (Take notis.) No coroner never yet sot on the remanes of my customers and enny one hiring me doan't have to be good layin' up money to buy a gravessone. Come won, come awl."

This man is said to be doing a good business, and his patients are full of his praises, saying that he cures thoroughly and quickly. — *Independent.*

The Locomotive.

HARTFORD, AUGUST 15, 1896.

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

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Heat Engines and Carbon Batteries.

The triumph of the steam engine over all other generators of motive power is one of the most marked revolutions of the century. Many other motors have been tried, and we frequently read in our daily papers, of wonderful inventions that are destined to overturn all of our industries, and relegate the steam engine to the scrap heap. The hot-air engine, for example, promised very well; but it has not fulfilled its promise, and although it is often quite serviceable where a small amount of power is needed, it has never been in any sense a rival of steam. Motors using the vapors of ammonia, ether, carbon disulphide, and other volatile substances, have fared even worse; and thermo electric batteries, pyromagnetic generators, and other such devices, have never been found to be of any practical use. In spite of the discouraging failures of these various contrivances, inventors are still busy at the problem. Its solution, we think, is bound to come. Man seldom invents a thing that cannot be replaced by something better; and it would be strange indeed if the steam engine proved to be the last product of inventive genius — a device to be improved, indeed, but not to be supplanted.

The trouble with most of the inventors who are seeking for a better motive power is, that they do not know the fundamental laws that underlie the heat-engine. These laws are only two in number, but one of them, unfortunately, cannot be fully understood without a considerable knowledge of mathematics. The first law governing the action of heat-engines — known as the "first law of thermodynamics" — is the familar one which declares that heat and mechanical energy are mutually convertible, 780 foot-pounds of work (or thereabouts) being equivalent to one unit of heat. This law is readily grasped, and is universally understood and admitted by engineers. The *second* law of thermodynamics is even simpler, for it merely states that heat always tends to pass from a hot body to a cold one, and never from a cold body to a hot one; but although it is indeed simple, its full consequences are by no means easy to trace out.

The "first law" has received a considerable amount of attention from writers on popular science, and was very clearly examined and discussed in Tyndall's book on *Heat Considered as a Mode of Motion.* The "second law," however, has never been treated in the same way, so far as we are aware; and we are by no means sure that it could be so treated. Rankine pointed out the lack of popular information of this kind nearly thirty years ago. "The science of thermodynamics," he said, "is based on two laws, the first of which states the fact of the mutual convertibility of heat and mechanical energy, while the second shows to what extent the mutual conversion of those two forms of energy takes place under given circumstances. In the course of the last few years the first law has been completely 'popularized'; it has been amply explained in books and lectures, composed in a clear and captivating style, and illustrated by examples at once familiar and interesting, so as to make it easily understood by those who do not make science a professional pursuit. The *second* law, on the other hand, although it is not less important than the first, and although it has been recognized as a scientific principle for nearly as long a time, has been much neglected by the authors of popular (as distinguished from elementary) works; and the consequence is that most of those who depend altogether on such works for their scientific information remain in ignorance, not only of the second law, but of the fact that there *is* a second law; and knowing the first law only, imagine that they know the whole principles of thermodynamics."*

The "second law" which, in its simplest form, merely states that heat always tends to pass from a hotter body to a colder one, is far-reaching in its consequences. It was first proposed, as a broad and universal principle of nature, by Clausius; and although numerous distinguished mathematicians and physicists have questioned its validity from time to time,† it is now recognized as a great, universal truth, applicable without exception to all classes of phenomena. It is obvious enough in its simpler manifestations: every housewife knows that to make the kettle boil, she must put it on the stove, and not in the refrigerator. In less familiar cases, however, its truth is not always so obvious, and that is why it did not at first receive the general acceptance that has since been accorded to it.

We cannot undertake to trace out the results of the "second law" in this place. One of its important consequences, however, is that no engine could utilize *all* the heat that it takes in, even if it were absolutely perfect in workmanship, and entirely free from friction, radiation, and other similar losses incident to all actual engines. There is a limit to the performance of every kind of heat-engine, which cannot be exceeded, however perfect its construction may be. In the case of a condensing steam-engine, in which the drip from the condenser is returned to the boiler again, the greatest possible efficiency is expressed by the fraction

$$\frac{T - t}{T + 460^\circ},$$

where T is the temperature of the boiler and t is the temperature of the condenser, both being expressed on the Fahrenheit scale. For example, let us suppose such an engine is using steam at 115 lbs., and that the back-pressure in the condenser is 2.9 lbs. The temperatures corresponding to these pressures are $T = 347^\circ$ and $t = 140^\circ$, respectively; and hence the greatest possible efficiency of such an engine is

$$\frac{347^\circ - 140^\circ}{347^\circ + 460^\circ} = \frac{207^\circ}{807^\circ} = .256,$$

or 25.6 per cent. That is, we can build the engine as finely as we please, guarding against every conceivable kind of loss, and yet, so long as we run it under these conditions, it will never utilize more than 25.6 per cent. of the heat supplied by the boiler; nor could we realize more than this, by using any other vapor in the place of steam.

A similar limitation is set by nature on every imaginable form of motor, which transforms heat-energy into mechanical energy. The thermo-electric battery, for

* *The Engineer* (London), for June 28, 1867; *Miscellaneous Scientific Papers*, page 432.

† For an account of the objections urged against the second law by Hirn, Wand, Tait, and others, see Clausius' *Mechanical Theory of Heat* (Browne's translation), chapter XIII.

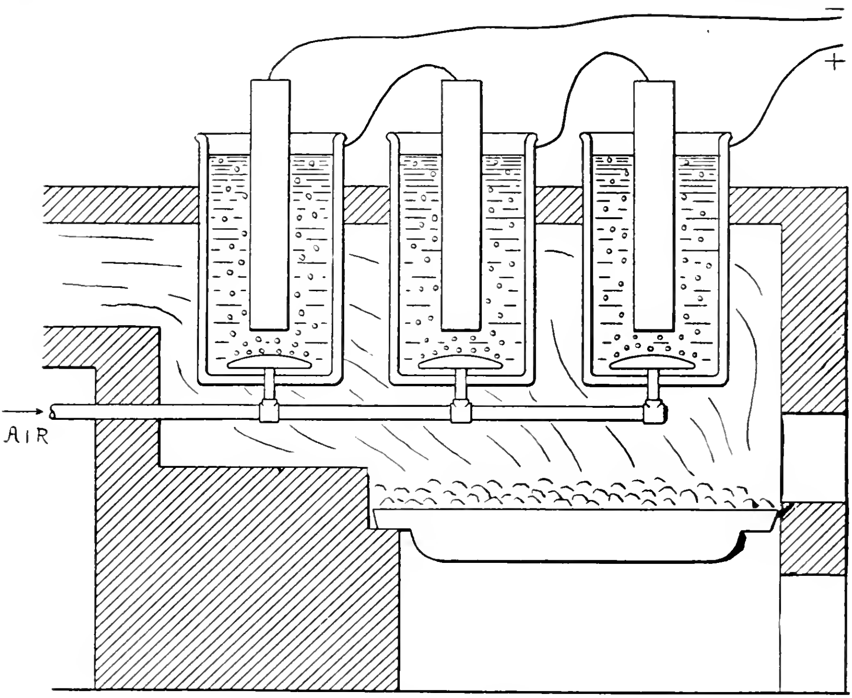
example, is subject to just the same law as the condensing steam-engine. The thermo-electric battery, in its best known form, consists of a series of bars of bismuth and antimony, soldered together at their alternate ends, so as to form an electrical circuit. Every other junction (*i. e.* the first, third, fifth, seventh, etc.,) are heated, and the remaining ones (*i. e.* the second, fourth, sixth, etc.,) are cooled. Under these circumstances a part of the heat that is supplied to the hot junctions is transformed into electrical energy, and an electric current is obtained. This, in turn, may be used to operate an electric motor, and so, by a kind of roundabout process, we have heat-energy transformed into mechanical energy. If T represents the temperature of the hot junctions, and t that of the cold ones, the greatest possible efficiency of the apparatus (when considered as a heat motor) is given by the formula quoted above, just as in the case of the condensing steam engine. The efficiency may indeed be far *less* than the formula indicates, but it cannot, under any circumstances, be greater, no matter whether the thermo-electric arrangement is constructed of bismuth and antimony, as assumed above, or of any other substances. Inventors have spent a great deal of time and labor upon the improvement of the thermo-pile, which might have been saved and devoted to some more useful end, if the limitation imposed by the second law of thermodynamics had been properly understood. (The *irreversible* character of the thermo-pile brings its commercial efficiency far below the figures indicated above, but a discussion of this point is outside of our present purpose.)

The second law, as has been said, imposes a limit on the efficiency of every form of heat-motor. We cannot evade this limitation by superior modes of construction, for it is fixed by the very *nature* of heat. Any apparatus that first converts the chemical energy of the fuel into *heat*, and then transforms the resulting heat into mechanical energy, is necessarily subject to the law referred to; but if we could discover some method of obtaining mechanical energy from the fuel *without* the intermediate transformation into heat, the second law would no longer apply, and we could very likely devise a form of motor that would greatly exceed the steam engine in efficiency.

It is very likely that this problem is solved in the animal body, for here we find muscular force and mechanical work, derived, to all appearance, directly from the chemical energy that resides potentially in the highly organized tissues of the body. There is little or no evidence that the animal body is a heat motor. Mammals and birds are warm, it is true, but that is probably because the requisite chemical changes cannot occur at a lower temperature. Frogs, fishes, worms, and molluscs are cold, and yet they can solve the problem too, — sometimes in most vigorous fashion. We know very little about the processes that go on in the muscular system. Further research will probably give inventors some valuable suggestions, but at present our knowledge of physiology is too slight to show us how to build a successful motor.

Leaving the animal economy out of account, the only other method that we know of, for transforming chemical energy into the mechanical form, without the intermediate use of heat, is afforded by the galvanic battery. This method is certainly full of promise, though so much thought has already been spent upon it that the present outlook is not so encouraging as it might be. The great difficulty with the galvanic method is, that heretofore every convenient and practicable form of battery consumes *zinc*, and zinc is too expensive to be of much use as a fuel. If we could only devise some feasible kind of a battery that would consume *carbon* instead of zinc, we should stand some chance, perhaps, of removing the steam engine from its present proud position. Numerous attempts of this kind have been made already. Twenty years ago, or more, a form of battery was devised by Jablochkoff, in which carbon was the substance consumed. The Jablochkoff cell does not pretend to be more than a scientific curiosity, but it is nevertheless interesting.

"The liquid of this cell," says Niaudet, "is melted nitrate of potash or nitrate of soda; one electrode is of coke, and the other of platinum, or even of cast-iron. The coke is burned at the expense of the oxygen of the nitrate, and produces torrents of carbonic acid. The cast-iron remains unattacked. The coke [cast-iron?] is therefore the positive electrode, and the cast-iron [coke?] the negative. It is the contrary of that which would take place in a battery with an ordinary liquid, acid, or salt dissolved in water. The nitrate should be previously melted, but as soon as the action begins the



Dr. Jacques' Carbon-Consuming Battery.

salt remains liquid on account of the great heat produced by the combinations which take place; and if the element be left to itself it suffices, to put it in action, to bring the end of the coke to a glowing red heat, and then to press it against the surface of the salt. The chemical action begins immediately. . . . It might be found that such a battery cell presents nothing practical in its actual form, and we do not hesitate to express that opinion, but we believe that it points out a new way in which much progress might be made if the attention of physicists were turned in that direction. Volta's battery itself, when invented, was a purely scientific novelty, and it was far from being regarded as an object of any practical utility."

The quotation here given will show that the idea of constructing a carbon-consuming battery is by no means new. We have no doubt that it was tried even before Jablochkoff's time, but we have no record, at this office, of any earlier experiments. The latest attempt in this direction is due to Dr. William W. Jacques, an electrician in the employ of the Bell Telephone Company. Dr. Jacques' invention has attracted so much attention that a description of it in some detail may be of interest.

The engraving shows the general arrangement of the apparatus. It is merely intended to illustrate the principle of the battery, and it does not pretend to be drawn to scale. Each cell consists of a cast-iron pot, which serves as a containing vessel, and at the same time acts as the positive electrode. The negative electrode consists in a stick of carbon, which is placed centrally in the cell. The iron cell is nearly filled with caustic soda or caustic potash, which is kept in a state of fusion by means of a furnace, as shown in the illustration. A stream of air is blown into each cell at the bottom, and is caused to bubble up through the liquid caustic by means of a sort of rose nozzle, as indicated. (Of course the air pipe must be properly insulated from the iron pots where it enters them.) The apparatus being constructed as described above, and connected up with wires as shown, it is found that a considerable current of electricity can be obtained from it.

Dr. Jacques' theory of the cell seems to be, that the only function of the *furnace* is to keep the caustic melted; so that by jacketing the battery thoroughly the consumption of fuel in the furnace could be reduced so as to be relatively insignificant and unimportant. He appears to ascribe the electric current to the oxidation of the carbon rods in the cells, the oxygen needed for this oxidation being furnished by the air which is blown up through the molten potash. In the course of some tests carried out by Dr. Jacques and others with this idea in mind, the loss in weight of the carbon rods was compared with the output of electrical energy yielded by the battery, the result being that the apparatus showed an efficiency, in one case, of no less than 87 per cent. The fuel burned in the furnace, being supposed to be of minor importance for the reason stated above, was not estimated. The electromotive force of a single cell of the battery was found to be about nine-tenths of a volt. There is a strong similarity between Dr. Jacques' battery and the earlier form invented by Jablochkoff, the chief difference being that the oxygen is furnished by the electrolyte itself in one case, and by the stream of air bubbles in the other case.

If further experiment should substantiate the assumption of Dr. Jacques, that the electrical energy obtained from his battery is due solely to the oxidation of the carbon rods, there can be no doubt that the invention would be of the first importance; for although carbon rods are more expensive than ordinary coal, and the battery would be more likely to get out of order than a modern steam engine is, the wide margin of efficiency in favor of the new device would probably much more than compensate for these difficulties. But unfortunately such outside experiments as have been made do not justify the inventor's hypothesis at all. Mr. C. J. Reed, for example, has shown that the carbon rods act merely as *conductors*, and that they can be replaced by iron, brass, copper, German silver, or other metallic bodies, without detriment to the battery. He found, further, that the disintegration of the carbon rods is merely incidental, and that if good arc-light carbons are used, they do not suffer any sensible loss. He also found that the cell works much better and lasts much longer if the caustic potash is replaced by nitrate of potash, precisely as originally recommended by Jablochkoff. Finally, Mr. Reed found that illuminating gas may be substituted for the air, without lessening the electrical yield of the apparatus.*

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* Mr. Reed's paper on *The Transformation of the Energy of Carbon into Other Available Forms* was read before the Franklin Institute on May 26, 1896. It is reprinted in the *Electrical World* of July 11th, July 18th, and August 1st. See also an important contribution by the same author, on *The Jacques Carbon Battery*, in the same journal for July 25th.

Mr. Reed's experiments establish the fact, beyond a reasonable doubt, that the source of the energy given off by the Jacques battery is the fuel that is consumed in the furnace below the pots. The device is not a galvanic battery at all, but a sort of thermo-electric apparatus, working on the same principle as the old bismuth-antimony arrangement, and subject to precisely the same laws. The chemical energy of the coal in the furnace *is first transformed into heat*, and then into electrical and mechanical energy. The significance of these italicized words is great, for they show that Dr. Jacques has not evaded the second law of thermodynamics. His battery and motor constitute a true heat-engine, and are subject to the very limitations that fix the maximum efficiency of the steam engine.

We do not say that the new battery will not be useful. It is no small advance to construct a thermo-electric combination that can yield so large a voltage; and if the efficiency of the battery turns out to be as great as five or six per cent., it will doubtless be useful in many ways. But the ideal galvanic battery, which consumes carbon instead of zinc, is yet to be discovered.

Working in Compressed Air.

E. W. Moir, in a paper read before a recent meeting of the Society of Arts, gave some interesting data regarding the effects upon the human system of working in compressed air, and the various practical means of lessening the danger and overcoming any sudden collapses. Mr. Moir had charge of the work on the Hudson River Tunnel for a time, and has had some connection with most of the underground tunneling ventures of the last two decades. He says: "When I first came to New York the men had been dying at the rate of one man per month out of forty-five or fifty men employed — a death rate of about twenty-five per cent. per annum. With a view to improving this state of things, an air compartment like a boiler was made, in which the men could be re-immersed in compressed air. It was erected near the top of the shaft, and when a man was overcome or paralyzed, as I have seen them often, completely unconscious and unable to use their limbs, he was carried into the compartment, and the air pressure raised to about one-half or two-thirds of that in which they had been working, with immediate improvement. The pressure was then lowered at the very slow rate of one pound per minute, or even less, the time allowed for equalization being from twenty-five to thirty minutes, and even in severe cases the man went away quite cured. No man ever suffers by *going into* compressed air, unless his Eustachian tubes are obstructed, in which case intense pain is produced, owing to the great difference in pressure between the two sides of the ear drum. The 'lock' described above should be used as soon as the prostration occurs, as it appears to be of little value after some time has elapsed. A slight increase of carbonic oxide [acid?] in the compressed air chamber leads to increased sickness. The impurity never affects a man while below, but only after he comes out. Every man should be medically examined, and hot coffee should be given him before he comes out of compressed air. A warm room to dress in, and extra clothing for passing through the 'lock,' should be provided. At the Blackwall Tunnel, with the experience gained, and attention to the foregoing points, we have not had a single death. Sparely built men stand air pressure best. A man with weak lungs may work and improve, but one with a weak heart or any apoplectic tendency should not go in at all."

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES — VOL. XVII. HARTFORD, CONN., SEPTEMBER, 1896. No. 9.

Standard Sizes of Wrought Iron Pipe for Steam, Water, and Gas.

At the sixth annual meeting of the American Society of Mechanical Engineers, held at Boston in November, 1885, a committee was appointed by the president of the society, to confer with manufacturers of pipe, pipe dies, and pipe fittings, for the purpose of establishing a series of standard gauges for pipes and pipe threads, so that a uniform system might prevail throughout the country. The committee so appointed did its work thoroughly and well, and it is to their labors that we owe the system now in general use.

Upon the introduction of wrought-iron pipe with the taper thread, the veteran engineer, Robert Briggs, adopted and published a table of thicknesses and threads for

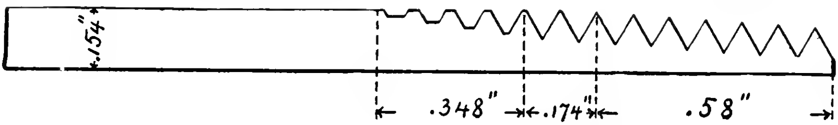

FIG. 1. — SECTION THROUGH A TWO-INCH PIPE.

various sizes of pipe, and his proportions became known as the "Briggs standard," and were adopted by most manufacturers of pipe and fittings. Its use was not universal, however, and as the pipe industry had grown to immense proportions, a uniform standard had become not only desirable, but necessary.

The committee of the American Society of Mechanical Engineers met in Hartford in February, 1886, and its first extended report was presented at the seventh annual

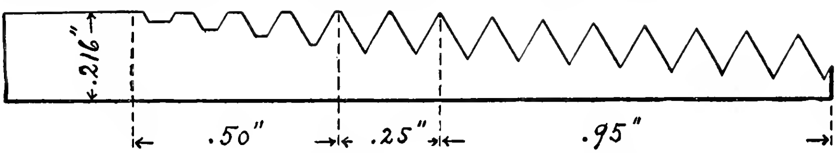

FIG. 2. — SECTION THROUGH A THREE-INCH PIPE.

meeting of the society, which was held at New York in November, 1886. "The opinion of this committee is," says the report, "that the Briggs standard, which nearly all, if not all, of the pipe manufacturers once adopted, is the proper standard to be adhered to, and that it only requires definite co-operation on the part of pipe manufacturers with the committee, in order to bring their product strictly to that standard, and to adopt means of strictly adhering to it within practical limits." Such co-operation was heartily given by the Manufacturers of Wrought Iron Pipe and Boiler Tubes, the Cast Iron Fittings Association, the Manufacturers of Brass and Iron, Steam, Gas, and Water Work, and others. A joint conference was held in June, 1886, with a committee of pipe manufacturers, and it was decided to ask each manufacturer to send to the Pratt & Whitney Company of Hartford sample pieces of all sizes of pipe from six inches down, threaded on one end, to be tested by the Pratt & Whitney Company, and compared with the Briggs standard gauges. Thirteen manufacturers complied with the request and furnished the desired samples, which were then carefully tested; the results of the tests were tabulated, and submitted to the Pipe Manufacturers' Association, at its regular convention held at Philadelphia in August, 1886. The variations from the Briggs standard, as shown by the tests, were small except in the cases of the three-quarters and one inch sizes. Another conference of committees was then held, and finally, in October, 1886, the Briggs standard was definitely adoped by the Manufac-

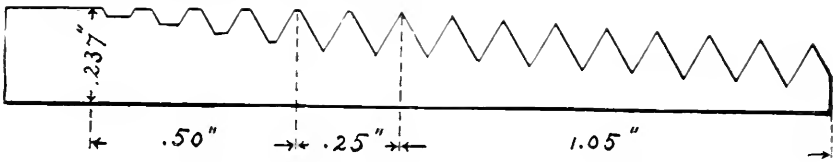

FIG. 3. — SECTION THROUGH A FOUR-INCH PIPE.

turers of Wrought Iron Pipe and Boiler Tubes, and in December of the same year it was also adopted by the Manufacturers' Association of Brass and Iron, Steam, Gas, and Water Work; so that now it may be regarded as a national standard.

The Briggs standard thread may be described, in general terms, somewhat as follows: The threads have an angle of 60°, but are rounded off slightly at top and bottom, so that the depth of the thread is only four-fifths as great as it would be if the threads were sharp. The outside surface of the tube is tapered to a certain distance from the end, the standard taper being such that the tube-surface inclines toward the axis of the tube by 1 in 32. This makes the *total* taper, as measured by the variation in outside diameter, equal to 1 in 16, or $\frac{3}{4}$ of an inch to the foot. The total *length* of the tapered part is given by the empirical formula,

$$Length\ of\ taper = (4.80'' + \tfrac{4}{5} D) \div n,$$

where D is the actual external diameter of the tube in the straight part, in inches, and

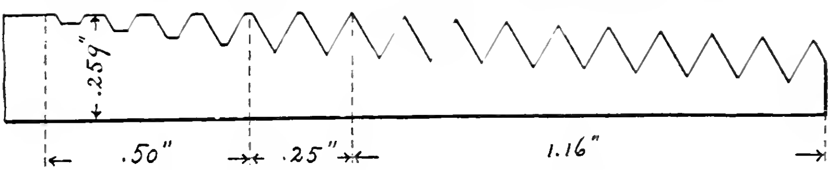

FIG. 4. — SECTION THROUGH A FIVE-INCH PIPE.

n is the number of threads per inch. For example, the actual outside diameter of a 5-inch pipe is 5.563", so that to find the length of the tapered part we proceed as follows: $\frac{4}{5} \times 5.563'' = 4.450''$, and $4.450'' + 4.80'' = 9.250''$. There are 8 threads to the inch on pipe of this size, and hence we have, finally, $9.250'' \div 8 = 1.156''$, which is the length of the taper. The tapered part of the pipe is threaded with threads that are perfect at both top and bottom. Further back, beyond the perfect threads, come two threads that have the same taper at the bottom, but which are imperfect at the top. The remaining part of the screw, which consists of four threads that are imperfect at both top and bottom, is not essential to the Briggs system, but is "simply incidental to the process of cutting the thread at a single operation."

The accompanying table gives the nominal or commercial inside diameter of pipe up to 10 inches in diameter, with the actual inside and outside diameters, the thickness of metal in the body of the pipe, the length of the taper and perfect screw, the outside diameter of the thread at the end of the pipe, and the diameter at the bottom of the thread at the end of the pipe. These dimensions are all according to the Briggs standard, with one exception. At a meeting of the Manufacturers of Wrought Iron Pipe and Boiler Tubes, held at New York in May, 1889, action was taken regarding the outside diameter of 9″ pipe, and the standard for this dimension was made 9.625″ instead

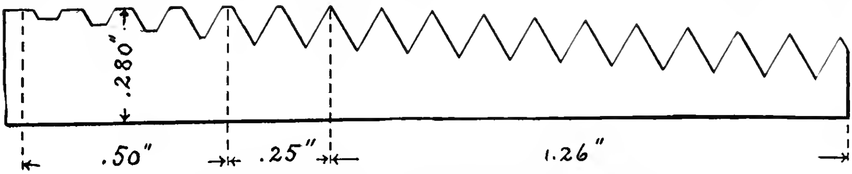

FIG. 5. — SECTION THROUGH A SIX-INCH PIPE.

of 9.688″, as had been recommended by Briggs. Aside from this change the proportions here given agree with those adopted in 1886.

The taper thread for pipes and fittings is an American invention. It was first used about 1840 by Walworth & Nason of Boston, with whom Mr. Robert Briggs was associated for many years.

The engravings show the standard proportions of pipe threads for several sizes of pipe, except that the *taper* has been slightly exaggerated for greater clearness. Two threads, it will be seen, are perfect at the bottom but flat on top, and four are imperfect at both top and bottom.

STANDARD PROPORTIONS OF PIPES AND PIPE THREADS.

Diameter of Tube.			Thickness of Metal.	Screwed Ends.		Diameter at End of Pipe.	
Nominal inside.	Actual inside.	Actual outside.		Number of threads per inch.	Length of taper and of perfect screw.	Outside.	At bottom of thread.
1/8″	0.270″	0.405″	0.068″	27	0.19″	0.393″	0.342″
1/4	.364	.540	.088	18	.29	.522	.445
3/8	.494	.675	.091	18	.30	.656	.579
1/2	.623	.840	.109	14	.39	.816	.717
3/4	.824	1.050	.113	14	.40	1.025	.926
1	1.048	1.315	.134	11 1/2	.51	1.283	1.162
1 1/4	1.380	1.660	.140	11 1/2	.54	1.626	1.505
1 1/2	1.610	1.900	.145	11 1/2	.55	1.866	1.745
2	2.067	2.375	.154	11 1/2	.58	2.339	2.218
2 1/2	2.468	2.875	.204	8	.89	2.819	2.646
3	3.067	3.500	.216	8	.95	3.441	3.268
3 1/2	3.548	4.000	.226	8	1.00	3.938	3.765
4	4.026	4.500	.237	8	1.05	4.434	4.261
4 1/2	4.508	5.000	.246	8	1.10	4.931	4.758
5	5.045	5.563	.259	8	1.16	5.491	5.318
6	6.065	6.625	.280	8	1.26	6.546	6.373
7	7.023	7.625	.301	8	1.36	7.540	7.367
8	7.982	8.625	.322	8	1.46	8.534	8.361
9	9.000	9.625	.312	8	1.57	9.527	9.354
10	10.019	10.750	.366	8	1.68	10.645	10.472

Inspectors' Report.

JULY, 1896.

During this month our inspectors made 8,025 inspection trips, visited 17,737 boilers, inspected 8,151 both internally and externally, and subjected 775 to hydrostatic pressure. The whole number of defects reported reached 14,806, of which 1,270 were considered dangerous; 47 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment.	1,279	37
Cases of incrustation and scale,	2,765	47
Cases of internal grooving,	140	9
Cases of internal corrosion,	1,188	38
Cases of external corrosion,	995	38
Broken and loose braces and stays,	219	193
Settings defective,	523	27
Furnaces out of shape,	511	15
Fractured plates,	335	73
Burned plates,	273	30
Blistered plates,	419	21
Cases of defective riveting,	1,567	125
Defective heads,	133	19
Serious leakage around tube ends,	2,329	327
Serious leakage at seams,	538	44
Defective water gauges,	401	57
Defective blow-offs,	201	62
Cases of deficiency of water,	13	9
Safety-valves overloaded,	55	14
Safety-valves defective in construction,	82	20
Pressure gauges defective,	694	47
Boilers without pressure gauges,	11	11
Unclassified defects,	135	7
Total,	14,806	1,270

Boiler Explosions.

JUNE, 1896.

(138.) — The boiler of engine No. 1904 of the Southern Pacific Company exploded on June 3th, at Shuman, a small station near Guadaloupe, San Luis Obispo county, Cal. The entire locomotive was ruined, but nobody was killed. The engine was attached to a long train of gravel cars in front of the station, and near by a large force of men was at work in a gravel pit. At the time of the explosion Engineer F. T. Simpson and his fireman were sitting in the cab, and Conductor Williams was standing by the tender. Cinders and burning coal were thrown into the cab, and the engineer and fireman were hurled violently from their seats, but were not seriously hurt. The locomotive was totally wrecked, the entire front end and side being blown away. The men in the gravel pit escaped injury.

(139.) — On June 3d a boiler exploded in Taylor & Sons' saw-mill, at Farmland, Ind. The mill was torn to pieces and timbers were scattered in every direction; but nobody was seriously injured.

(140.) — A boiler exploded on June 5th, in Nobles & Gill's saw-mill, at Swift Creek, near Petersburg, Va. Samuel Nobles and Abraham Gill, the owners of the mill, were both painfully injured, and Mr. Gill's injuries are pronounced very serious. The mill was completely destroyed.

(141.) — A boiler exploded, on June 11th, at the Michigan Salt Works, two miles south of Marine City, Mich. William Mobray, fireman, was instantly killed, and John Haley was fatally injured. Peter Booth, another fireman, had his left arm cut off just below the elbow, and Serenus O'Neil received lesser injuries. The explosion blew away the north walls of the works, and set fire to the ruins. The total property loss amounts to from $50,000 to $75,000. The works had been in operation about two years and a half.

(142.) — On June 13th a small upright boiler exploded at a small village in the county of Picton, Nova Scotia. It was carrying 80 pounds of steam at the time. All of the boiler except the grate bars went up through the roof and landed outside of the building, about fifty yards away. Nobody was injured.

(143.) — A boiler exploded, on June 16th, at Cisney, Todd county, Ky. The building was demolished, but, of the fourteen men that were in it at the time, only one was injured.

(144.) — A peculiar boiler explosion occurred, on June 16th, on the Levi Simon farm, at Welker, near Bowling Green, Ohio. A gang of men was at work drilling an oil well, and during the night they were obliged to stop for a time. When an attempt was made to start the engine from the derrick it would not move. Upon going outside to investigate it was found that the boiler had exploded with such violence that it was torn into fragments. The boiler stood only eight rods from the derrick, and yet none of the workmen noticed the explosion, as there was a violent storm at the time, and the noise of the explosion was doubtless masked by the heavy peals of thunder.

(145.) — A portable boiler, belonging to Benjamin Wright & Co., of Captina, near Caldwell, Ohio, exploded on June 18th. Fortunately no one was injured.

(146.) — While the steamer *Hon. Titus Sheard*, with twenty-seven passengers on board, was approaching Taylor Park, on the Erie Canal, near Little Falls, N. Y., on June 18th, her boiler exploded with fearful effect. Charles Bradford, George Denman, Annie Golden, Thomas Hull, W. F. Simmons, Edward J. Tressell, Elon Walker, George White, Charles Wormuth, William Wormuth, Van Buren Young, and one other man, were killed. Rhoda E. Warren, Perry Kingston, Mr. and Mrs. Irving Stroup, George H. Casler, and Hammond Wiles were also severely injured, and later advices say that Casler and Mr. Stroup will die. The boat was torn to pieces, and the horror of the scene is indescribable. There were to be bicycle races at the park, and the *Sheard* made trips through the canal to the grounds at short intervals. The explosion occurred in full view of those who had already assembled at the park. The injured were carried into the bicycle riders' headquarters, which was transformed into a temporary hospital.

(147.) — A kitchen boiler exploded, on June 20th, in J. Lynch's residence, on Broad and Westmoreland streets, Philadelphia, Pa. Elizabeth Loughlin was painfully injured by flying fragments of iron, and Frances Smith was burned on her face, hands, arm, and body, by hot coals that were thrown from the fire. The kitchen was badly damaged.

(148.) — The boiler of one of the donkey engines used by the Pennsylvania Railroad improvement gangs, at Portage, near Altoona, Pa., exploded on June 22d. The boiler and engine were entirely demolished. Nobody was hurt.

(149.) — Two boiler tubes failed, on June 22d, on the steamship *City of San Antonio*, of the Mallory line, while she was off Sandy Hook. Paul Murray, one of the firemen, was seriously scalded. Signals of distress were hoisted, and the steam pilot station boat *Alaska* responded. She took Murray on board, and transferred him to the Marine Hospital at Clifton, L. I. The *San Antonio* was so much disabled that she could not proceed on her voyage.

(150.) — On June 22d a tram engine boiler exploded at Doucette, three miles north of Woodville, Tex. One of the wheels of the engine got off the track, and a number of men gathered around to assist in putting it back. The explosion occurred while they were engaged in this way. A. L. Doucette, Grant Hammerly, Charles Walforth, Charles Smith, Wylie Sargent, and two other men, whose names we could not learn, were killed. Dana Harman, Dennis Sullivan, and a man named Dowling were also seriously and perhaps fatally injured.

(151.) — The boiler of locomotive No. 705, one of the ponderous mogul freight engines on the Central Hudson railroad, exploded on June 23d, near the Park avenue crossing at Utica, N. Y. Fireman Charles Angus was injured so badly that he died within a short time. Engineer Frank Markhart was also fearfully scalded, and died a few days later. The locomotive was blown to pieces, and parts of it were scattered all about for a distance of several hundred feet. At the coroner's inquest Robert Lockart, a boiler-maker, who was thoroughly familiar with the wrecked engine, said: "This is the only boiler explosion in which I could not assign a cause. There seemed to be no especially weak spot, judging from the appearance of the boiler after the explosion. I am not prepared to say that the explosion was caused by any fault of the fireman or engineer. I do not think it was caused by a burn, or by low water." Engineer Markhart also certified, before his death, that the boiler contained plenty of water.

(152.) — Six boilers exploded on June 25th, at the breaker of M. S. Kemmerer, at Sandy Run, near Scranton, Pa. The boiler-house was completely demolished, and John Kusmick, a fireman, was severely scalded. One of the boilers was blown about 600 feet, through the side of the breaker. Another boiler was blown 400 feet in a different direction, landing in the machine shop.

(153.) — A boiler exploded, on June 27th, in Ehrman's mill, at Clanton, near Birmingham, Ala. Engineer McCall was killed.

(154.) — On June 27th, a boiler exploded at Snow Bros.' mill, about four miles from Placerville, Cal. The mill was torn to pieces, but only one man of the four who were in the building at the time was seriously hurt. Daniel Kenirk was painfully injured about the head, face, and hand.

(155.) — A boiler exploded, on June 29th, in the Kennedy mill at Rarden, near Portsmouth, Ohio. The employes were at dinner at the time, so that nobody was injured. The mill was completely wrecked.

(156.) — On June 29th a boiler exploded on the premises occupied by the *Daily Age* newspaper, of Houston, Tex. Henry Lyons, Martha Loeb, and Edward R. Emery were killed, and W. G. Van Vleck, vice-president and general manager of the Atlantic system of the Southern Pacific railway, was seriously injured. The property loss was about $10,000. Miss Loeb was a stenographer, and was taking a dictation from Mr. Van Vleck, when the boiler crashed through a brick wall into the rear of the building, taking everything in its way. Miss Loeb was carried nearly twenty feet from her chair, and was found afterwards, buried under a mass of debris. In the next office were two telegraph operators, Edward R. Emery and Theodore Grice. Emery was struck by the boiler and instantly killed, as already recorded; but Grice escaped practically uninjured.

By an oversight, the article on "Working in Compressed Air," in the last issue of The Locomotive, was not credited to *Appleton's Popular Science Monthly*, as it should have been.

Benjamin Mayer, who was injured by a boiler explosion at Augusta, Iowa, on May 23d, has since died. In our account of this explosion (see No. 128 in our August issue) he was said to be likely to recover.

Further advices concerning explosion No. 137, in our last issue, show that John Lloyd died from his injuries, but that Augustus Berndt has recovered. We learn, further, that a man named Steiber was painfully injured in the same explosion.

The issue of the *Scientific American* for July 25th is one of which the publishers of that journal may justly be proud. It commemorates the fiftieth anniversary of the founding of the paper, and is filled with interesting articles, copiously illustrated, relating to the material progress that has been made during the past half century by the world in general, and by this country in particular. We reproduce, elsewhere, the leading editorial article on the "Effect of Inventions on the People's Life."

Explosion of a Toy Boiler. — Robert Nickel, a twelve-year-old boy living in Anaconda, near Butte City, Mont., was instantly killed on June 1st, by the explosion of a toy boiler. In company with several playmates, he had made a boiler out of a gas tank from a plumber's stove, and had filled it with water and built a fire under it. When the pressure ran up, they would open a small valve and relieve it; but on one occasion the boiler was left too long, and steam began to issue from all its joints The other boys ran away, but young Nickel tried to save his toy. It exploded as he leaned over it, and one of the pieces struck him in the head and killed him.

A contemporary tells of a certain Dennis O'Houlihan, who was once elected tax assessor in Harlem. Mr. Michael O'Toole, who was a friend of O'Houlihan, confidently looked for some recognition of that friendship in his tax bill; but when the bill came, Michael was filled with wrath. His estate was indeed treated with consideration, but his goat was taxed eight dollars, and he expressed his indignation rather freely.

"Be aisy now," replied the assessor. "Shure I couldn't help it. 'Tis down in the book 'two dollars a running foot,' an' begorra, yer dom goat has *foor* of thim."

The Locomotive.

HARTFORD, SEPTEMBER 15, 1896.

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

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THERE is a tendency, on the part of the press and the general public, to lay the blame for a boiler explosion solely upon the engineer — especially when the unfortunate man is dead, and cannot defend himself. We have a fine illustration of this before us. One account of a certain explosion states that "the unfortunate engineer whose carelessness probably caused the horror, was torn to pieces and literally dismembered. Near his left hand, which was blown off of the arm and carried some distance from the body, lay the stop-cock which was used to turn cold water into the boiler, open. He was seen in a saloon shortly before the disaster, and left there with the remark that he must go and attend to the boiler. The theory is that during his absence the water got low, and the turning on of the cold current caused the explosion. He had no relatives in this section." Now we don't know anything about the merits or demerits of this particular engineer, but we have twenty-six several accounts of the explosion in question, and no mention is made of the "stop cock" nor of the saloon, in any of the other twenty-five. This story was published over a thousand miles from the scene of the disaster. None of the local papers knew anything about it, and yet they needn't have feared to say what they thought, for the man had "no relatives in this section," to call them to task.

Postscript Concerning the Jacques Battery.

In an article on *Heat Engines and Carbon Consuming Batteries*, in the August issue of THE LOCOMOTIVE, Dr. Jacques' battery was declared to be a thermo-electric apparatus, similar in principle to the bismuth-antimony combinations that have long figured in our text-books. Since preparing the article in question we have noticed that Dr. Thomas Andrews made a series of experiments in this direction, as long ago as 1837. In a paper published in the London and Edinburgh *Philosophical Magazine* in that year, he says: "The interesting discovery made by Faraday of the high conducting power of certain fused salts for voltaic electricity, led me to expect that electrical currents might be produced by bringing them into contact with the metals, analogous to the thermo-electric currents observed by Seebeck." He then goes on to tell some of the details of the experiments tried for the purpose of testing this idea. He worked principally with a couple of platinum wires, which were separated at the ends by a globule of melted borax. When the spirit lamp that was used for keeping the borax fused was placed so that one of the platinum wires was hotter than the other, and the wires were connected to a galvanometer, a vigorous electrical action was observed, the direction of the current being such that it passed through the borax from the hotter wire to the cooler one. Carbonate of soda, carbonate of potash, chloride and iodide of potash, sulphate of soda, chloride of strontium, and various other salts, were substituted for the borax with success, an electrical current being obtained in every case — slight currents being obtained even when the wires were separated by thin layers of glass or mica. Other metals were tried in the place of platinum, and the same phenomena were observed in every instance, except when masked by a direct chemical action between the metal and the interposed borax or other salt. With two borax globules and four platinum wires Dr. Andrews obtained a current strong enough to decompose water into its constituent gases. "It is certainly very interesting," he says, "to see powerful chemical affinities thus overcome by simply bringing two metallic wires, at different temperatures, into contact with a fused salt, between which and the wires no [chemical] action takes place." He estimated the electro-motive force of his borax-platinum combination, by comparing it with a galvanic cell consisting of a plate of platinum and plate of silver, immersed in dilute nitric acid; and he found that, under ordinary conditions, the thermo-electric arrangement was the more powerful of the two. (We do not know the precise electro-motive force of the platinum-silver cell used by Dr. Andrews, but Poggendorff found that a similar cell containing muriatic acid instead of the nitric acid gave 0.62 of a volt; so that it is perhaps fair to infer that the electro-motive force of Dr. Andrews' borax-platinum couple was greater than half a volt.)

Dr. Andrews sums up his investigations as follows: "It appears from the preceding experiments that an electrical current is always produced when a fused salt capable of conducting electricity is brought into contact with two metals at different temperatures; and that when chemical action does not interfere, the direction of the current is not influenced by the nature of the salt or metal, being always from the hotter metal through the fused salt to the colder metal. This current has an intensity inferior to that of the hydro-electric [galvanic] current developed by platina and zinc plates, but greatly superior to that of the common thermo-electric currents, and is capable of decomposing with great facility water and other electrolytes."

We have reviewed these experiments of Dr. Andrews' at some length, because we conceive them to be of special interest at the present time. They appear to cover precisely the same ground that has lately been explored, independently, by Dr. Jacques. Indeed, the Jacques "carbon battery" resembles Andrews' crude device so closely that the two may be said to be essentially identical.

The Effect of Inventions on the People's Life.

The material world has advanced so rapidly during the last half century, and with a pace so accelerated, that mankind has almost lost one of its most important faculties, and one essential to happiness — that of surprise. The *nil admirari* faculty is attaining a wide spread. The most marvelous developments are taken as a matter of course; the condition of things fifty years ago is seldom pictured to the mind; and all the material blessings which we now enjoy are used as conveniences of daily life, and no more. Formerly there was an idea prevalent that surprise and astonishment were emotions of the ignorant. To-day they are rather emotions of the scientist. The educated engineer cannot without such emotions contemplate the insignificant feed wire of a trolley road carrying silently hundreds of horse power to points all along the line — he cannot without these feelings contemplate the electric motors, drawing power in proportion to the work they have to do, all regulated by the automatic government of counter-electromotive force — he cannot see the unstable though gigantic ocean liner filled with every refinement of electrical and mechanical art, all working perfectly on their never quiet, never level platforms — he cannot follow the construction of a cantilever bridge with the ensuing changes from compressive to tensile stress and the reverse, as the span is completed — these things all excite in him such emotions that he cannot observe them and know them without a feeling of true astonishment at the achievements of mankind.

The steam engine has been greatly improved. The Corliss valve motion and the compounding of cylinders, leading to more perfect expansion and a longer range of working temperature limits, have brought about great economy so that one-tenth the fuel will do the same work as compared with many engines of the middle of the century. In details, such as the supply of water to the boilers by injectors and inspirators, doing away with the feed pump, the machine stoker for supplying fuel, and the feeding of oil drop by drop to the cylinder, the drops passing through a glass tube so as to give sight feed lubrication, the steam power plant has had many and great developments.

The machine shop has not been neglected, and America can boast of the finest machine tools, for wood and metal, such as automatic lathes, milling machines, and shapers, that the world can show. The development of abrasives, emery, and carborundum, has made the emery grinder a necessary tool in every machine shop. The miner even shares in the advance, special machinery for extraction of ore, for undercutting and drilling being invented, while modern explosives of graduated power and quickness make the work of placing shots much safer. Compressed air has been used in some classes of underground work, but electricity is making its presence felt there also, and electric machinery for tunneling and mining is in extensive use.

The work of St. Clair Deville in the days of the last Napoleon has borne fruit, and now aluminum has a recognized place among commercial metals. In its reduction the electric furnace and the electrolysis of fused salts have been tried, and the cheapened production of sodium has had its effect on the cost of production.

The lightness of this metal led to hopes that it might lead to the construction of a flying machine. The development of the laws of moving aeroplanes have given a better basis perhaps in this direction than any preceding work, and the theory of the internal energy of the atmosphere gives a possibility of the solution of the problem of soaring flight. Yet very little has been really accomplished, although more has been done during the last five years to raise the rational hopes for true mechanical flight than during the fifty years that preceded.

Food for the family is now procurable in endless variety, independent of the season of the year. The enormous development of the canned goods industry, of cold storage and of cheap transportation makes the salmon of Oregon, the delicate fruits of California, and the vegetables of the West familiar to the residents of the most distant cities. The winter kitchen can have every summer vegetable, and the feats of the Romans in supplying the tables of its emperors are daily surpassed, only it is now done for the benefit of the poor. Even in the treatment of food, notably of the cereals, there is great advancement, and the roller mill turns out flour of greatly improved quality, and with larger yield from the grain than was done by the old grist mills.

In the matter of the transportation of water the most impressive achievements of engineering are executed in order that at the turning of a kitchen faucet water may flow into the kettle of the cook. The contrast between old and new methods is nowhere more forcibly presented than in the two Croton aqueducts — one of the year 1842, following approximately a contour line from the Croton Lake to the Central Park, New York, its path being traceable from the surface over nearly all its extent — the new one of 1890 driven deep underground wherever possible, as a matter of preference, and built without surface disturbance except at the shafts and in one or two difficult places. To supply cities with water through such aqueducts, great dams are built or natural lakes are utilized. The fact that the lake or dam is to be fifty or more miles distant plays no part.

Perhaps the manufacture of shoes supplies as good an illustration as any of the substitution of factory for hand work in supplying domestic wants. The American shoe factory with its workshops filled with machinery and with trained operatives, each practised in performing one single operation, using ingenious sewing machines, producing welt shoes or shoes without welt, sends its products to all parts of the world, and the hand-made shoe is used less and less.

Foremost among the developments of the last half century is the India rubber industry. The discovery of the vulcanization of India rubber at once brought into the realm of practical uses a unique material, India rubber. At first it had been unsatisfactory, subject to change of qualities and uncertain in every way and affected by variations in temperature. But Goodyear's great invention of vulcanization produced a new and wonderful material, which has affected every department of modern life, and which, as not the least of its achievements, has created the modern pneumatic bicycle. It is hard to believe that this invention goes back only a little over fifty years.

In the march of progress the farmer has also participated. Reaping, mowing, raking, harvesting, plowing, cultivating, form but an incomplete statement of work now executed for him by machinery. Steam has long been used to do his work — now electricity is stepping in to his assistance, and we find an electric plow under trial. Patent churns, centrifugal and deep-pan cream separators make his dairy work easy, and it is further simplified by the creamery to which he delivers his milk for butter and cheese making by machinery. To-day America exports cheese in enormous quantities, and many a tourist has eaten in foreign lands, under foreign titles, cheese from cheese-factories of the Empire State.

The stock farmer who raises cattle for market to supply meat is not neglected. His market has expanded enormously, until the "roast beef of old England" has to be supplied by countries thousands of miles away from London. Cattle ships, which in all their appointments represent the finest marine engineering, receive them and they are despatched across the ocean with as little concern or uncertainty as if it were a ferry which was to be crossed. The docks on the Thames receive steamer-load after steamer-load of cattle for the supply of the great metropolis and of the country at large. It really seems as if, without modern improvements, the world would have to go unfed. It would be fairer to say that it is the concentration of population in such centers as London and New York which has made it necessary to provide food supply by such methods. Under the conditions of former days, in a society more in accord with Mr. Ruskin's ideas, we might find the cattle ranges dotted with little villages, and London as yet not unified and consolidated, its constituent settlements still having independent existence. At present it is the other way, and there are in the West deserted cities whose inhabitants were unable to resist the tendencies of the day. The cattle trade and food supply systems indicate the tendency of the world toward life in great centers of population. The deserted farms of New England, like the deserted cities of the West, tell the same story.

There is often a companionship in disease and its remedy. Cities grow large, and dwellers in the suburbs identify themselves with the metropolis. For their benefit special rapid transit methods are developed. It is very few years since the horse-car was welcomed by the American city as an improvement on the old rattling omnibus.

The writer recollects the day when there were many omnibus lines in New York and when the horse railroads of Philadelphia were an object of pride and rejoicing. Now all is changed. The horse railroad is archaic, and with a few exceptions in the way of compressed air, steam and electric motors, transit within city limits is done by central station methods. The city resident who desires to see the finest example of steam engineering has but to visit the power-plant of his municipal railroad. The maintenance day after day and month after month of the great cable roads of New York and other cities is a wonderful triumph of engineering practice. The electric trolley road is, however, the most powerful of these factors in what we have alluded to as the work remedial of the ills of modern centralization. From the central station it sends its power lines in all directions through the suburbs of cities, and at almost nominal charge carries passengers for miles at a speed of ten to twenty miles an hour or more. The city worker is no longer obliged to live in closely built up streets. The cars escape to the region of green fields. The trolley may yet modify cities until they become centers of work and not of residence.

The trolley line with single overhead wire and rail and ground return is not a satisfactory thing. Much damage has been done by escape, or rather branching of current from its rails. The underground trolley has been in use on a couple of roads, one in Ireland and one in Hungary, but only recently has it been introduced into America. The cities of Washington and New York have excellent examples of it. As it avoids the unsightly aerial wires, with attendant dangers, and as the underground system has two insulated conductors, avoiding destruction of pipes by electrolysis, the best wishes of civil engineers should be extended to it.

The self-contained motor car which can work independently of any central station is still in embryo. Many are in use, especially in Paris, but they are few in number compared to the central station car lines. A car motor needs such an exceptional reserve of power that the problem of devising an adequate motor for it is far from easy. The storage battery, for which such boundless fields of utility are open as soon as it shall become lighter and more practical, has been tried on street cars and operates a number to-day. The explosion oil engine may yet solve the problem. Hitherto the weight of the motor mechanism and the difficulty of establishing a sufficient reserve of power are the difficulties to be overcome.

We have already alluded to cold storage. Another domestic use to which the science of the day has been devoted is the production of ice. Ice formerly was harvested entirely from natural sources. Now it is made artificially in great quantities, and every first-class ocean steamer or large steam yacht can make its own ice and cool its own refrigerators. In southern regions this art makes itself most directly felt, for Florida need no longer import ice from Maine. It can be made by machinery in quantities required for daily consumption.

The business man and the litterateur, even the newspaper reader, share in the advance. Quick processes of illustration have changed the daily journal into an illustrated publication, and color printing is used in it, as well as for works of the highest art.

The typewriter, a product really of the last twenty years, has effected a perfect revolution in the old time secretary's art. There is no longer the striving after a legible hand of definite style, but the even work of the typewriter makes the handwriting of a secretary a thing of no importance. The typewriter brings the writer's art in close juxtaposition with that of the printer, and, following out the analogy, we find the modern printer in possession of machines for composing.

It has long been a dream with inventors to do away with the hand composition. Early in the fifties William Mitchell's type-setting and distributing machines were experimented with at the Trow printing office in this city, and were used for some years there. Other inventors attacked the problem in other ways; some devoted their efforts to the production of a matrix, by means of which a stereotype or electrotype could be produced. At last the idea of a matrix-setting in contradistinction to a type-setting machine occurred, and a complicated and highly ingenious machine was invented for carrying out this idea. This machine, the Mergenthaler so-called Linotype machine (which might more properly be written Lineotype), set, by means of a key-board, individual letter moulds or matrices. For justification, wedge-shaped spaces or quads were used. These were inserted between words, and when the line was nearly filled and a syllabic division or end of a word was reached, the line was completed by thrusting in the wedges. This accomplished the missing function of preceding machines — the machine did its own justification. When a line of moulds was set up the casting of metal against their faces was automatically done, and a "slug" of one complete line of text resulted. Quantities of printer's work is now done on machines of this class. It marks the solution of a problem of four centuries' standing.

A very important line of work is in the field of the gas and oil explosion engines. In these we have a long range of temperature change acting to increase the low economy due to the second law of thermodynamics. These machines are now made without ignition tube, flame or electric spark igniter, and, as they operate without boiler and require scarcely any attention, they go far to bring power within the use of all. Ericsson, Roper, and others have done well in a parallel line of work with hot-air engines, and the entire subject of displacement of the steam engine is affected by them as well as by electric motors. These smaller motors, because they require so little plant, are now entering into the daily life of the individual. They are used in small machine shops, small boats are driven by them, and industrial conditions may yet be gravely modified by the possibility of economically producing small units of power with small investment of capital.

While this indicates the possibility of the division of industries into small units, we are confronted on the other hand by immense industrial settlements, the tendency of the day having brought about consolidation of interests. Thus we have the car shops of Pullman, Ill., supporting a city. We see the great Carnegie Iron Works, at Homestead, Pa., covering 110 acres of ground and employing 8,000 men, a veritable industrial army, beyond the imaginations of the past generation.

Formerly watches and clocks were individual creations, the tradesman turning out the finished product from his little shop. Now the great factory produces them, employing every refinement of automatic machinery and specialized labor, the principle of interchangeability affecting the product to the last degree. The foreign industry has been profoundly affected, and the New England timekeeper equals in quality the best hand-made product of an earlier day.

Our theme in this retrospect has been the wonder of it all, and in that wonder every few years an awakening is observed which finds expression in what has become an institution of the last fifty years — great expositions. Started in England by Prince Albert, the Consort of Queen Victoria, with the World's Fair of 1851, held in London, every few years have witnessed the inauguration of a new exposition. After having been started as world's fairs and exhibitions of the industry of all nations, they have become differentiated and special exhibitions have been prepared, covering either special articles or special countries, and lately these exhibitions have been very numerous. But the long series is punctuated throughout at intervals of a few years by real world's fairs, each one in splendor and completeness striving to outdo its predecessor, until, in 1893, at the great Western metropolis, all former efforts were eclipsed by the Columbian Exposition, designed to commemorate the discovery of America by the great Genoese. It was an exposition where a mingling of history and art led to the erection of the most magnificent group of buildings and architectural trophies that the world has ever seen — where the water from the lake made easy the introduction of water into the scene, which water, circulating in beautiful lagoons, was traversed by the Venetian gondola, the relic of past centuries, and by the electric launch, the production of the very moment — where the most beautiful art products of the world were fairly rivaled in interest by the trophies of the mechanics' and technologists' art — where in the reproduction of the features of life in foreign lands the human element was made to vie in interest with all the rest. The great fair ended, far outdoing anything that the world had ever seen. The destruction of its buildings by fire formed a fitting culmination of its necessarily short life. It is hard to be believed that it will soon be surpassed. It seems to represent the proper ending of the nearly fifty years period during which such fairs have been held.— *Scientific American.*

The United States Standard Gauge for Iron and Steel Plate.

As every mechanic knows, there has been much confusion, in this country at least, in the gauges that are used in specifying the size of wire and the thickness of metal sheets and plates. To avoid this confusion, and to fix, definitely, the significance of the gauge numbers as used by the United States Government, an Act of Congress was passed in 1893, which defines what is declared to be "the only standard gauge for sheet and plate iron and steel in the United States of America."

We present, herewith, a table that shows the standard sizes that were thus determined, and which is taken from an able and interesting address on "Legislation Relating to Standards," delivered before the National Academy of Sciences, by Dr. T. C. Mendenhall, and published in a recent issue of *Science.* We have changed the arrangement of the table somewhat, and have not preserved as many decimal places as are given, in some of the columns, in the original. For example, the standard thickness of a steel sheet whose gauge number is 37 is said, in the table in *Science*, to be 0.168671875 of a millimeter; while in the table as here given we have preserved only three decimals, giving the thickness as 0.169 of a millimeter, which is in error by less than the 50,000th part of an inch, and is more convenient for practical use.

The thicknesses corresponding to the new gauge numbers begin with half an inch (which is the thickness of No. 0000 000), and then diminish regularly by $\frac{1}{32}$ of an inch between every two successive numbers up to No. 1. From No. 1 to No. 14 the sizes diminish by equal intervals of $\frac{1}{64}''$. From this point to No. 16 the change in thickness for one gauge number is $\frac{1}{128}''$, and from No. 16 to No. 20 it is $\frac{1}{160}''$. From No. 20 to No. 26 the corresponding change is $\frac{1}{320}''$; from No. 26 to No. 31 it is $\frac{1}{640}''$; from No. 31 to No. 36 it is $\frac{1}{1280}''$; and from No. 36 to No. 38 it is $\frac{1}{2560}''$.

In computing the columns giving the weights of the different sizes, it has been assumed that a cubic foot of iron or steel weighs 489 pounds, which is the figure given by Rankine for "average wrought iron."

With reference to the variation of specimens of plate from the standard sizes, the Act provides that "in the practical use and application of the standard gauge hereby established, a variation of two and one-half per cent., either way, may be allowed."

U. S. Standard Gauge for Iron and Steel Plate.

Number of Gauge.	Thickness in Inches.		Weight per Square Foot.			Thickness in Millimeters.	Weight per Sq. Meter.	
	Expressed fract'nally	Expressed decimally.	Ounces.	Pounds.	Kilograms.		Kilograms.	Pounds.
0000 000	1-2	.500	320	20.00	9.072	12.70	97.6	215.
000 000	15-32	.469	300	18.75	8.505	11.91	91.5	202.
00 000	7-16	.438	280	17.50	7.938	11.11	85.4	188.
0 000	13-32	.406	260	16.25	7.371	10.32	79.3	175.
000	3-8	.375	240	15.00	6.804	9.52	73.2	161.
00	11-32	.344	220	13.75	6.237	8.73	67.1	148.
0	5-16	.3125	200	12.50	5.670	7.938	61.0	134.6
1	9-32	.2812	180	11.25	5.103	7.144	54.9	121.1
2	17-64	.2656	170	10.62	4.819	6.747	51.9	114.4
3	1-4	.2500	160	10.00	4.536	6.350	48.8	107.6
4	15-64	.2344	150	9.38	4.252	5.953	45.8	100.9
5	7-32	.2188	140	8.75	3.969	5.556	42.7	94.2
6	13-64	.2031	130	8.12	3.685	5.159	39 7	87.4
7	3-16	.1875	120	7.50	3.402	4.762	36.6	80.7
8	11-64	.1719	110	6.88	3.118	4.366	33.6	74.0
9	5-32	.1562	100	6.25	2.835	3.969	30.5	67.3
10	9-64	.1406	90	5.62	2.552	3.572	27 5	60.6
11	1-8	.1250	80	5.00	2.268	3.175	24.4	53.8
12	7-64	.1094	70	4.38	1.984	2.778	21.36	47.09
13	3-32	.0938	60	3.75	1.701	2.381	18.31	40.36
14	5-64	.0781	50	3.12	1.417	1.984	15.26	33.64
15	9-128	.0703	45	2.81	1.276	1.786	13.73	30.27
16	1-16	.0625	40	2.50	1.134	1.588	12.21	26.91
17	9-160	.0562	36	2.25	1.021	1.429	10.99	24.22
18	1-20	.0500	32	2.00	.907	1.270	9.76	21.53
19	7-160	.0438	28	1.75	.794	1.111	8.54	18.84
20	3-80	.0375	24	1.50	.680	.952	7.32	16.15
21	11-320	.0344	22	1 375	.624	.873	6.71	14.80
22	1-32	.0312	20	1.250	.567	.794	6.10	13 46
23	9-320	.0281	18	1.125	.510	.714	5.49	12.11
24	1-40	.0250	16	1.000	.454	.635	4.88	10.76
25	7-320	.0219	14	.875	.397	.556	4.27	9.42
26	3-160	.0188	12	.750	.340	.476	3.66	8.07
27	11-640	.0172	11	.688	.312	.437	3.36	7.40
28	1-64	.0156	10	.625	.284	.397	3 05	6.73
29	9-640	.0141	9	.562	.255	.357	2.75	6.05
30	$\frac{1}{80}$	.0125	8	.500	.227	.318	2.44	5.38
31	$\frac{7}{640}$	.0109	7	.438	.198	.278	2.14	4.71
32	$\frac{13}{1280}$	.0102	6½	.406	.184	.258	1.98	4.37
33	$\frac{3}{320}$	.0094	6	.375	.170	.238	1.83	4.04
34	$\frac{11}{1280}$	.0086	5½	.344	.156	.218	1.68	3.70
35	$\frac{5}{640}$	.0078	5	.312	.142	.198	1.53	3.36
36	$\frac{9}{1280}$	.00703	4½	.281	.128	.179	1.37	3.03
37	$\frac{17}{2560}$	.00664	4¼	.266	.120	.169	1.30	2.87
38	$\frac{1}{160}$	.00625	4	.250	.113	.159	1.22	2.69

The Locomotive.

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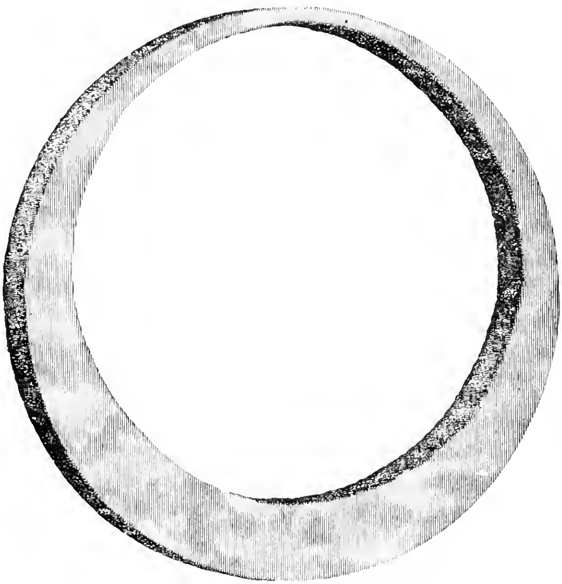
Cast-Iron Steam Pipe.

It has been said that "things that are not constant are mighty uncertain"; and the truth of this aphorism is nowhere better illustrated than in the use of cast-iron steam pipe. We have in mind a large manufacturing establishment not a thousand miles from Connecticut, where a line of 8″ cast-iron pipe had been in use as a steam main for fourteen years, carrying a pressure of 75 pounds. That part of the pipe which was in the boiler room had failed on several occasions, but each time there was some very fortunate circumstance about the accident, so that no great damage was done. It



SECTION OF CAST-IRON STEAM PIPE.

was feared, however, that this continued run of good fortune might not always prevail; and as a matter of precaution it was decided to take out the cast-iron and put in something better. The pipe in the boiler room was removed and broken up for old iron, and was replaced by a modern wrought-iron pipe with riveted flanges. The cast-iron that had been in the boiler room was entirely discarded, as we have said; but those lengths that were in the *engine* room were supposed to be of superior quality, inasmuch as they were extra heavy, and were made "on honor," and so it was thought best to preserve this part of the piping for possible future use. Not long after the pipe had been changed, the company wanted a cast-iron column for some purpose or other, and bethinking themselves of the high grade piping that they had reluctantly taken out of the engine room, they put a section of it in a lathe to cut it off to the right length; and when they made the cut, they made a discovery also. The nature of the discovery is shown in the engraving, which is made to scale from a ring of the pipe that was sent to us for the purpose. On one side the pipe was $1\frac{1}{4}$ inches thick, and on the other its thickness was a scant *quarter of an inch.* It is hardly necessary to say that the firm that had used this pipe as a steam main for fourteen years, has had enough experience with cast-iron steam pipe, even when it is "made on honor."

We do not question the good faith of the makers of the cast-iron pipe that we have described. It is probable that they believed it to be sound and perfect; and we must therefore look to the process by which such pipe is made, if we wish to find the most likely explanation of the defect. In casting large pipe a hollow iron core is used, which is perforated with numerous holes, and also studded, on the outside, with little points or projections. The core is coated to the proper thickness with a composition of flour, coarse sand, and molasses, which is held in position by the projections or studs, and the whole is placed in an oven and baked. (Bolland recommends the following mixture for covering the core: "8 parts fire-sand, 2 parts Jersey moulding-sand, 1 part flour; mix with thick clay-water.") When the covering is hard and dry, the core is placed in the mould, and the casting is made. Now the core, being hollow, and being immersed in the melted iron, will be buoyed up powerfully, and means must be provided to hold it in position. Yet even if the *ends* of the core are held firmly in position, there is danger of the middle of it springing upward by a sensible amount, unless it is quite stiff and rigid. A small amount of yielding will be sufficient to destroy the uniformity of thickness that is essential to good pipe. In the case described above, the core must have been about ten feet long, and a "spring" of half an inch at the middle (which is not at all impossible) would have been quite sufficient to account for the observed inequality in thickness.

The general conclusion to be drawn from this example, we suppose, is, that cast-iron should not be used for steam-pipe. This is a corollary to the more general proposition that cast-iron should not be used in *any* place where it will be exposed to a tensile stress. It is a good enough material for resisting compressive strains, but it is altogether too uncertain in its behavior to be trusted under tension.

Inspectors' Report.

AUGUST, 1896.

During this month our inspectors made 7,489 inspection trips, visited 15,388 boilers, inspected 6,640 both internally and externally, and subjected 723 to hydrostatic pressure. The whole number of defects reported reached 11,605, of which 1,253 were considered dangerous; 59 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment, - - - -	999 - -	45
Cases of incrustation and scale, - - -	2,047 - -	93
Cases of internal grooving, - - - - - -	103 - -	11
Cases of internal corrosion, - - - - - -	712 - -	26
Cases of external corrosion, - - - - - -	790 - -	35

Nature of Defects.	Whole Number.	Dangerous.
Broken and loose braces and stays,	164	35
Settings defective,	308	40
Furnaces out of shape,	438	30
Fractured plates,	296	63
Burned plates,	263	21
Blistered plates,	221	9
Cases of defective riveting,	1,180	178
Defective heads,	129	20
Serious leakage around tube ends,	1,953	366
Serious leakage at seams,	474	48
Defective water gauges,	445	67
Defective blow-offs,	213	55
Cases of deficiency of water,	13	5
Safety-valves overloaded,	58	25
Safety-valves defective in construction,	89	31
Pressure gauges defective,	588	47
Boilers without pressure gauges,	3	3
Unclassified defects,	119	0
Total,	11,605	1,253

Boiler Explosions.

July, 1896.

(157.) — On July 2d, the boiler of locomotive No. 230, on the Louisville & Nashville railroad, exploded, while the south-bound freight, to which the locomotive was attached, was going at twenty miles an hour down a steep grade just south of Hartselle, near Birmingham, Ala. Engineer James Jones, Fireman Daniel Atkins, and Brakeman L. Jenkins were killed, and Flagman A. C. Sanford was painfully injured, but will recover.

(158.) — The boiler of the small steamer *Hiawatha* exploded, on July 4th, at Lenape on the Brandywine, near West Chester, Pa. It does not appear that anyone was injured.

(159.) — A boiler exploded, on July 4th, in a feed mill at Keota, Keokuk County, Iowa. The property loss was considerable, but nobody was injured.

(160.) — On July 6th a boiler exploded in the Kehlor Bros. Milling Co's. "Rex" mill, at Toad-a-Loup, on the Kaw River, near Kansas City, Mo. Fireman Henry Pierce saw steam escaping from the boiler into the furnace, and warned his fellow workmen to run for their lives. Ezekiel A. Hollis, the head fireman, heard the warning, but was unable to get to a place of safety before the explosion occurred. He was pinned to the ground by tons of debris, but was protected to a certain extent by several large iron pipes. He was taken from his perilous position as soon as possible, but he had received internal injuries, and died from the effects of them on July 12th. The boiler-house was wrecked, and the property loss was estimated by Mr. D. M. Kehlor at about $10,000.

(161.) — A serious accident occurred, on July 8th, on the Peninsular division of the Chicago & Northwestern railroad, at Prombley, about twenty miles north of Escanaba, Mich. The locomotive of a north-bound freight train exploded its boiler at that place, instantly killing Engineer John Stonehouse, and seriously injuring Fireman Frank Buell. Conductor William Rogers and Brakeman Conrad Joergenson were also painfully hurt.

(162.) — On July 10th a boiler exploded at Coyote Creek, San Jose, Cal. Giacomo Carmicio was instantly killed, and James Parish, the owner of the boiler, was seriously injured. Giovanni Barbagelata and C. Malatesta also received lesser injuries.

(163.) — A boiler explosion occurred, on July 10th, at a drilling well on the Hamilton farm, in Cherrytree township, near Titusville, Pa. The dome of the boiler was torn off, and blown several hundred feet into the air, and the engine house was blown down. P. H. Quinn was struck in the head by a flying piece of grate bar, but he will recover.

(164.) — A boiler exploded, on July 11th, at the brickyard at Harrisville, near Putnam, Conn. Fortunately nobody was injured.

(165.) — A tube failed, on July 11th, in the boiler-room of the steam yacht *Aida*, as she was steaming through Long Island Sound, near New Haven. Engineer John Baker and Fireman Burton Bennett were fearfully scalded, and it is believed that Bennett will die. Baker, crazed by his pain, jumped into the sea, but was quickly rescued. The *Aida* was disabled by the bursting of a steam pipe, on July 7th; but the damages had been repaired at New London, and she was believed to be in good condition.

(166.) — A Lehigh Valley passenger train jumped the track, on July 13th, at Pond Creek, near Hazleton, Pa., and rolled down into a ravine 100 feet deep. Four persons were killed and thirty others were injured. To add to the horror of the situation the crown sheet of the boiler blew out, and the escaping steam scalded a number of the passengers.

(167.) — Albert Jameson's saw-mill, at Pembroke, near Beaver, Pa., was badly wrecked by a boiler explosion on July 13th. Mr. Jameson was scalded about the face The other members of the crew escaped unharmed.

(168.) — A boiler belonging to Dorney & Ware, at Portage, near Findlay, Ohio, exploded on July 16th, completely wrecking the power-house in which it stood. The dome of the boiler was found 1,200 feet away from its original position. No lives were lost.

(169.) — A boiler used in operating an oil well, on Davis Run, at Doddridge, near Parkersburg, W. Va., exploded on July 16th. Forrest Adams, a pumper, was instantly killed, and his body was blown to pieces.

(170.) — On July 17th, a boiler exploded in Darrett & Anderson's saw-mill, at Rossington, near Paducah, Ky. Samuel Anderson was killed, and John McCade was fatally injured, a piece of the boiler being blown through his body. Several other employes were slightly injured.

(171.) — A boiler belonging to J. B. Aaron, of Lyons, Ga., exploded on July 17th, scalding Henry Walker, the fireman.

(172.) — Charles Taylor was seriously and perhaps fatally scalded, on July 18th, by the explosion of a boiler at Bellefontaine, Ohio.

(173.) — On July 18th, a boiler exploded in James Cranston's mill, at English, Ind. Mr. Cranston, who was taking the place of the regular engineer at the time, was instantly killed. We have seen no estimate of the property loss.

(174.) — A small boiler exploded, on July 21st, in the building occupied by the Nashville Saddlery Company, of Nashville, Tenn. Jefferson Harmon was painfully injured. The pressure on the boiler at the time of the explosion was quite low.

(175.) — A boiler exploded, on July 23d, on the premises occupied by the *Syracuse Journal*, of Syracuse, Neb. Thomas Dunn, a son of the editor of the paper, was painfully scalded about the hands and legs, and had a narrow escape from death. Nobody else was injured.

(176.) — On July 25th a boiler exploded on the Housley plantation, about two miles from Crowley, La. A Mr. Carnet, to whom the place was leased, was seriously scalded and otherwise injured, as were also the engineer and a laborer. The engine and pumps used for irrigating purposes were totally demolished, and the boiler was torn to shreds.

(177.) — A small boiler used for power purposes in the residence of Henry Kettering, on the Waynesburg road, near Canton, Ohio, exploded on July 27th. Mr. Kettering, who was working at a lathe near by, was almost instantly killed, and the house was badly wrecked. According to the Canton *Repository* the property loss will amount to some thousands of dollars.

(178.) — On July 27th a boiler exploded at Dowling, a small oil town about eight miles north of Bowling Green, Ohio. Samuel Miller and Arlo Brown were killed outright and Charles Clark was fatally injured, so that he died later in the day.

(179.) — A terrible boiler explosion occurred, on July 29th, in Sullivan & Whitman's shingle mill, at Cedar, a small town about ten miles from Traverse City, Mich. Engineer Walter Scott was fatally injured, and died within two hours. Ernest Merrifield, John Cregg, William Sturgis, Charles Chinner, and John Peterson were badly scalded and otherwise hurt, and five other men received lesser injuries. Fragments of the boiler were found nearly half a mile away. The building in which it stood was partially wrecked, so that the damage to property will amount to about $3,000.

(180.) — Forty-two persons were killed and eighty others injured, on July 30th, in a railway collision about two miles west of Atlantic City, N. J. A few minutes after the collision the boiler of one of the locomotives exploded, throwing scalding steam and water over many of the injured passengers.

August, 1896.

(181.) — A boiler exploded, on August 1st, at the Hugh Morrow brick and tile works, about one mile south of Lisbon, Ohio. John McGeehan was fearfully scalded about the head, arms, and body, and his recovery is doubtful. Homer Fleming was also scalded over his entire right side, and Frank Spence was slightly burned about the legs. The accident fortunately occurred in the morning, about fifteen minutes before the men had assembled for work.

(182.) — A boiler belonging to John Aylward, and used to pump water on the railroad reservation at Livermore, Cal., exploded on August 2d. The fire-box was found about 1,500 feet from its original position. Nobody was injured, although there were two narrow escapes from death.

(183.) — On August 4th a boiler tube failed at the New York Steam Heating Company's plant, on Washington street, New York city. Joseph Moore was severely scalded.

(184.) — A boiler explosion occurred, on August 4th, in a flouring mill owned by the James Quirk Milling Company, at Montgomery, Minn. Engineer John Budarsh was killed, and the engine-room, boiler-room, and the north side of the mill were wrecked. The property loss is estimated at $10,000. W. H. Miller, who formerly owned the mill, became violently insane when he learned of the explosion and its consequences, and attempted to commit suicide.

(185.) — The boiler of a threshing machine outfit belonging to Joel Menefee exploded on August 6th near Anderson, Ind. David Wynant was instantly killed, and Daniel Wynant and several others were injured. The threshing outfit was blown to fragments.

(186.) — On August 6th a boiler exploded in the Barrs Lumber Company's mill, at High Springs, Fla. Nelson Bell was fearfully scalded and will die. J. C. Barrs and J. F. Easterling were seriously injured, so that Barrs died next day. Easterling will recover. We have seen no estimate of the damage done.

(187.) — A small upright boiler exploded, on August 7th, at the Park Place Collieries, near Ashland, Pa. Percival Snell was instantly killed and Michael Condren was fatally scalded Edward Davis and John Reese were also badly scalded and bruised, but their injuries, though serious, did not prove to be fatal. The boiler was used for pumping, and the fire had not been started under it more than an hour when the explosion occurred. At the inquest Reese testified that five or ten minutes before the explosion the steam gauge registered 20 pounds. Davis testified that he examined the gauge not more than one minute before the explosion, and that it then registered 24 pounds. The jury did not fix the responsibility for the accident.

(188.) — A threshing machine boiler exploded, on August 7th, at Elgin, near Rochester, Minn. Schuyler Bigelow and one other man were seriously injured, and it is not certain whether they will recover or not.

(189.) — A boiler exploded on August 7th, in Layman's canning factory at Troutville, twelve miles north of Roanoke, Va. A. L. Linkenhoker, W. Tallmer, and A. F. Shannon were killed, and the factory was demolished. Fragments of the boiler were thrown 300 yards.

(190.) — On August 8th a boiler exploded in a hide and fat rendering establishment operated by Chas. D. Parks at Mill Plain, near Danbury, Conn. A fire followed the explosion. The property loss was about $3,000. Nobody was injured.

(191.) — A boiler exploded on August 10th in a mill near Cabot, Ark. Dennis Beasley was killed, and P. P. Benson and three other persons were badly scalded and otherwise injured. The mill was completely demolished.

(192.) — A boiler explosion occurred on August 11th at the Mt. Pleasant mines, near Paris, Ohio. No one was injured.

(193.) — On August 13th a boiler exploded in the Louisville Brick and Tile Company's plant at Maximo, five miles west of Alliance, Ohio. Isaac J. Johnson was fatally injured by a fragment of the boiler. Levi Eshelman, Eugene Grisez, John Rufenaft, William Sefong, Sheridan Sell, and Samuel Snyder were severely injured. The ruins took fire after the explosion, and were consumed. The property loss is estimated at $18,000.

(194.) — A disastrous boiler explosion occurred on August 13th at Somerford's mill in the Brazos bottom, about five miles from Navasota, Tex. James Winzer, Benjamin

Johnson, and Henry Williams were killed outright, and Edward Johnson was fatally scalded. Frank Somerford, M. R. Henry, and Edward Henry were seriously injured. The mill was blown to atoms, and the flues of the boiler were projected across the Brazos River and into another county.

(195.) — By the explosion of a boiler in A. W. Gillingham's saw-mill near Prince Albert, and some forty miles from McLeod, N. W. T., on August 15th, three men named Smith, May, and Edsall were killed, two of them being torn to pieces. The mill was completely wrecked, and its owner was slightly injured.

(196.) — The boiler of switch engine No. 35, on the Colorado Midland Railroad, exploded at Basalt, Colo., on August 16th. Charles Peterson was hurt badly, but not fatally, and a tramp received slight injuries. The boiler was blown over a thousand feet away, and the locomotive was completely wrecked.

(197.) — On August 15th a boiler exploded in the Big Four pumping station at Shelby Junction, near Mansfield, Ohio. The building was completely demolished. Nobody was present at the time.

(198.) — A boiler exploded on August 16th at the Fisher Oil Co.'s No. 8 well, on the Tull farm, just across the Ohio River from Sistersville, W. Va. The derrick and a tank containing 250 barrels of oil took fire, and were consumed. The loss is estimated at $3,000.

(199.) — On August 17th a threshing-machine boiler exploded in a harvest field owned by Dr. Sidney Allen of Allensville, ten miles south of Winchester, Ky. Dallas Haggard, Travis Haggard, Will Berryman, and Alex. Turpin, four boys on their way home from school, were killed.

(200.) — On August 17th a boiler exploded in Taft's mill at Troy, Montgomery County, N. C. Samuel Ewing, John Ellis, Edward Dickson, Charles Morris, and James Capet were instantly killed, and four other men were injured, three of whom will die.

(201.) — A boiler belonging to Joseph C. Holmes, of Williamsport, Pa., exploded on August 18th. Walter Holmes, a son of the owner of the boiler, was thrown 100 feet, and received severe bruises and scalds, from which he may not recover.

(202.) — A boiler used in constructing a sewer at Rochester, N. Y., exploded on August 19th. John H. Holliday was killed, and William Fuller, John A. Metzger, Frank Sloan, and Patrick Slattery were badly injured, but will recover. Charles Palmer and several others received minor injuries.

(203.) — On August 20th a boiler exploded in Thomas T. Miller's saw-mill at Clear Creek, fifteen miles northeast of Nevada, Mo., killing Miller and William Hines, and fatally injuring William Brown. The boiler was blown 250 feet from its original position.

(204.) — The boiler of the steamer *Manitou*, at Clark's Lake, near Jackson, Mich., exploded on August 20th, while carrying 100 passengers to meet a train. Engineer Frederick Hinckley, Robert Tawse, and a Mrs. Jewell were badly scalded, but will recover. A number of the passengers jumped into the lake, but all of them were rescued. F. C. Badgley, the owner of the *Manitou*, says that that boiler was tested at 150 pounds by a Government inspector only about three weeks before the explosion. The canopy of the steamer was blown away, but fortunately her hull was not injured.

(205.) — A small boiler belonging to Jebeles Brothers, of Anniston, Ala., exploded on August 20th. Nobody was hurt, and the damage was not great.

(206.) — A threshing-machine boiler exploded, on August 20th, at Farmersville, near Dayton, Ohio. The workmen were at supper at the time, and nobody was injured. A tobacco shed was partly destroyed.

(207.) — A boiler exploded, on August 21st, in the Pennsylvania railroad car shops at Pavonia, near Philadelphia, Pa. Frank Smith, a fireman, was badly scalded about the face and legs, and the boiler-house was wrecked.

(208.) — A boiler in the Elm Grove cotton mills, at Lincolnton, near Charlotte, N. C., exploded on August 21st. Nobody was injured. We have seen no estimate of the property loss.

(209.) — A boiler in George Taylor's boiler shop at St. Thomas, Ontario, exploded on August 22d. George Taylor, Mrs. George Blanchard, Arthur Charlton, Alexander Taylor, and David McManus were slightly injured, and the roof and one side of the building were torn away.

(210.) — On August 22d, a boiler exploded in C. W. Smith's grist mill, at Boston, Ky. C. W. Smith, William B. Troutman, George Hill, John Starks, Jefferson Wells, and Wiley Edwards were slightly injured.

(211.) — A threshing-machine boiler exploded, on August 26th, on Jacob Weidrick's farm at Tripp, near Mitchell, S. D. Jacob Eisenbaum and Philip Hirsch were killed, and Weidrick was injured so badly that he died on the 29th.

(212.) — A boiler exploded, on August 26th, in the flouring mill of H. Keppel & Son at Zeeland, near Holland, Mich. Cornelius Zwagerman, the engineer, was seriously injured, and remained unconscious from the shock for twenty-four hours. He may recover. L. Schut and several others were slightly hurt. The damage to the mill and to adjoining buildings was about $2,000.

(213.) — On August 26th, a small boiler exploded in a barber shop and bath house owned by D. H. Sniffins, of White Plains, Westchester county, N. Y. Nobody was hurt, and the damage was small.

(214.) — A boiler exploded, on August 26th, in the steam laundry at Sheldon, Iowa. We have not received particulars.

(215.) — A boiler exploded, on August 27th, in Level & Smith's mill at English, Ind. Tolbert Doodey and Samuel Doods were instantly killed, and William Cumming was badly scalded about the body and face.

(216.) — On August 27th a boiler exploded at an oil well at Jersey City, near Bowling Green, Ohio. Some warning of the impending explosion was given by the boiler, and the men escaped without injury. The pump house was blown to atoms, and a hole was made in the ground ten feet deep where the boiler stood. The entire boiler was blown about 300 feet from its original position, passing through a tank of oil on the way. The gas and oil were ignited and a terrible fire followed.

(217.) — A threshing-machine boiler, belonging to Alexander Curtiss, exploded at Wood Lake, Minn., on August 28th. Nobody was hurt.

(218.) — A terrible boiler explosion occurred on August 28th, at Harris' cotton gin, near Whitney, Texas. Two men were killed and five others were injured.

(219.) — On August 29th, a boiler exploded in the new flax mill at Shakespeare, near Stratford, Ont. The stone building in which it stood was completely wrecked.

(220.) — The first accident that has occurred on the cog-railroad up Pike's Peak, Colo., took place on August 30th. The side bars on the locomotive broke, rendering the compressed air-brakes useless. The engineer and fireman saved themselves by jumping. The conductor stopped the passenger car by the emergency brakes, but as no couplings are used (the cars being merely pushed up the road), the locomotive rushed down the 25 per cent. grade at a terrific speed and jumped the track. As it did so, the boiler exploded. The train was a special one, carrying a party of English railroad men with ladies.

(221.)— A boiler exploded on August 31st, in Thomas Moore's saw-mill at Garrett's Bend, Lincoln county, W. Va., killing the proprietor of the mill and his son Thomas, and severely injuring Henry Platt and Tandy Chandler.

Asbestos.

There is probably no production of inorganic nature about which there is so much popular mystery and misconception as asbestos. It is vaguely understood that the principal claim of this remarkable product to attention is that it cannot be consumed by fire, and not infrequently the effect of the mention of asbestos is to carry the hearer back to the days when the people of the Pharaohs wrapped their dead in cere-cloths woven from the fiber, in order to preserve them, the body having been first embalmed. Romantic stories have also come down to us of ancient demonstrations of magic in which asbestos has played the leading part, but the real interest in asbestos centers in the present. It is of more importance to the human race to-day than it has been in the whole range of history.

Asbestos has been found in all quarters of the globe. It comes from Italy, China, Japan, Australia, Spain, Portugal, Hungary, Germany, Russia, the Cape, Central Africa, Canada, Newfoundland, this country, and from Southern and Central America. The asbestos generally found in the United States, especially in Virginia, the Carolinas, and Texas, also in Staten Island, New Jersey, and Pennsylvania, is in appearance like fossilized wood.

Notwithstanding this wide distribution of asbestos, the only varieties which at present appear to demand serious consideration, from a commercial point of view, are the Russian, the South African, the Italian, and the Canadian. The principal claim possessed by the Russian fiber to a place in this quartet is based on the enormous extent of the deposits which have been discovered in East Russia, beyond the Ural Mountains, and Russian Siberia. So far their specimens have been of comparatively poor quality. The yield is used almost entirely in Europe, where it is mixed with the Canadian for spinning, making paper, and other purposes where an inferior grade can be utilized.

Before the development of the Canadian fields, the Italian asbestos was supreme in the market. For nearly twenty years Italy has been looked to for the best grades of the fiber. But the Italian asbestos industry, once so important, is already on the down grade The difficulties of mining are very great, and unduly increase the cost of production. The asbestos itself, judged by the latest standards, is of inferior quality; it is not easy to spin, and it does not pulp well in the making of paper. As a matter of fact, Canada contains the great asbestos region of the world, in the sense that while its mines are practically unlimited in productive capacity, the product is of a quality which fully meets the requirements of the newest and most exacting of the innumerable uses that are daily being found for it. — H. G. Guy, in the *N. Y. Post.*

The Locomotive.

HARTFORD, OCTOBER 15, 1896.

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

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

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

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

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

WE are indebted to Messrs. John Wiley & Sons, 53 East Tenth Street, New York, for a copy of the second edition of Mr. H. C. Reagan's *Locomotive Mechanism and Engineering.* The first edition of this work was noticed in THE LOCOMOTIVE for March, 1894, and the necessity of issuing a second edition within two years and a half shows that it has met with the reception, among engineering men, that it so well deserves. The work has been amplified, in the present reproduction, by the addition of over a hundred pages of new matter relating to *The Modern Electric Locomotive*, which will materially increase its usefulness.

Boiler Inspection and Insurance.

We take the following from the *Practical Engineer*, a bright and enterprising contemporary published in Manchester, England:

"The work of boiler insurance and inspection [in England] has, during the last year or two, steadily drifted into the hands of the leading companies. Some few years ago quite a number of companies undertook to do this work, but the stress of competition and enlargement of responsibilities have made the struggle for existence much keener and more difficult to sustain by the smaller ones. Several years ago the Midland Insurance Company was absorbed by the England and Scottish Company, which, we believe, also took over the boilers of the Scotch Insurance Company. Subsequently the Yorkshire Boiler Insurance Company absorbed the London Mutual Insurance Company, and also, we believe, another small one known as the Leeds and North of England Company.

"This swallowing process has since been continued a step further by the absorption in its turn of the Yorkshire Company, which has been taken over by the Boiler Insurance and Steam Power Company, of Manchester, which is now, we believe, the largest boiler insurance and inspection company in the world, having upwards of 40,000 boilers under its care.

"A few weeks ago an agreement was made between the Engine, Boiler, and Employer's Company and the British Steam Users' Insurance Company, both having their headquarters in Manchester, by which the latter virtually becomes extinct, its work being taken over by the Engine and Boiler Insurance Company.

"The whole work of independent engine and boiler inspection and insurance in this country is now, therefore, conducted exclusively by four companies, all of which, with the exception of the English and Scottish Company, have their headquarters in Manchester. Although we cannot give the precise number of boilers enrolled with each company we shall probably be within the mark in stating that the aggregate of the four companies named is upwards of 80,000. In addition to these companies there is also the Manchester Steam Users' Association, which at the present time has about 6,000 boilers under its care."

We are pleased to learn of the growth and prosperity of our neighbors across the pond, but we take this occasion of saying that we cannot yet concede to the Boiler Insurance and Steam Power Company of Manchester the credit of being "the largest boiler insurance and inspection company in the world." A few figures concerning our own business may be permissible, perhaps, because we do not often thrust them upon our readers' attention. On June 30, 1896, we had under our charge no less than 62,563 boilers, which exceeds, by more than fifty per cent., the number enrolled with the English company. If the magnitude of our business be estimated by the amount of money we have at risk upon these boilers, we are confident that we shall make a still better showing; for the sum total of all the policies in force on June 30, 1896, was $269,835,668, or about £54,000,000. The United States Government, in its work of inspecting marine boilers, and other boilers that may come under its jurisdiction, employs 72 inspectors; while the Hartford Steam Boiler Inspection and Insurance Company employs 140 inspectors, or about twice as many.

Notes on Coal Mining.

By an Idle Correspondent.

Having learned all there is to be known about soft coal mining (as related in The Locomotive of some months ago), and having filled my note-book with data and my pocket with specimens, I went forth into Pittsburgh again, and cast about for something else to see. I found it; but I am not going to tell, yet, what it was, partly because my thoughts are not quite ripe for expression, but principally because while I am on the question of coal, I want to treat it exhaustively, so that any person who reads what I have to say may be prepared to go into the mining business at once, without further preparation. So we will suppose, for the sake of argument, that I went straight to Scranton, and gave my undivided attention to what the miners do there; and later on we will return again to Pittsburgh.

Promptly upon reaching Scranton I expressed a consuming desire to go down a mine, and I found that it was not hard to gain the coveted permission. Superintendent Phillips, of the Oxford mine, kindly offered me the privilege, and sent along a most intelligent workman, named Evans, to serve as guide, philosopher, and friend. Evans, from his intimate knowledge of the place, was ideal as a guide; as a philosopher, too, he has few peers, for sage thoughts oozed out from him at every pore; and lastly, his friendship was amply proven, the moment he took me in charge, by a timely warning that very likely prevented my heart from popping out of my mouth. The engineers in charge of the hoisting apparatus, he explained, take delight in frightening tenderfeet by letting them down the shaft so swiftly as to give them the impression that the end of all things is at hand, and that the heavens are about to be rolled up into a scroll, with the mine on the inside. I found it was even so. We stepped into the cage and Evans rang a bell. Then the bottom fell out of something, and away we went, down into voids below that I knew not of. We fell, I think, about fifty yards, our feet barely touching the floor of the cage. A hurried calculation showed that at the rate we were falling we should knock a hole in China in four minutes; but things began to slacken up about that time, and in a few seconds more we came to an easy stop at a depth of three hundred feet.

Evans had a smoky torch in his hands, but it did me little good, for my eyes were not accustomed to such sudden plunges into darkness. We passed from the cage into a particularly black-looking hole in the rock, which, as I presently found, led to where the men were at work. The coal is handled below ground by means of cars running on rails and drawn by mule power. We would go first to the "stable", he said; and we did so. As we approached it I saw numerous lamps and torches flitting about, and heard Evans call out familiarly to the men that were carrying them. Presently he cried out to me to "look out," and I sprang back just in time to miss a friendly pass that had been made in my direction by the hind legs of a mule that I hadn't seen before. "They don't like strangers," explained Evans; but I begged him not to apologize, because a mule, *being* a mule, couldn't be expected to know a good thing when he saw it. The stable was really an interesting place, and although the poor animals are well fed and cared for, I dare say they stay there till they die. Some friend of the mule ought to post a notice over the entrance to the mine, stating in mule language, that "who enters here, leaves hope behind." Evans led me up to one of the mangers very quietly, and then suddenly thrust his torch down into it. Two enormous rats sprang up, and made tracks for elsewhere. I should like to say how big a mine-rat is, but a strict statement of the facts would injure the reputation of THE LOCOMOTIVE for veracity, and so I will be conservative and only say that both of those that I saw were larger than good-sized cats.

FIG. 1.—FLASH LIGHT VIEW IN A COAL MINE.

Leaving the stable, we passed through numerous tunnels and passages, which were closed every here and there by air-tight doors, whose purpose it is to regulate the ventilation of the mine. I had expressed a wish to photograph some part of the lower regions by a flash-light, and permission had freely been given, on condition that I would allow Evans to select the place. This he did, and when we reached a part known as the "Zacharias Chamber," I took the view which is reproduced in Fig. 1. The upright timbers on the right and left of the picture are used to support the roof of the chamber, which is about three hundred feet below the surface of the ground. In parts of the mines that have long been worked out, the decay of these timbers occasionally allows the roof of a passage or chamber to cave in, and this often makes trouble in the city of Scranton, overhead. I saw numerous buildings which had been cracked or thrown out of plumb by a subsidence of the surface due to this cause. I do not know whether the mine owners are legally liable for that kind of damage or not. I learned of one case in which damage done to a church was made good, but that may have been simply on account of the Christian character of the majority of the directors of the mine.

Some curious results follow, at times, from the caving of a chamber or tunnel. In most places when a man buys a piece of land, he buys a solid cone of it, that goes way down to the center of the earth; but in the coal regions he gets nothing for his money but the top skin, with enough thickness for a reasonable cellar; and he doesn't know whether his house is built upon a solid rock, or upon an aching void. In one instance that came to my attention a house owner went down cellar, and nearly stepped off into space, discovering, just in time, that the bottom of his cellar had dropped out. In another case a sewer was put through a certain street, and one person who had a cess-pool, but who was not prepared to pay his assessment for the sewer, was taken to task by the board of health. Legal complications followed, but the matter was amicably settled by a cave-in, which tied a knot in the sewer, and drained the contents of the cess-pool down into the bowels of the earth.

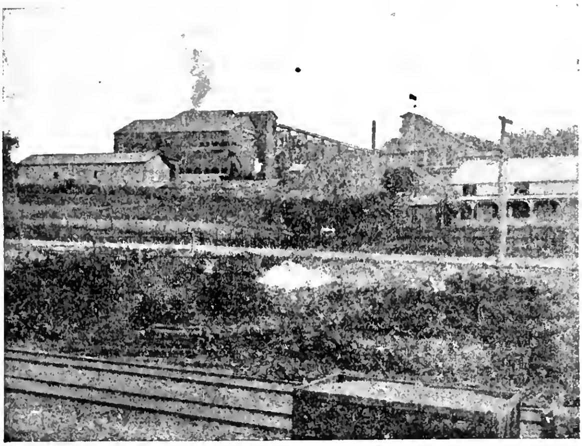


Fig. 2.—A Breaker near Scranton, showing Coal Dust.

Having seen the mine from below, I went to the surface and looked it over critically from above. The coal is brought up from the mines on cars, each car containing about $2\frac{1}{4}$ tons, about one-third of which is waste. It is first thrown into a crusher which reduces it to the size desired, after which it is screened to separate the smaller particles, and then it rolls down through a series of conductors or chutes, where a small army of boys are supposed to watch it with eagle eyes as it passes by, for the purpose of extracting such fragments of slate as it may contain. As a rule the boys have no great love for the work, and one or more overseers stand over them constantly, urging them, by word, action, and a broom or other equivalent device, to "get busy." The language of one of the overseers that I watched was chaste but vigorous, and he understood his broom thoroughly. One might fancy himself, for the moment, in a slave-holders' camp, instead of a modern coal-breaker; but the resemblance is purely superficial, for the best of feeling prevailed, so far as I could learn, and the boys are as happy as any boy could hope to be, when restrained from going fishing or playing marbles. I wanted to photograph the boys at work, but the light in the breaker was not strong enough. The best that I could do, under the circumstances, was to take the view shown in Fig. 2, where the "smoke" that is seen rising from the breakers is not smoke at all, but merely coal-dust that is rising from the coal below as it rattles down the chutes. A reader with active imagination can perhaps picture to himself about three dozen dirty-faced boys inside the building, watched over by a voluble foreman, who is doubtless even now punctuating his remarks with the all-important broom.

The *waste* from a hard coal mine is far more imposing than the salable product, since it remains behind, near the mine, and gives mute testimony of the size of the hole from which it was drawn, and of the vast magnitude of the coal interests. The piles of waste or culm ("collom", they call it down there.) form marked features of the landscape all through the region about Scranton. They stretch along the Lackawanna valley for over thirty miles, from Forest City to Nanticoke, Avondale, and Plymouth, and across to the Schuylkill region. Some idea of their vast size may be had from Fig. 3, which shows one of the Scranton culm piles with two women in the immediate foreground, picking particles of coal from the bank for cooking the family dinner. Fig. 4 may possibly give an even better idea of the culm piles, as it shows a railroad bridge between two of them, the distance from the rails to the roadway below being upwards of eighty feet.

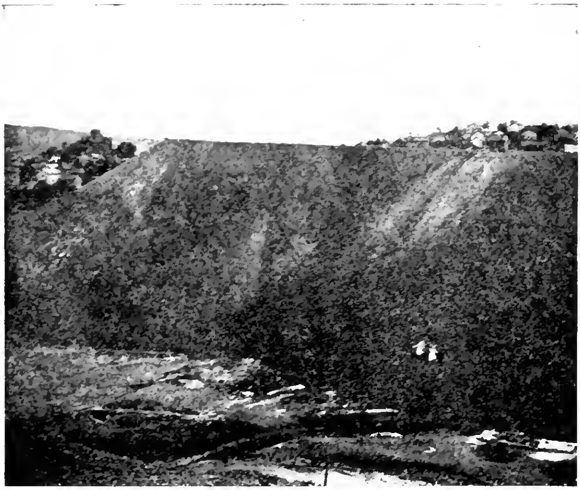


FIG. 3. — A CULM PILE.

Many attempts have been made to utilize the culm, and special grates and other devices have been invented for burning it. The mine owners usually dump the better grades of waste in a particular place, where they sell it quite cheaply to those who may want to use it for fuel. Some idea of the expense of the culm as fuel may be had from the following figures, which were given me by a Scranton mill superintendent who uses it almost exclusively: The mill in question has nine boilers, which furnish about 1,300 horse-power. The average culm consumption is 28 loads per day, each load containing about 1½ tons. The culm itself costs 15 cents a load, and the cartage costs 35 cents, making the total cost of the culm, delivered in the boiler room, about 33 cents a ton. These figures show that the consumption of good culm, per horse-power per hour, with an efficient power plant, is about 6½ pounds. The cartage, it will be seen, costs more

FIG. 4. — RAILROAD BRIDGE BETWEEN CULM PILES.

than twice as much as the fuel itself, in the special case here quoted. To lessen this item of expense, factories are often built close to the culm bank, so that the fuel requires very little handling.

The first impression that one has, upon viewing the great culm piles of this region, is that something ought to be done to utilize the carbon thus thrown to waste. Dear reader, this thought has occurred to thousands of inventive minds, and its solution has been attempted from various directions. I do not want to disparage what has been done, nor to frighten the genius who may show us the key to the secret; but a mere glance at the region is sufficient to show that the efforts that have been made, thus far, have not met with unqualified success. One fact that is not immediately obvious, but which may chill the fervor of the most enthusiastic inventor, is, that many of these piles are afire on the inside, and have been burning so long that they are probably reduced to mere heaps of slate and ashes, except near the surface. Smoke can sometimes be seen rising lazily from them, and even those that appear quite sound may prove to be red-hot within, if we dig down into them a few feet. I know nothing of the *origin* of the culm fires, but for a guess I should say that the banks take fire spontaneously, by some process not yet understood.

We have received the *Report*, for 1895, of the Chief Engineer of the Engine, Boiler, and Employers' Liability Insurance Company, Limited, of Manchester, England. Among other noteworthy and interesting features, we observe, with a certain feeling of relief, that in England as well as in some other countries there is occasionally a disposition on the part of those having second-hand boilers for sale, to conceal their defects with a beautiful coat of tar or other equally effective "protective" covering. Two cases cited in the *Report* are here quoted: The first of them relates to a "second-hand Lancashire boiler, offered for sale to work at 65 pounds pressure. The inspector found the heads grooved over the furnaces, and the furnace and shell plates grooved at all the circular seams. All these defects had been *most carefully covered by a hard cement*, apparently of cast-iron borings, and the surfaces made perfectly smooth and even. This cement was exceedingly hard and difficult to remove, but as far as the inspector could estimate, the boiler was generally reduced by about $\frac{1}{8}$ of an inch, and in places more. Indeed, having regard to the care which had evidently been taken in preparing it for examination, it is quite likely that its real condition was much worse than it appeared to be to the inspector. Anyhow, it was not fit for the pressure required, nor was it, in other respects, a desirable boiler to purchase." The second case relates also to a Lancashire boiler, which was examined by one of the company's inspectors on behalf of a prospective purchaser, and found quite unfit for the pressure required, and unfit for any pressure without considerable repairs. The furnace plates were grooved from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. around the edges of the Bowling hoop by which the several rings were joined, and also in other places. "The grooving in the furnaces *had been carefully filled with cement*, and the entire boiler tarred inside. Under such circumstances it was difficult to ascertain the true condition of the plates. However, the inspector saw sufficient to convince him that the boiler was not a desirable one, even at the price of £60 [$300], which was to include 'an excellent set of mountings.'"

We cannot understand the particular streak in human nature that would lead a man, or a corporation, to fill up a dangerous groove with cement, and then try to realize $300 on the boiler, by selling it to an innocent man who may presently be blown by it beyond the orbit of Saturn. We don't expect, in the boiler business, that the man that sells a boiler is going to make a too literal application of the Golden Rule, but it is reasonable to ask him not to imperil the lives of half a dozen men with families, for the sake of a few more cart-wheels in his inside pocket. This state of things is not peculiar to England, however. As intimated above, we have known of its occurrence elsewhere.

So far as the number of boiler explosions in England is concerned, the *Report* says that "the Board of Trade Reports for 1895, so far as they have been received, contain particulars of 111 explosions, collapses, and mishaps of various kinds, causing the death of 43 persons."

The Locomotive.

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A Form of Quadruple-Riveted Butt Joint.

In the issue of THE LOCOMOTIVE for July, 1891, a triple-riveted butt joint was described, and the method of calculating its efficiency was explained and illustrated by a numerical example. The joint to be considered in the present article is similar to it in general design, except that it has *four* rows of rivets on each side of the joint instead of *three*, the pitches of the rivets being proportioned as follows: The two inner rows on either side of the joint are pitched alike, at a distance denoted by p in Fig. 1. These rivets pass through the main sheet, and through both of the covering straps. Next outside of these, there comes a row of rivets in double pitch, as indicated by $2p$ in Fig.

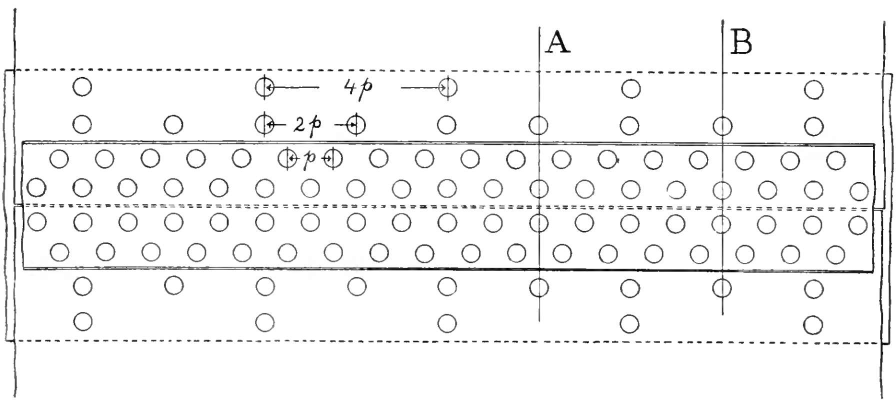

FIG. 1 — QUADRUPLE-RIVETED BUTT STRAP JOINT.

1, these rivets passing through the main sheet and through the *inner* strap. Thus far the joint is like the triple-riveted one already referred to; and its distinctive peculiarity lies in the fact that the inner strap is further extended, as shown in Fig. 1, so as to admit of a *fourth* row of rivets, whose pitch is $4p$.

The advantage claimed for these quadruple-riveted butt joints is, that they may be made to have a greater efficiency than the triple riveted form; and as the quadruple joints are coming somewhat into use, we shall describe the method of calculating their strength.

In this joint, as in every other form, it is necessary to consider each possible mode of failure separately, calculating the efficiency in every case, and taking the smallest of the various results as the true efficiency of the joint. This is in accordance with the general maxim that the strength of any structure is equal merely to the strength of its weakest part. The various possible modes of failure in the present case may be enumerated thus: (1) the joint may fail by the plate fracturing through the outside row of rivets, as indicated in plan and section in Fig. 2; (2) it may fail by a fracture of the plate through the next-to-outside row of rivets, combined with a shear of the outermost row, as shown in Fig. 3; (3) it may fail by a fracture of the plate through the next-to-inner row of rivets, and a shear of the two outer rows, as indicated in Fig. 4; and lastly (4) it may fail by shearing all the rivets, as in Fig. 6. These are the modes of failure that must always be considered in calculating the strength of a joint of this kind. Several other modes may also appear to be possible at first sight, and although these ought certainly to be considered, it will not, in general, be necessary to make any additional computations in order to cover them, since in any joint that even approaches to reason, these other modes of failure cannot occur. One of them is indicated in Fig. 5, which shows the main plate fractured through the inner row of rivets, all the other rivets being sheared. It is plain that this cannot happen in the actual joint, however, because the area of plate fractured in Fig. 5 is precisely the same as in Fig. 4, while the number of rivets that must be sheared is much greater in Fig. 5, and therefore the joint would always give way in the mode shown in Fig. 4, before the strain could become great enough to cause a fracture by the method shown in Fig. 5. Again, it might be thought that the joint could fail by some sort of a fracture of the straps, combined perhaps with a shear of certain of the rivets; but any mode of fracture involving a break across these straps can be prevented by making the straps thick enough. They should always be made of material as good as that of which the plate itself is composed, and in order to secure the necessary strength, the thickness of each strap should not be less than three-fourths of the thickness of the plate. Some engineers recommend making them the full thickness of the sheets, but this is not necessary. To show that the straps are stronger than other parts of the joint, we shall consider them in detail at the close of this article; but for the present we shall confine our attention to the four probable modes of failure enumerated above.

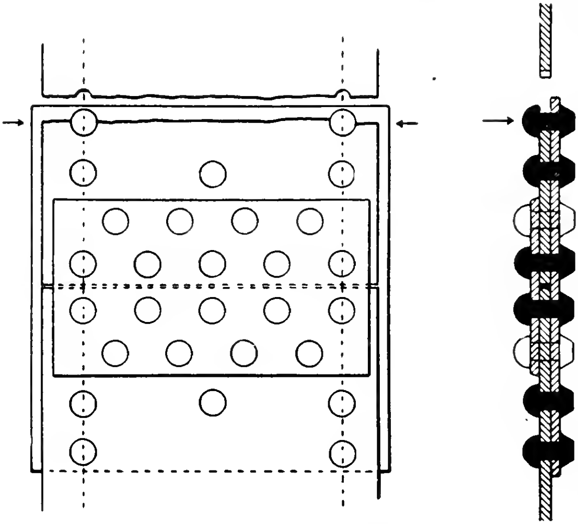

FIG. 2.—FRACTURE THROUGH OUTSIDE ROW OF RIVETS.

PROPORTIONS OF THE ILLUSTRATIVE JOINT.

As a basis for the calculations, we shall assume the following data:

Plates are of steel, with tensile strength of 60,000 pounds.

Rivets are of iron, with shearing strength of 38,000 pounds.

Thickness of plate = $\frac{7}{16}''$.

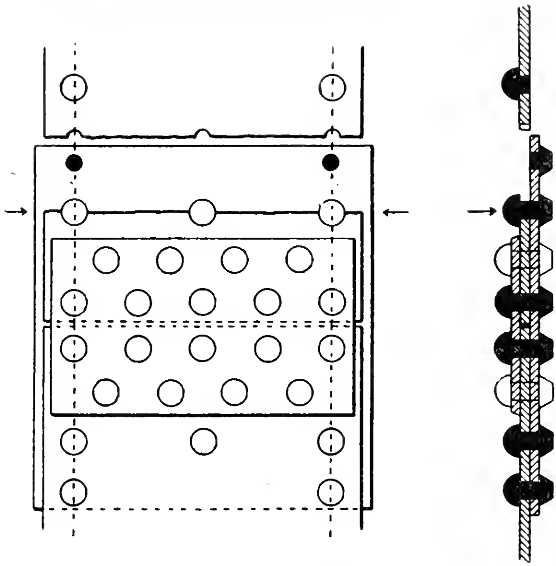

Fig. 3.—Fracture through the Next-to-Outside Row of Rivets.

Diameter of rivet = $\frac{13}{16}''$.

Diameter of rivet hole = $\frac{7}{8}''$.

Pitch of rivets in inner rows (= p in Fig. 1) = $4\frac{1}{16}''$.

From these data we find

Sectional area of rivet when driven = $.7854 \times \frac{7}{8} \times \frac{7}{8} = .6013$ sq. in.

Shearing strength of one rivet (single shear) = $.6013 \times 38,000 = 22,850$ lbs.

If the joint fails as shown in Fig. 6, the rivets that are shaded with cross lines must each be sheared in two places. It is found by experiment that the force required to double-shear a rivet in this way is not twice as great as that required for a single shear, but is only about 85 per cent. greater. That is, a rivet with a sectional area of one square inch will resist a double shear with a force 85 per cent. greater than 38,000 lbs.; 85 per cent. of 38,000 is 32,300, and hence the resistance of an iron rivet to double shear is to be taken as $38,000 + 32,300 = 70,300$ pounds for each square inch of sectional area.

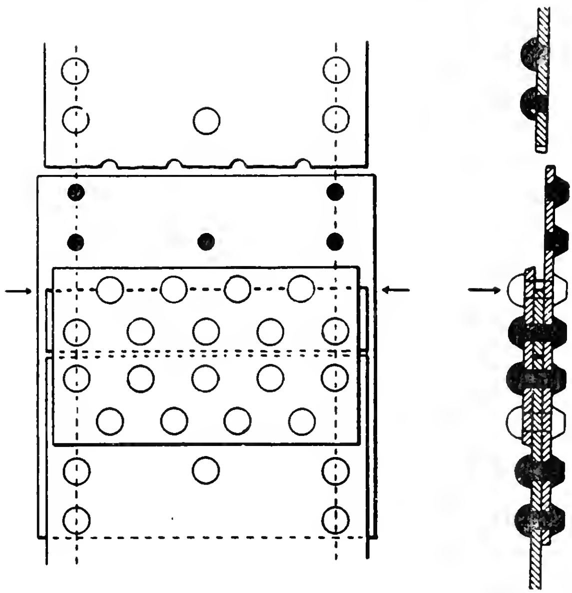

Fig. 4.—Fracture through the Next-to-Inside Row of Rivets.

In computations on riveted joints it is not necessary to consider the whole length of the joint. It is sufficient to investigate a unit of such length that the entire joint consists in a mere repetition of units of this kind. In Fig. 1, for example, it will only be necessary to consider that part which lies between the vertical lines *A B*; for it is evident that by repeating this portion indefinitely the entire joint may be constructed. The length of this section, in the form of joint under consideration, is equal to four times the pitch of the rivets in the inner rows. That is, with the data given above, the length of the unit *A B* is $4 \times 4\frac{1}{16}'' = 16\frac{1}{4}''$.

FIRST MODE OF FAILURE.

If the joint breaks across the outer row of rivets, as shown in Fig. 2, the length of the fracture, in each unit of the joint, is equal to $16\frac{1}{4}''$ less the diameter of one rivet hole; that is, it is $16\frac{1}{4}'' - \frac{7}{8}'' = 15\frac{3}{8}'' = 15.375''$. The efficiency of the joint, if failure occurs in this way, is found by comparing this length with the length ($16\frac{1}{4}''$) that must be broken across if the solid plate should fracture. Hence the efficiency of the joint, so far as this form of failure is concerned, is $15.375 \div 16.25 = .946$, or 94.6 per cent.

SECOND MODE OF FAILURE.

If failure occurs as shown in Fig. 3, we have a fracture whose length is $16\frac{1}{4}''$ less the diameter of *two* rivet holes, and also the shear of one rivet. (The cut, it is true, shows two sheared rivets; but only one-half of each of these is between the dotted lines that mark the limits of the unit-length of joint that is under consideration, and hence only half of each rivet is to be counted. Care must be taken, in all computations relating to joints, to take into account exactly as much as lies within the unit-length of the joint, and no more.) The combined diameters of two rivet holes are equal to $1\frac{3}{4}''$; and hence the length of the fracture in the plate is $16.25'' - 1.75'' = 14.50''$. The plate being $\frac{7}{16}''$ thick, we find that the sectional area of the fracture is $\frac{7}{16} \times 14.50 = 6.344$ sq. in.; and hence the force that must be exerted to produce this fracture is $6.344 \times 60,000 = 380,640$ lbs. To this we must add 22,850 lbs., which is the strength of the rivet that must be sheared in the outer row. Hence we find that the total force required to fracture the joint by the method shown in Fig. 3, is $380,640 + 22,850 = 403,490$ lbs. To get the efficiency of the joint for this mode of failure, we must compare the strength so obtained with the strength of the solid plate. The length of the unit of joint under consideration being $16\frac{1}{4}''$, and the thickness of the plate being $\frac{7}{16}''$, the sectional area of the solid plate is $16.25 \times \frac{7}{16} = 7.109$ sq. in.; and this, multiplied by 60,000 lbs., gives $7.109 \times 60,000 = 426,540$ lbs., which is the strength of the solid plate. Hence the efficiency of the joint, so far as this form of failure is concerned, is $403,490 \div 426,540 = .946 = 94.6$ per cent.

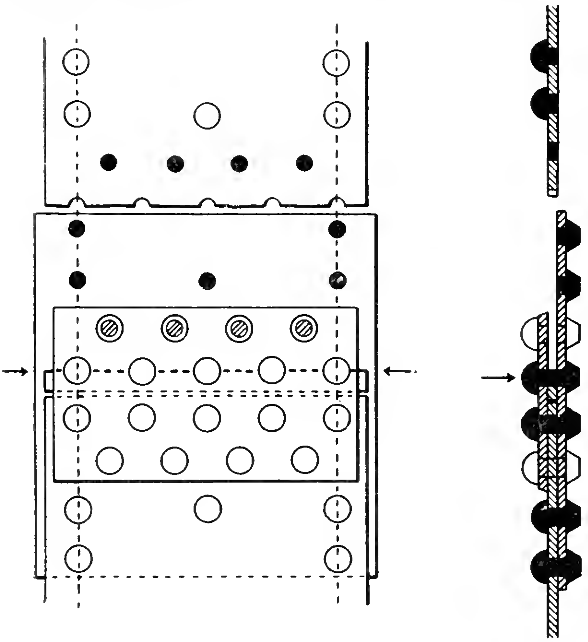

FIG. 5.—FRACTURE THROUGH THE INSIDE ROW OF RIVETS.

THIRD MODE OF FAILURE.

In the third mode of failure, the plate is broken as shown in Fig. 4, and in the two outside rows a rivet-section equal to three whole rivets is sheared. The plate-fracture, as will be seen, passes through four rivet holes, the combined diameters of which are $4 \times \frac{7}{8}'' = 3\frac{1}{2}''$. Hence the net width of plate to be broken is $16\frac{1}{4}'' - 3\frac{1}{2}'' = 12\frac{3}{4}''$. The sectional area of the fracture is therefore $12.75 \times \frac{7}{16} = 5.578$ sq. in., and the force required to effect the fracture is $5.578 \times 60{,}000 = 334{,}680$ lbs. The shearing strength of the three rivets in the outer rows is $3 \times 22{,}850 = 68{,}550$ lbs. Adding this to the tensile strength of the net section of the plate, we find that the total force required to cause the joint to fail as shown in Fig. 4, is $334{,}680 + 68{,}550 = 403{,}230$ lbs. Dividing this by 426,540, which is the strength of the solid plate, we have, as the efficiency of the joint for this mode of failure, $403{,}230 \div 426{,}540 = .945$, or 94.5 per cent.

FOURTH MODE OF FAILURE.

In the fourth mode of failure, shown in Fig. 6, the rivets are all sheared, and the plate is not broken at all. Three rivets in the outer rows fail by single shear, and eight in the inner rows (shown shaded with oblique lines) fail by double shear. The strength of the three in single shear is $3 \times 22{,}850 = 68{,}550$ lbs. According to the data given above, the strength of one rivet in double shear is found by multiplying the sectional area of the rivet, as driven, by 70,300. The area of a $\frac{7}{8}''$ hole we have already found to be .6013 sq. in.; and hence the strength of one rivet in double shear is $.6013 \times 70{,}300 = 42{,}270$ lbs. The combined strength of the eight rivets that are double sheared in the joint under discussion is therefore $8 \times 42{,}270 = 338{,}160$ lbs. Adding to this the strength of the three rivets in single shear, we have, as the total resistance of the joint to failure by the method shown in Fig. 6, $338{,}106 + 68{,}550 = 406{,}710$ lbs.; and dividing this by 426,540 lbs., which is the strength of the solid plate, we have, as the efficiency of the joint so far as the fourth mode of failure is concerned, $406{,}710 \div 426{,}540 = .953$, or 95.3 per cent.

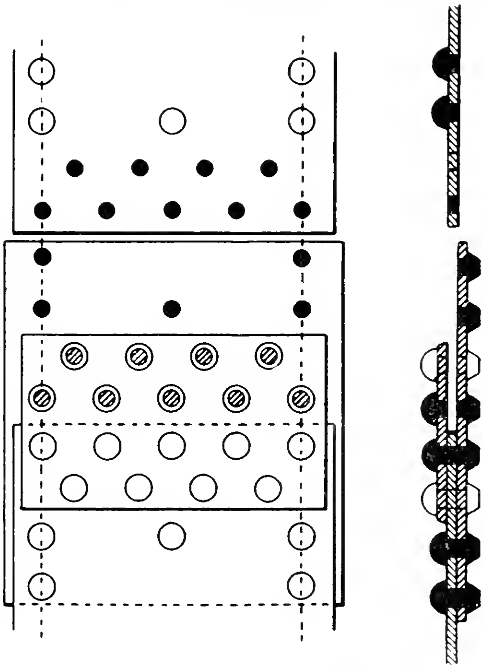

Fig. 6.—All the Rivets Sheared.

RÉSUMÉ OF THE RESULTS.

We have found that if the failure of this joint occurs as in Fig. 2, the efficiency is 94.6 per cent.; if it occurs as in Fig. 3, the efficiency is again 94.6 per cent.; if it occurs as in Fig. 4, the efficiency is 94.5 per cent.; and if it occurs as in Fig. 6, the efficiency is 95.3 per cent. In a joint that is perfect, both in theory and in workmanship, these various efficiencies should be precisely equal; but a limitation is always imposed upon the proportions of a joint by the fact that trade sizes of rivets must be used; and moreover, it is customary to make the efficiency a little greater, for the method of failure shown in Fig. 6, since it is practically impossible for the workman to make all the rivet-holes in the plates and straps come perfectly fair with one another; and any imperfection of this sort necessarily lessens the effective section of the rivet, and therefore lowers the shearing efficiency. The small range in the various efficiencies of the joint here calculated shows that if the workmanship is of good quality, and the holes are all fair with one another, the joint is practically perfect in design. In computing the bursting pressure of the boiler, the smallest of the various efficiencies is to be taken as the true or *effective* efficiency of the joint. In this case, therefore, the concluded efficiency is 94.5 per cent., which corresponds to the mode of failure shown in Fig. 4.

It is important to note that the pitches and rivet diameters which are adapted to this particular thickness and strength of plate, may not be at all satisfactory when used for plates of other thicknesses and tensile strengths. The truth of this statement is easily established by computing the efficiency of a joint proportioned precisely as above, when applied to sheets that are *one-half inch* thick, instead of *seven-sixteenths.* By proceeding as before, we shall find that if the joint fails as in Fig. 2, its efficiency is 94.6 per cent., as before. If it fails as in Fig. 3, its efficiency is 93.9 per cent. If it fails as in Fig. 4, its efficiency is 92.5 per cent.; and, finally, if it fails as in Fig. 6, its efficiency is only 83.4 per cent.! The joint that we have considered is therefore a good one for a $\frac{7}{16}''$ plate, *but it is a very poor one for a half-inch plate.* A better joint for a half-inch plate would be as follows: Pitch of inner rows of rivets, $4\frac{5}{8}''$; diameter of rivets, $\frac{15}{16}''$; diameter of rivet holes, 1"; resulting efficiency of joint, 94.5 per cent. (instead of only 83.4 per cent., as before). We trust that this example will sufficiently show the importance of always having the proportions of the joint adapted to the plates that are to be joined together.

FRACTURE OF THE STRAPS.

Returning now to the straps by which the plates are united, we proceed to show that failure of the joint through fracture of one or both of these is not possible, provided they are at least $\frac{3}{4}$ as thick as the plates themselves, and of equally good material; and for this purpose we shall first confine our attention to the particular joint whose efficiencies in other respects we have already computed in detail. Logically, we should give a complete analysis of every way in which such failure can occur; but this would require so much space that we shall refer to only four of the possible modes of failure, leaving it to the reader to see for himself that every other method will give a higher efficiency than some one of these. The four ways that we shall consider are as follows:

(1.) — The plate does not break, but both of the straps break across the inner row of rivets.

(2.) — The outer strap does not break, but the plate and the inner strap break through the next-to-inner row of rivets.

(3.) — The plate remains whole, but the inner strap breaks through the inner row of rivets, and the plate frees itself from the outer strap by shearing the rivets that unite them.

(4.) — The plate remains whole, but the outer strap breaks through the inside row of rivets, and the plate frees itself from the inner strap by shearing the rivets that unite them.

We now proceed to consider these various modes of failure in detail.

First Method.— The line of fracture in each strap passes through four rivet holes, whose combined diameters are equal to $4\times\frac{7}{8}''=3\frac{1}{2}''$. The length of the actual fracture in each case is therefore $16.25''-3.50''=12.75''$. The plate being $\frac{7}{16}''$ thick, the straps must have a thickness of not less than $\frac{3}{4}\times\frac{7}{16}''=\frac{21}{64}''$. But $\frac{21}{64}''$ is greater than $\frac{5}{16}''$ and less than $\frac{3}{8}''$; so that if we introduce the condition that the thickness of the straps must be some integral number of sixteenths of an inch, the least thickness that we can allow them to have is $\frac{3}{8}''$. Taking this as the thickness, we find that the area of fracture in each strap is $12.75'' \times \frac{3}{8}'' = 4.781$ square inches. The combined area of fracture of both straps is therefore $2 \times 4.781 = 9.562$ square inches, and hence the tensile strength of the two straps is $9.562 \times 60.000 = 573,720$ pounds. We have already found that the strength of the solid plate is only 426,540 pounds; and hence it appears that in the joint under consideration the first of the four modes of strap failure is impossible. This point is of such importance that in our opinion it calls for a more general proof than this special problem can be assumed to give. We therefore introduce the following algebraic demonstration: Let p be the pitch of the two inner rows of rivets, and let d be the diameter of a rivet hole (assumed to be $\frac{1}{16}''$ greater than the diameter of the rivet). Then if the joint fails by a fracture of the plate through the outside row of rivets, the efficiency is

$$E = \frac{4p - d}{4p}.$$

Now let us consider the strength of the straps. If one of them breaks across the inside row of rivets, the length of the fracture will be $4p - 4d$. If t is the thickness of the plate, $\frac{3}{4}t$ will be the least allowable thickness of the strap; and hence the fractured area of the strap will be $\frac{3}{4}(4p - 4d)t$, or $3(p - d)t$; and the fractured area of the *two* straps will be $6(p - d)t$. Now if the solid plate should break, the area of its fracture would be $4pt$; and hence the efficiency of the joint, so far as the straps are concerned, is

$$\textit{Strap-efficiency} = \frac{6(p - d)t}{4pt} = \frac{6(p - d)}{4p} = \frac{4p - d}{4p} + \frac{2p - 5d}{4p} = E + \frac{2p - 5d}{4p}.$$

That is, the efficiency of the straps, for the mode of failure under consideration, is equal to the efficiency of the joint as computed by the ordinary methods, *plus* a fraction whose numerator is $(2p - 5d)$. Now it will be found that in a well-designed quadruple-riveted butt joint, the least pitch, p, is always greater than $3d$. Hence $2p$ is greater than $6d$, and therefore $(2p - 5d)$ is necessarily *positive*, and the straps, for the mode of failure here contemplated, are stronger than the plate is, along the outside row of rivets. It follows that if the straps are made of material as good as the plates, and are *not less* than *three-fourths as thick* as the plates, they cannot, in any case, break across the inner row of rivets.

Second Method of Strap-Failure.— In this mode of failure the fractured area of the inner strap is the same as before, but the fractured area of the plate is *greater* than the corresponding area of the outer strap, as computed in the first method, because the plate is thicker than the strap. The joint therefore cannot break by the second mode of strap-failure, because it resists fracture in this manner more strongly than by the first mode.

Third Method of Strap-Failure.— Failure by this method implies a break in the inner strap of the same character as in the first method; and hence, referring back to our previous figures, we find that the area of the fracture is 4.781 square inches. The resistance of the inner strap to fracture is therefore equal to $4.781 \times 60,000 = 286,860$ pounds. To free itself from the outer strap, the plate must also single-shear eight rivets. The shearing strength of these rivets is $8 \times 22,850 = 182,800$ pounds. Hence the total resistance of the joint to the third method of strap-failure is $286.860 + 182,800 = 469,660$ pounds. We have already found that the strength of the solid plate is only 426,540 pounds; so that it is evident that so far as to third method of failure is concerned, the straps are stronger than the solid plate. In order to show that the third mode of strap failure is not possible in *any* joint whose straps are of the best material, and not less than $\frac{3}{4}$ the thickness of the plate, we shall again make use of a general algebraic proof. Using the same notation as before, we have

$$E = \frac{4p-d}{4p}$$

as the efficiency of the joint, so far as fracture through the outside row of rivets is concerned. The fractured area of the inner strap is also equal to $3(p-d)t$, as before, and the tensile strength of this strap is therefore $3(p-d)tT$, where $T = 60{,}000$. The area of the hole filled by one rivet is $.7854d^2$, and the shearing strength of each rivet is therefore $.7854d^2S$, where $S = 38{,}000$. The united strength of the 8 rivets that must be sheared in order for the joint to fail in the manner contemplated, is eight times this quantity, which is $6.2832d^2S$. Hence the combined resistance of the strap and rivets is

$$3(p-d)tT + 6.2832d^2S.$$

The efficiency is found by dividing this expression by the strength of the solid plate, which is $4ptT$. Hence

$$\textit{Strap-efficiency} = \frac{3(p-d)tT + 6.2832d^2S}{4ptT} = \frac{3p-3d}{4p} + \frac{6.2832d}{4p} \cdot \frac{d}{t} \cdot \frac{S}{T}.$$

In a quadruple butt joint which is well designed, the diameter of the rivet hole must always be very closely equal to twice the thickness of the sheet, since with any other proportion it is not possible to make the joint equally strong with regard to the four standard methods of plate and rivet failure. Hence we may assume, in the foregoing formula, that $d = 2t$. We also find that $S \div T = 38{,}000 \div 60{,}000 = .6333$. The last term of the formula therefore becomes

$$\frac{6.2832 \times 2 \times .6333d}{4p} = \frac{7.979d}{4p} = \frac{8d}{4p} \text{ (approximately).}$$

Therefore the formula becomes

$$\textit{Strap-efficiency} = \frac{3p-3d}{4p} + \frac{8d}{4p} = \frac{3p+5d}{4p} = \frac{4p-d}{4p} + \frac{6d-p}{4p} = E + \frac{6d-p}{4p}.$$

That is, the efficiency of the straps, in resisting the third mode of failure, is equal to the efficiency of the plate, in resisting fracture through the outside row of rivets, *plus* a fraction whose numerator is $6d-p$. Now d being always closely equal to $2t$, we may write $6d-p = 12t-p$. But it will be found that in order to design a good quadruple riveted joint, the pitch of the inner rows of rivets must be materially less than twelve times the thickness of the sheets. Hence $12t-p$ is positive, and it follows that the strap-efficiency is always greater than the efficiency of the joint in other respects, *provided*, of course, that the straps are at least three-quarters as thick as the plates, and of equally good material.

Fourth Method of Strap-Failure. — It will not be necessary to consider this method in detail, because the area of strap-fracture is the same as in the third method, while the number of rivets to be sheared is *eleven* instead of *eight*. Hence the straps always resist failure by the fourth method more strongly than they do by the third method.

We have devoted a considerable amount of space to the discussion of the covering straps, because Seaton, in his *Marine Engineering*, repeatedly refers, with apparent approval, to straps whose thickness is only $\frac{5}{8}$ that of the plates.* It is true that these references relate to joints unlike the one here discussed; but in the absence of definite information concerning the present joint, boiler makers, and even engineers, might naturally adopt the same thickness for the quadruple joint that Seaton quotes with approval for other types. The reader who wishes an example to prove the inadequacy

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* See for instance, pages 303, 364, and 454, in the eleventh edition (1893).

of straps $\frac{5}{8}$ the thickness of the plate may take the following: Thickness of plate, $\frac{1}{2}''$; diameter of rivet hole, $1''$; pitch of rivets in inside rows, $4\frac{5}{8}''$; thickness of cover-straps, $\frac{5}{16}''$; tensile strength of material, 60,000 lbs.; shearing strength of rivet-iron, 38,000 lbs. It will be found that although this joint gives an efficiency of 94.5 per cent. when computed according to the four standard methods of plate and rivet failure, it gives only 92 per cent. when its resistance to the third mode of strap-failure is considered.

RULES FOR QUADRUPLE-RIVETED BUTT JOINTS.

The proper method for computing the efficiency of a joint of the kind shown in Fig. 1 may be summarized as follows:

(1.) — Make sure that the straps are at least three-quarters as thick as the plate, and of equally good material.

(2.) — Subtract the diameter of *one* rivet hole from the pitch of the outside row of rivets, and divide the remainder by the pitch of the outside row. (This gives the efficiency of the joint, so far as failure as shown in Fig. 2 is concerned.)

(3.) — Subtract the diameters of *two* rivet holes from the pitch of the outside row, and multiply the remainder by the thickness of the plate, and again by the tensile strength of the material. To the product add the shearing strength of *one* rivet, and divide the sum by the tensile strength of a section of the solid plate, whose length is equal to the pitch of the outside row of rivets. (This gives the efficiency of the joint, so far as failure as shown in Fig. 3 is concerned.)

(4.) — Subtract the diameters of *four* rivet holes from the pitch of the outside row, and multiply the remainder by the thickness of the plate, and again by the tensile strength of the material. To the product add the shearing strength of *three* rivets, and divide the sum by the tensile strength of a section of the solid plate, whose length is equal to the pitch of the outside row of rivets. (This gives the efficiency, so far as failure as shown in Fig. 4 is concerned.)

(5.) — The efficiency of the joint, so far as resistance to the shear of all the rivets is concerned, may be computed most easily by the following method, which is equivalent to the method given in the foregoing article, but is much shorter: Multiply the sectional area of *one* rivet hole by the constant 676,400, and divide the product by the tensile strength of a section of the solid plate, whose length is equal to the pitch of the outside row of rivets.*

(6.) — The *least* of the four results thus obtained is to be taken as the true efficiency of the joint.

A. D. R.

A REVOLUTION has been quietly effected in the method of refining copper, and nearly half of that produced in this country is now refined by electricity. The method consists in electroplating the metal from an anode composed of the "blister" or impure copper upon a cathode of refined copper, the strength of the current and the composition of the liquid both being so chosen that nothing but copper is deposited upon the cathode, the impurities in the crude metal falling to the bottom of the tank in the form of mud. The great electrolytic refinery of the Anaconda Company, in Montana, produces from 100 to 120 tons of refined copper daily, by this process, and is the largest plant of the kind in the world.

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* This rule is obtained as follows: There are three rivets in single shear, whose combined strength is $3 \times (\textit{area of one hole}) \times 38{,}000$; and there are eight in double shear, whose combined strength is $8 \times (\textit{area of one hole}) \times 38{,}000 \times 1.85$. Hence the total shearing strength is

$$3 \times (\textit{area of one hole}) \times 38{,}000 + 8 \times (\textit{area of one hole}) \times 38{,}000 \times 1.85.$$

But this is equal to

$$(3 \times 38{,}000 + 8 \times 38{,}000 \times 1.85) \times (\textit{area of one hole}),$$

which is the same thing as

$$676{,}400 \times (\textit{area of one hole}).$$

The Locomotive.

HARTFORD, NOVEMBER 15, 1896.

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

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The Animal as a Machine.

Under this heading Professor R. H. Thurston contributes an article to the *North American Review*, from which we make the following extracts:

"The vital system, in spite of the study bestowed upon it from the days of Plato and Aristotle, and by the most acute of modern men of science, remains to-day the most mysterious of all the wonders of creation. It embodies the representative energies of all the realms of nature. The chemist, the physicist, the engineer, the biologist, the sociologist, the student of mental philosophy, and the moralist,— all thinkers and investigators in all departments of science,— find here problems as yet absolutely defying solution, enigmas of sphinx-like obscurity and of infinitely more sphinx-like antiquity. They stand perpetually before us, challenging and tantalizing us by their familiar externals, by their always mysterious internal operations. All that we really know is that every animal, human or other, from the greatest of scientific men or the most famous statesman down to the most insignificant worm or almost protoplasmic organism, is a machine of marvelous intricacy and astonishing perfection; self-perpetuating; self-repairing; capable of performing tasks of the utmost difficulty as a 'prime motor,' and as a vehicle for the contained and directing soul; automatic in its essential internal movements; competent to conduct all those unseen and mysterious operations often for years, for decades, sometimes for a century or more, without the slightest knowledge on the part of the imprisoned mind, of their character, of their method, or of their mutual relations.

"We have no positive clue to the nature of that mysterious force which flexes the muscles, bends a finger, moves a limb, or keeps the whole automatic system in operation for threescore years and ten, still less of the method of telegraphy which directs it, or of the even more mysterious mental and intellectual forces and powers back of all and hidden in the most inaccessible recesses of the complicated mechanism within which we 'live and move and have our being.'

"The anatomical structure of this singular machine is well understood, and the surgeon can do wonderful work in its dissection, its repair and reconstruction; but of its mainspring and its moving forces we are hardly more perfectly informed than were our barbarous ancestors of the days of the Greek and Roman civilization, or even of the time of Homer and the prehistoric ages. From the point of view of the mechanician, this machine — marvelous as it is as a study in anatomy, or to the investigator in physiology, in psychology, or in physics and chemistry — is strange and crude. It has not a revolving wheel or shaft, cam, or a gear, a belt or a piston, or a rigid system of mechanical 'pairing' in the whole complicated and wonderful construction. Its operations, so far as mechanical, are all carried on by systems of levers, jointed in curious ways and worked by cords of elastic muscle. Its mechanical movements and operations are all simple and easily traced and understood; but the forces and energies transferred and transformed are as mysterious in nature and method of action as their resultant effects in producing motion are simple. Some force — no one knows precisely what,— and some energy, equally unidentified, cause contraction and relaxation of muscles and transformation of the unknown form of energy into mechanical power and muscular force and work. Where this energy of primary form is originated, what is its course, and how it affects the muscle, no one can say.

"The question whether the animal machine is a heat-engine characterized by singularly low-temperature combustion, as formerly assumed, is promptly settled, and beyond dispute, by the fact that the whole system is of substantially uniform temperature. In all known heat-engines, the conversion of thermal into mechanical energy is consequent upon variations of pressure and volume of working fluids within a range of temperature, the extent of which limits the proportion of heat which may be thus utilized. The narrower this range the less is the work performed and the smaller the proportion of the heat supplied which is transformable into dynamic energy and work. In the best modern steam-engines this range is, at best, not above one-fourth the whole scale measured from the temperature of the steam down to the absolute zero at which all heat motion ceases, and only this proportion could be utilized, at best, in a perfect machine. The proportion is higher in gas engines; but the wastes are more than proportionally greater in the engine as actually operated, and the two forms of heat-engine are practically to-day about equal. In the animal machine this range is very nearly zero; all parts of the fluid mass and contained solids being, in the human body, for example, held at about ninety-eight degrees Fahrenheit. The animal machine, therefore, cannot produce thermo-dynamic transformations, unless by some as yet undiscovered process which entirely evades the well-established laws of thermo-dynamics as applied to the heat-engines familiar to us. To produce such effects it will be necessary to carry parts of the system through a range of temperature equal to that of the steam engine, if the known efficiency of the machine is to be secured in that manner. This is obviously an impossibility. The deduction follows that the animal machine is not a heat-motor, or a thermo-dynamic engine, which deduction may be accepted as very nearly, if not absolutely, certain.

"Many distinguished men of science have been attracted by these riddles of the vital machine, and have tried to read its oracles, but with little success as yet. Joule, as early as 1843, called attention to the fact that the machine must be one for transformation of energy, and found that the result should be a lower proportional development of heat, for a given volume of product of oxidation exhaled, when at work than when at rest. This conclusion was experimentally confirmed by Hirn, in 1858, by actually confining men and women and youths in hermetically sealed chambers into which air could be introduced and the contaminated atmosphere discharged only through ducts so arranged that he might readily and accurately measure its volume and analytically determine its constituents. He found that the heat, the work, and the volume of carbonized gases had those general relations of quantity which had been predicted by Joule as a consequence of the then newly accepted laws of energy-transformation. The larger the amount of energy applied to external work, the less the quantity of energy rejected in other forms. The human machine and motor obeys the laws of energy as precisely as does the steam or the gas engine; although this fact is not a proof that it is a heat-engine, but, simply indicates that it is a transformer of energy by processes the nature of which we have not yet ascertained.

"Messrs. Becquerel and Breschet and later investigators have found by actually introducing slender, needle-like thermometers into the flesh, that the temperature of the body is substantially the same in all parts. The muscles are one or two degrees higher in temperature than the skin tissue, and, during exercise, they may rise a degree or two higher still; but there is no point in the body, so far as can be ascertained, at which the heat exceeds the mean to any important extent. Hirn and others have shown that the human machine has at least the efficiency of the best steam-engines; that is to say, it converts as large a proportion of its supply of energy into work as the best heat-engines. This would, were it a heat-engine or a thermo-dynamic machine of similar character, compel the provision of steam-boiler temperatures within the body — a simple impossibility in a mass composed mainly of fluids evaporating at the boiling-point under atmospheric pressure, and of tissues altered by temperatures not greatly in excess of that standard. Experiment also shows the arterial blood to be but two or three degrees, at most, above the temperature of the venous; cold blooded animals, as the fishes, usually exhibit no greater excess of heat over the fluid in which they live, and the molluscs practically coincide in temperature with the water about them. Exercise, increasing the temperature of all living mechanisms, notwithstanding the increased amount of energy drawn from the store and converted into work, raises the temperature of the whole machine and causes large increase in the quantity of heat conducted, radiated, and exhaled; but this very possibly comes mainly of the increased heart-action, accelerating the flow of the currents in the arteries and veins and the conversion of its friction-work into heat. The fact gives no clue to the secrets of the vital sphinx.

"Summarizing the argument: The animal machine, the vital prime motor in which we live, is supplied daily with an amount of energy in its food, equivalent, dynamically, to the potential energy of a pound of coal. This is, in turn, the equivalent of one-fifth of a horse-power for twenty-four hours. A day's work is at most one-eighth of a horse-power for one-third of a day at steady labor, which is the same as one-twenty-fourth of a horse-power exerted continuously for the twenty-four hours. Thus measured by the labor of a working man, the animal machine utilizes one-fifth of the energy supplied to it — just the efficiency of the best steam engines that the greatest inventors and best mechanics of our time have been able to produce. But it does much more than this. The brain takes from one-fifth to one-tenth of the original stock of energy; all the work of digestion, respiration, and circulation, and of every muscular movement, voluntary and involuntary, and all that of reconstructing and repairing tissue of muscle and nerve and bone, must be added, and the efficiency of this prime mover is thus very far in excess of twenty per cent., and of the performance of the best engines. The experiments of Hirn, showing the rejected heat-energy to be twice as great, proportionally to oxygen inhaled, when at rest as when at work, indicate the total efficiency to be about fifty per cent., or two and a half times as great as in the best engines of human construction; the production of power being the gauge. Langley has shown that, where the animal machine produces light [as in fireflies and glow-worms], it does so at a cost, substantially all heat being eliminated, of one per cent. of that of our familiar lights; and other investigations show that, where adapted to the production of electricity of high tension, as in the gymnotus, it does this by consuming food — combustibles composed of the same elements, mainly, as our fuels — and, by this direct evolution, escapes the loss of nine-tenths or ninety-five hundredths of the energy drawn upon in our artificial methods of electric light and power generation. Heat production must be similarly economical in the animal machine; as there are no important losses from it, it produces just enough to keep its temperature normal and constant under its covering of non-conducting hair or wool. In all these vital operations, heat and power are always produced and observable. Indications of the generation and use of electricity or some similar energy are detected in all animal machines, and sometimes electricity also in large quantity and of high intensity. In some instances the production of light is a result of transformation of energy in these machines, and thus the animal system illustrates the transformation of energies in all known ways, exhibits direct transformations unknown in applied science and engineering, and excels always, and sometimes enormously, in the efficiency with which it effects these transformations and performs its special tasks."

Ants used by Surgeons.

In the July issue of THE LOCOMOTIVE we reproduced under this heading, a short article from the Chicago *Chronicle.* The following item from Appleton's *Popular Science Monthly* gives additional information concerning this curious practice: "A paper read some time ago in the Linnæan Society by Mr. R. Morton Middleton, recording the observation of Mr. Miltiades Isigonis of the use of ants by the Greek barber surgeons of Asia Minor for holding together the edges of a cut, brought out the fact that the same custom exists in Brazil as among these Greeks. The Eastern barbers hold the ant — a large-headed *Camponotus* — in a forceps, when it opens its mandibles wide, and, being permitted to seize the edges of the cut, which are held together for that purpose, its head is cut off as soon as a firm grip is obtained. A similar practice was observed in Brazil several years ago by M. Mocquerys of Rouen, and is cited by Sir John Lubbock, but it is not mentioned by either Bates or Wallace."

An Underground River in New England.

When the late Professor Denton of Somerville, Mass., first declared that there was an underground river of considerable size flowing from the White Mountains across and under the States of Massachusetts and Rhode Island, people laughed at him. He insisted that he was right, and said many times: "I have discovered a supply of the purest water below the surface. I am of the opinion that the supply is adequate for all central New England for all time. You may laugh, but sooner or later some one will strike the rolling torrent and find a never-ceasing supply of the purest water."

Professor Denton died in South America a few years ago. Were he alive now, he would find that men of Massachusetts and Rhode Island had experienced a change of mind on the subject of his river. The great underground current has been tapped, and at several points along the course, as laid by the geologist, large manufacturing concerns are using the supply in the place of the local service. The water reached by driven wells is better than any found in springs or lakes in these parts.

It was between 1882 and 1885 that a large bleachery in Providence drove a well in the northerly part of the city and found an underground supply, which from that day until this has never failed it. The water was struck eighty or one hundred feet below the surface, under a layer of stone from six to eight feet in thickness. From the pipe ice-cold water spurted several feet in the air. Fifteen feet below the under side of the first rock the pipe struck another layer of stone. When the well pipe was forced into that rock the flow of water stopped. People who examined it were of the opinion that the well had reached a spring of unusual size. Eighteen years ago Professor Denton was engaged by a straw hat manufacturing concern at Foxboro, Mass., a few miles from here, to locate a source of pure water, as only pure water could be used in the bleaching of the material employed in the manufacture of fine summer hats. H. E. White, now of Attleboro, but at that time of Foxboro, was engaged to assist in the search. He and Denton made several expeditions through the interior of the Bay State, and on one of these tours Professor Denton made a discovery that remained a secret with him for a long time. One of the places visited by the geologist and his party was on the south side of the main road to Foxboro from the south. At that point are situated three ponds, one called The Boggs, the second Sheppard's pond, and the third Witches' pond.

Professor Denton noted a peculiar formation of the surface in that section. In The Boggs, from which Foxboro now gets its supply of water, a few springs were found, and a few were also discovered in Sheppard's pond. Witches' pond contains several springs of great size. These three lakes are located on high land, the eastern Massachusetts divide, and so situated that the outlet of The Boggs flows to the northeast, through Canton, to Massachusetts Bay, while the outlet of Sheppard's pond flows southerly toward Taunton, where it empties into the river of that name in the vicinity of Dighton. Witches' pond has an outlet, but it is not visible. It makes its course below the surface in a southwesterly direction, and finds tide water beneath the ledge on the west shore of Narragansett bay, below the port of Wickford.

Witches' pond was so named years ago on account of the many peculiar noises heard there. At intervals there were distinct rumblings beneath the surface. Superstitious persons were alarmed and afraid to go near it. People who had no fear of ghosts watched the action of the water with interest. They always found the water icy cold in summer, and it ever rolled and boiled. A water pail would not cover some of the largest bubbles.

The pond covers fifteen acres, and in winter ice forms there long before there are signs of ice on other ponds. Ice six inches thick forms on Witches' pond to every inch of ice on other ponds in the vicinity in the same length of time. Only a few years ago four men who were fishing through the ice narrowly escaped losing their lives. There was a sudden upheaval while the men were on the pond, and ice fourteen inches in thickness, that covered the peculiar lake, was thrown about. The men, having heard the internal rumblings, took warning and reached the shore just in time to avoid being precipitated into the boiling pond. Lily-pad roots as large as one's arm were brought to the surface at the same time.

Professor Denton heard several stories about the pond, and out of curiosity made an investigation into the cause of the great boiling of the water which occurred at intervals. He tried to take soundings, but in several places he was unable to find the pond's bottom. Gases were detected rising from the pond, and he was led to believe that they issued from some distance below the surface. The water remaining pure proved to him that the pond had an outlet as well as a source, and as it was not visible the investigation was all the more interesting. Pipes were driven about the pond, and coal and blue clay were brought to the surface. Over one hundred feet below the level the pipe struck a ledge, and, after drilling the ledge on the south side of the pond, water was found. That water, when examined, was found to be purer than any other found in New England. Several wells were driven, and Professor Denton came to the conclusion that Witches' pond was an outlet for an underground river. It was when he told of his discovery that people laughed at him. The river was located 110 feet below the level.

Above it was a covering of hardpan, and the bottom, twenty feet below the covering, was of rock. Professor Denton was of the opinion that there was no Witches' pond until there was an upheaval of the earth years ago, when the shelving rocks under and over the torrent were torn away. Aided by gases from the coal and other substances in the earth, a rent was torn, through which the water made its way to the surface.

The streams in the vicinity of Foxboro are from a different watershed. The underground river is believed to come from a glacial spring in the White Mountains of New Hampshire or beyond. It is known that the city of Lowell struck the river only a few years ago, and from that day to this has had a fine supply of water. At the time the Lowell wells were driven, no one had heard of the river flowing under New England from north to south. The underground current has been followed by wells through Attleboro, Dodgeville, and Hebronville to Lebanon, where it swerves to the west and passes under Pawtucket Falls on the Blackstone river, thence through Pawtucket southwesterly, and under Providence, Cranston, Warwick, East Greenwich, and Wickford, into North Kingston, and into the sea near Hazard's ledge. To the north the course of the river was followed to the New Hampshire line. Before Professor Denton found the source of the river he was called to Brazil to locate a water supply. He was stricken with the fever there and died. Within a very short time manufacturing concerns have driven wells and found an immense supply of water, and now there are probably 200 or 300 wells connected with the river in Providence, to say nothing of the Lowell wells and those at Foxboro and along the course. It is only on the course laid out by Professor Denton's party that the great current is struck.

This week a well was put down in Pawtucket. A steam fire engine was attached to it with the intention of pumping it dry. The pumping was kept up for seven hours, and at the last the well was supplying more water than at first. The water has been found better than ordinary spring waters, and when used in boilers does not act on the boiler materials as rapidly as other water. This is one reason why the New York, New Haven & Hartford Railroad has erected a new stand pipe and driven well in this town. Many of the locomotives take water here rather than in Boston. The railroad has struck the underground current not only here but on its property in Providence as well.— *N. Y. Sun.*

Big Hailstones. — "One is justified in many cases," says the *St. James's Budget*, "in giving only a tentative belief to many of the big hailstone tales over which some travelers delight to spread themselves. A correspondent in Dholi, Behar, however, sends the indubitable proof of photographs to quite convince us and our readers of the terrible nature of the hailstorm which occurred in his district recently. The storm passed over the greater part of the districts of Mozufferpore and Durbungah, but it appears to have concentrated itself with special fury over the indigo factory called Dholi. Here the storm was terrific, even for tropical regions, the hailstones weighing as much as five ounces. On an average they were as large as cricket balls, if not larger. It can be easily understood that the damage done was great. Not a whole tile was to be found in the roofs; trees were uprooted, birds were killed, and general destruction wrought all around. What is more astonishing, the corrugated iron roofing over many of the factory buildings was riddled as though it had been shelled by a battery. We can quite imagine, as our correspondent informs us, that no storm like it has ever occurred in the district. Hailstones, however, have had the same terrific force in Africa, a sample of corrugated iron pierced in a like manner having been recently shown in London."

The Locomotive.

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The Re-Enforcement of Man-Hole Openings.

There appears to be an impression among some engineers and designers to the effect that if a boiler shell is once made strong enough, it will continue to be so, in spite of the various openings that may be cut through it, here and there, for one purpose or another. Nothing could be more erroneous; for a boiler is not endowed with magical qualities, and it cannot resist strains unless there is the proper amount of material present, and in the right place. We often see large rotary boilers built with much care, so far as the thickness and quality of the plates and the design and workmanship of the

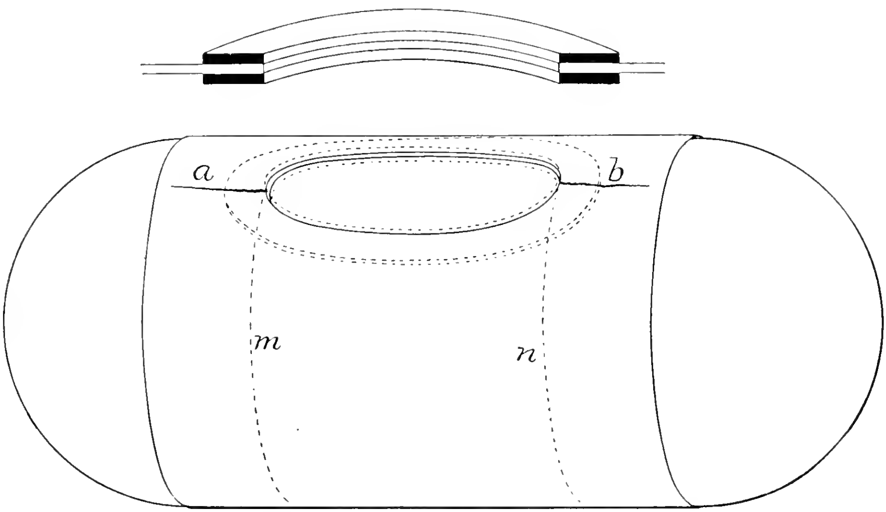

FIG. 1.— DIAGRAMATIC REPRESENTATION OF A ROTARY BOILER.

joints are concerned, which nevertheless have big stock-holes cut in them, apparently without any adequate conception of the weakening of the shell that is so produced, and certainly without any proper compensation for the material that has been cut away.

The tendency in recent practice has been towards larger boilers, with higher pressures, and bigger stock-holes; and so it has come about that modes of construction that were safe enough under the older conditions can no longer be regarded with favor among careful designers and builders, who have to meet the conditions of size and pressure that are demanded at the present day.

The stock-holes that are now most commonly met with range, say, from 26″ × 32″

up to about 32″ × 48″. Larger openings are sometimes seen, but the limits here indicated probably fairly represent the prevailing practice. For the purpose of forming a clearer idea of the significance of openings of this size, let us refer to Fig. 1, which represents a rotary with spherical ends, and with a cylindrical body. The engraving may perhaps be unlike any actual rotary that ever was on land or sea; but it will serve to illustrate the point to which we wish to call attention. Let us suppose, in the first place, that an opening has been cut in the shell, as shown, and for the moment we will assume that no re-enforcing ring is provided. It is evident that as soon as this opening has been cut there is a ring of the boiler, lying between the two dotted circles *m* and *n*, which is exposed to just as great a pressure as the rest of the boiler, but which is nevertheless entirely devoid of strength, *in itself*, because we have cut completely across it in making the stock-hole. Such power of resistance as this ring may possess is given to it indirectly by the rest of the boiler, which joins it along its edges. If a cover-plate were fitted to this stock-hole, and the rotary was put under pressure, the tensile strain that is due to the pressure against the ring *m n* will be transferred to those parts of the shell which are immediately to the right and left of *m n*, and the result will be, that the strain on the shell at the two ends of the stock-hole will be so great (when the stock-hole is of the large size now so common) that fractures like those indicated at *a* and *b* will be likely to occur. These cracks, when once started, will quickly extend, and a disastrous explosion is the result.

FIG. 2.—AN EXPLODED ROTARY.

In order to prevent the accumulation of the strains in the shell at the ends of the stock-hole, a re-enforcing ring should be provided, as shown by the dotted lines in Fig. 1. This ring should be made of wrought-iron or steel, and never of cast-iron, which is too notoriously uncertain a material to be trusted under tension in so important a place. Two rings of plate, of suitable width, thickness, and quality, one inside of the boiler and the other outside, make a satisfactory form of re-enforcing ring when the whole is properly riveted together with two or three rows of rivets. This form of ring is shown in the upper part of Fig. 1. When a ring is put in in this way, and the workmanship is good, it may fairly be assumed that the tensile strain on the ring *m n* is transferred to the re-enforcing ring, and hence, if the latter is properly proportioned, the main sheet, at the ends of the stock-hole, is protected from the extra strain that would otherwise be thrown upon it.

The function of the re-enforcing ring being once understood, the method of finding its width and thickness easily follows. For since the ring is intended to bear the strain due to the shell-section *m n*, it is evident that it should have a sectional area at least as great as the sectional area cut away from *m n* in making the stock-hole. That is, the combined area of the black sections in Fig. 1 should be at least equal to the sectional area of a strip of the main shell, of a length equal to the length of the stock-hole.

We proceed to illustrate this principle by an example, and for this purpose we assume the general proportions of the plates and stock-hole to be as follows: Plates are of steel (60,000 lbs. T. S.), and $\frac{3}{4}''$ thick. Stock-hole is 24″ wide and 42″ long. With these dimensions given it is easy to see that the sectional area cut away from the plate in making the stock-hole is $42'' \times \frac{3}{4}'' = 31.50$ sq. in. We therefore have to design the re-enforcing ring so that its total sectional area shall be at least equal to 31.50 sq. in. The width of the re-enforcing ring is often limited by the design of the rotary, either by a girth joint coming nearer the stock-hole than it ought to, or by some other circumstance. In the present case, however, we shall assume that there is no limitation of this sort. If the rings are to be put in place after the heads of the rotary have been riveted in, however, they cannot be more than about 9 inches wide; for that would make the least diameter of the ring (when measured along the curve of the shell) equal to $9'' + 24'' + 9'' = 42''$. The fact that the rings are curved, however, will allow the builder to introduce the inner ring into the rotary, even if its width, when measured along the curve, slightly exceeds the length of the stock-hole. We shall therefore assume, in the present case, that the re-enforcing rings are 9″ wide. The combined area of the four black sections being 31.50 sq. in., each one of them will have an area of $31.50 \div 4 = 7.875$ sq. in.; and hence the thickness of each of the rings must be $7.875 \div 9'' = 0.875''$, or seven-eighths of an inch. This process of calculation may be summed up in the following

Rule.—To find the least allowable proportions of a re-enforcing ring, proceed as follows: Multiply the thickness of the plate by the length of the stock-hole; this gives the sectional area of plate cut away in making the hole. The total sectional area of the re-enforcing ring must be at least as great as this, and the material of the ring must be as good as the material of the shell plates. The width of the re-enforcing ring is usually limited by circumstances, but when the width has been decided, the *thickness* of the ring may be determined as follows: If there are *two* rings, one inside and one outside as we recommend, and as is shown in Fig. 1, the thickness of each ring is found by dividing the sectional area of the ring by four times its width. (If only *one* ring is used, its thickness must be equal to the combined thickness of the *two* rings shown in Fig. 1.)

The stock-holes of rotary boilers are almost invariably re-enforced by the builders to some extent, but unfortunately the re-enforcement so provided is often *entirely inadequate* to the needs of the case; and the purpose of the present article is to show the importance of this question, and to point out what is necessary in order to make the boiler reasonably safe. We have thus far only considered the direct effect of the pressure within the rotary, but there are various secondary influences that serve to emphasize the importance of what has been already said. Prominent among these secondary causes is the shifting of the charge as the boiler revolves. At first the charge is of such a character that no special danger of this sort need be apprehended; but as the process of maceration and digestion goes on, the straw or other material becomes transformed into a pulpy mass that doubtless adheres to the sides of the rotary sufficiently to be carried up with it, in its rotation, for some distance. Gravity presently prevails, however, and the mass falls back into the lowest part of the boiler; after which the same cycle is repeated, over and over. This action needs only to be pointed out for its importance to be understood. A charge of five tons or more falling periodically upon the bottom of the boiler cannot fail to give rise to temporary stresses and distortions that will naturally make themselves most strongly felt about the stock-hole, where the symmetry of the boiler is interrupted. It is by no means easy to calculate stresses of this sort, but the fact of their existence shows how imperative it is that the stock-hole should be properly re-enforced. If any further argument in favor of the most substantial kind of re-enforcement were needed, we could find it in the slight but continual bending and distortion that necessarily occurs about the stock-hole, both when the load shifts from place to place in the boiler, and when the cover-plate is fastened in position and removed. Distortion of this sort is of great importance in boilers, because it tends to weaken the fiber of the iron, and because it induces grooving and other forms of corrosion, as has been explained in previous issues of THE LOCOMOTIVE. In order to reduce such motion as much as possible, the frame around the stock opening should be made very stiff and strong.

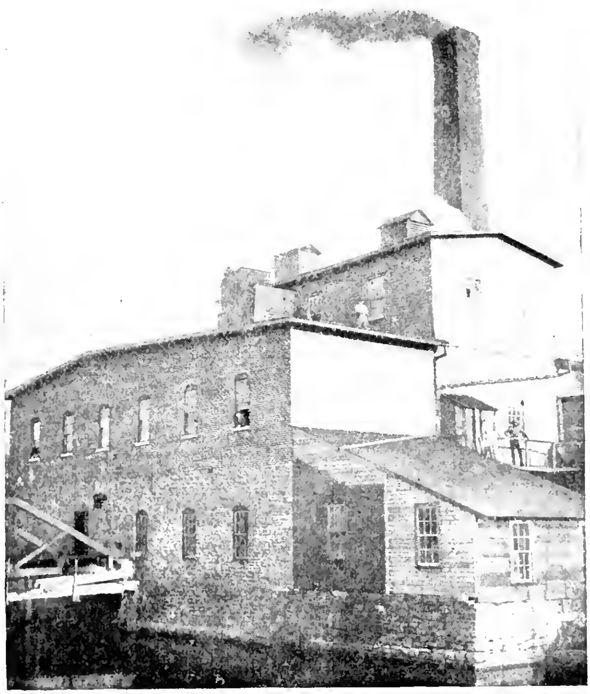

FIG. 3.— THE BUILDING THAT CONTAINED THE ROTARY IN FIG. 2. (BEFORE THE EXPLOSION.)

The reality of the danger from large stock-holes is well shown in the half-tone engravings that accompany this article. The explosion here illustrated occurred not long ago in a paper mill, the rotary that failed being 18 feet long and 14 feet in diameter, with approximately spherical ends, separated by a cylindrical section about four feet long. The stock-hole in this case was unusually large, being 48″ × 52″. It was re-enforced to some extent, but the re-enforcing was not designed in accordance with the foregoing rule, and it proved to be not strong enough. The line of initial fracture passed through the stock-hole, as shown in Fig. 2, which represents a portion of the rotary as it lay after the explosion. In this explosion four persons were killed and four others were seriously injured, and the property loss, on a conservative estimate, amounted to over $25,000.

Although we have confined our remarks, in this article, to the big stock-holes found in modern rotary boilers, the same general principle holds true of *all* openings in boilers, except the very small ones used for connecting water gauges and the like. *Man-holes* in the front heads of boilers, under the tubes, should be re-enforced with the greatest care, the dimensions of the re-enforcing rings being obtained in accordance with the foregoing rule. Man-holes on the shell-plates have recently been separately treated in this journal, and will not require special mention at present. (See THE LOCOMOTIVE for August, 1896.)

The Rules and Regulations of the United States Board of Supervising Inspectors provide for the re-enforcement of openings in boilers in the following terms: "When holes exceeding six inches in diameter are cut in boilers for pipe connections, man and hand-hole plates, such holes shall be re-enforced with wrought-iron or steel rings of sufficient width and thickness of material to equal the amount of material cut from such boilers, except that when holes are cut in any flat surface of such boilers, and such holes are flanged inwardly to a depth of not less than $1\frac{1}{2}$ inches, measuring from the outer surface, the re-enforcement rings may be dispensed with." (*Steamboat Inspectors' Manual*, 1895, page 123.)

FIG. 4.—THE SAME BUILDING AFTER THE EXPLOSION.

ACCORDING to Newton's law of gravitation, every particle of matter in the universe attracts every other particle with a perfectly definite force. This attraction is quite evident when large bodies, such as the sun and planets, are involved, but the gravitative force between objects that are small enough to be submitted to experiment in the laboratory is so weak that it can be detected only by the most refined and delicate apparatus. Measurements of the attraction between two small bodies of known mass are of fundamental importance in physics and astronomy, but they are so exceedingly difficult that no very accurate results had been obtained until the recent researches of Prof. C. V. Boys were undertaken. Prof. Boys's conclusion, when expressed in scientific terms, is, that two spheres, each containing one gramme of matter, and placed with their centers one centimeter apart, attract each other with a force of .000,000,066,576 of a dyne. Translated into ordinary language, this is equivalent to saying that two spheres of lead, each one foot in diameter, and in contact, attract each other with a force of about 319 ten-thousandths of a grain. The importance of these data is shown by the fact that they give us, for the first time, an accurate value of the average density of the earth. Thus it is easy to show, from the figures here presented, that the actual attraction that the earth exerts upon bodies is 5.527 times as great as it would be if the earth were composed of water. It follows, from this, that the earth, as a whole, is 5.527 times as dense as water. In spite of the extreme delicacy and difficulty of Prof. Boys's experiments, his final estimate of the earth's density is believed to be so accurate that future investigations will hardly change it by more than one unit in the third decimal place.

Boiler Explosions.

SEPTEMBER, 1896.

(222.) — On August 26th a boiler exploded in T. L. Merrill's mill, at Luverne, Ala. Mr. Merrill was badly hurt, but will recover. Four other men were also injured. Portions of the mill were blown to a great distance. [Received too late for insertion in the August list.— ED.]

(223.) — A boiler belonging to Herbert Lossing of Sanilac Center, Mich., exploded on September 1st, killing Lanson Lossing, Darius Lossing, and George Casterlion. James Davis and George Tallman were also seriously injured. All the men, except the two Lossings, were at least 100 feet away from the boiler at the time of the explosion.

(224.) — On September 1st a boiler exploded in Baldwin's sorghum molasses factory, Jamestown, Kan. Lewis Tebow was killed, and four others were badly, but not fatally, scalded.

(225.) — A boiler in W. T. Rutledge's gin house, at Crawford, Ala., exploded on September 1st. Nahum Ingram and Thomas Mitchell were killed, and John Adams and John Ashley were fatally injured. The boiler, machinery, and building were almost totally destroyed.

(226.)— On September 4th a boiler exploded in Samuel Johnson's cotton gin, five miles east of Houston, Tex. Henry Williams was killed, and Samuel Johnson, William Smith, and Henry Smith were badly hurt. It is believed that Johnson and William Smith will die, as their injuries are very serious. The gin house was wrecked, and the boiler was blown 75 yards from its setting.

(227.) — A boiler used for pumping water for a railroad supply tank at Edwardsville, Ala., exploded on September 4th. Elsie Black, George Black, and Daniel Turner were killed.

(228.) — A terrible boiler explosion occurred on September 5th at Willis Mountain, Buckingham county, near Farmville, Va. Thomas E. Burke, who was firing the boiler of his father's saw-mill, was blown to atoms, his body being found a long distance away from the place of the explosion. The owner of the mill was also badly injured, but it is thought that he will recover.

(229.) — A small boiler belonging to Morris Nebo of Noblesville, Ind., exploded on September 5th. Nobody was injured.

(230.) — The boiler of locomotive No. 1105, of the Central Railway of Georgia, exploded at Augusta, Ga., on September 6th. Four men were on the engine at the time. One of them, Charles Anderson, a Swedish machinist, was so badly scalded that it was thought that he could not recover. Later advices, however, state that he is slowly improving. The other three men received slight injuries. The engine was lifted from the rails and deposited fifteen or twenty feet from the track. It had just been overhauled, and was on a trial trip.

(231.) — A boiler explosion occurred, on September 6th, on George W. Carhart's farm, near Warren, Minn. A threshing crew was at work when the boiler exploded. Matthew Main, the engineer, was standing near the fire-box at the time, and the fire door, being blown from its hinges, struck him in the head, fractured his skull, and threw his body about five rods. Fortunately, nobody else was near the boiler.

(232.)—A boiler exploded, on September 9th, in Benjamin Connor's saw-mill, some eight miles from Reidsville, Ga. Connor's son was instantly killed, and he was himself so badly injured that it is doubtful if he can recover. Several other men also received lesser injuries.

(233.)—Artman & Wachtetter's mill, at Augusta, Ind., was completely wrecked, on September 10th, by a boiler explosion. The boiler itself was carried about 1,000 feet from its original position. Fortunately, there was nobody seriously hurt.

(234.)—The boiler at an oil well owned by Funk & Harrop, on the Wagner farm, in Allen township, near Findlay, Ohio, exploded with great violence on September 10th. Nobody was hurt, as the men were in the derrick at the time.

(235.)—On September 10th a threshing-machine boiler exploded on the Carlson farm, seven and a half miles northwest of Valley City, N. D. Oscar Lee, who was firing the boiler, was badly injured, but it is thought that he will recover.

(236.)—Two tubes failed, on September 11th, on the steam yacht *Allegra*, at the mouth of the Harlem River, near New York city. Christopher Anderson, the engineer, was badly scalded, and the boat took fire. The tug *Two Brothers* was near by, and her crew extinguished the flames and towed the disabled yacht to Morris Dock, where she was laid up for repairs. The *Allegra* was formerly the property of Col. S. Van Rensselaer Cruger, who sold her, three years ago, to Mr. Charles M. Pratt. While in Col. S. Van Rensselaer Cruger's possession, the *Allegra* was singularly unfortunate in meeting with accidents.

(237.)—A boiler belonging to Elias Stafford exploded, on September 12th, at Montezuma, a town on the reservoir, opposite Celina, Ohio. The engineer (whose name is given in some accounts as John Paulman, and in others as James Colson), was blown 75 feet, landing in the river. He was so badly injured that he could not stand up, but he will recover. Nobody else was seriously injured.

(238.)—A man named Osborne was severely burned, on September 13th, by a boiler explosion in the Oregon oil-field, near Toledo, Ohio.

(239.)—A spectacular railway collision was arranged and put into effect at Crush, about fourteen miles from Waco, Texas, on September 15th. Some 20,000 or 30,000 poeple were gathered together to "take it in," and the program was, to have the trains charge into each other with throttles wide open, and then pile up into a magnificent mass of wreckage. This much of the entertainment was carried out to the letter; but there was an unheralded addition in the way of a double boiler explosion, both locomotives giving way at the same time, with the result that the official photographer for the occasion lost an eye, and seven other people were injured more or less seriously. Two of these, Ernest Darnell and Miss Emma Ogletree, will probably die.

(240.)—A boiler blew up, on September 15th, at the Noble cotton gin, near Denison, Texas. Daniel McSwain and Peter Jugglett were instantly killed, and twelve others were injured.

(241.)—Panic was created among the guests of the Hotel Imperial, in New York city, on September 15th, by the explosion of a boiler in the basement. Steam from the exploded boiler burst out of the cellar holes on Thirty-second Street, and enveloped the entire side of the hotel, from sidewalk to roof; and the guests, believing that the hotel was afire, made for the fire-escapes and stairs. The panic was allayed as soon as it became known that the building was secure. The only person hurt was Frank Lawlor, a mechanic, who was thrown against the cellar wall and badly cut.

(242.) — One of the three boilers in Petit Bros.' hoop and stave mill, four miles from Comber, Essex County, Ontario, exploded on September 17th. Alfred Jacobs, the night fireman, was instantly killed, and the boiler-room was reduced to a mass of debris.

(243.) — On September 21st, a boiler explosion occurred in Hall's brickyard, Des Moines, Iowa. The boiler-house was wrecked. The dome of the boiler blew off, and the stack was thrown down, badly damaging the building. Portions of the boiler were hurled five hundred yards. Two men were struck by flying fragments, but received only slight injuries.

(244.) — The boiler of a ninety-ton, ten-wheel locomotive on the Big Four Railroad exploded at Pekin, Ill., on September 22d, hurling the enormous engine more than 100 feet, partially demolishing the large factory known as the Cummings Header Works, and killing James Long, the fireman. One of the big driving-wheels was found 400 feet from the track, and other parts of the locomotive were picked up 1,000 feet away.

(245.) — The boiler of a sorghum mill exploded on September 22d, on the farm of M. W. Votow, near Bowling Green, Ky. Mr. Votow's son, Nathan, was killed, and Flerry McCarthy was seriously burned and otherwise injured.

(246.)—A boiler exploded, on September 22d, in a mill belonging to James G. McDonald & Co., lumber merchants, Washington, D. C. The balance wheel of a big circular saw broke, the fragments flying in all directions, and one piece struck the boiler, causing it to explode. Mr. McDonald, who was near the boiler at the time, was thrown violently through an open door, and was severely scalded about the back and shoulders. The building in which the boiler stood was badly damaged, and one piece of the boiler was found 500 feet distant.

(247.) — On September 23d a boiler exploded in the Charter Oak elevator, at Petersburg, near Springfield, Ill. We have not learned further particulars, except that nobody was injured.

(248.) — A tube failed, on September 23d, on a locomotive on the Lehigh Valley Railroad, between Lyons Farms and Saybrook, N. J. (?). The train was stalled as a result, and had to be pushed to a side-track at Waverly by the next train following.

(249.) — A boiler exploded in the Squire & Higbee mill, at Marion, Ind., on September 24th. Fortunately, nobody was hurt.

(250.) — One of the boilers at the Big Muddy Coal & Iron Company's shaft No. 5, at Murphysboro, Ill., exploded on September 24th. Henry Foster, who was the only man near the boiler at the time, was severely bruised about the body, and had one arm broken. The boiler and engine rooms were destroyed, and the smokestacks were thrown down.

(251.) — The boiler of a threshing machine belonging to Franks & Packards exploded, on September 25th, near Twin Creeks, some twelve miles northwest of Millbank, S. D. Herbert Shannon and Herman Franks were killed, and Frank Manning was seriously injured.

(252.) — The boiler of a threshing machine belonging to John A. Johnson, of Wayside, N. J., exploded on September 27th while in operation at Tinton Falls, N. J. We have not learned particulars.

(253.) — Four boilers exploded, on September 28th, at the Harwood colliery, Hazleton, Pa. Peter Parker was instantly killed, and Michael and Andrew Hargand were fatally injured. The building in which the boilers stood was wrecked.

(254.) — On September 29th, a boiler exploded in Hell Gate, near New York city, on the Lehigh Valley Railroad Company's steam tug *Robert Lockhart*. The tug and her three coal barges were immediately at the mercy of the swift tide for which Hell Gate is notorious, and were in imminent danger of being thrown on the rocks, when the tug *Edna B. King* came to the rescue, and towed the *Lockhart* and its barges to a place of safety. Fire followed the explosion on the *Lockhart*, and the flames were mastered only after a hard fight of two hours.

(255.) — The boiler of a locomotive exploded in the round-house of the Pacific Coast Railway, at San Luis Obispo, Cal., on September 30th. One end of the round-house was completely wrecked, and some damage was done to a warehouse 75 feet distant. Fortunately, the men who had been on the engine a few minutes before had left the building, and nobody was injured.

Inspectors' Report.

SEPTEMBER, 1896.

During this month our inspectors made 8,106 inspection trips, visited 15,488 boilers, inspected 6,605 both internally and externally, and subjected 761 to hydrostatic pressure. The whole number of defects reported reached 11,255, of which 842 were considered dangerous; 40 boilers were regarded unsafe for further use. Our usual summary is given below :

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,035	53
Cases of incrustation and scale,	2,043	70
Cases of internal grooving,	112	5
Cases of internal corrosion,	824	42
Cases of external corrosion,	738	21
Broken and loose braces and stays,	185	33
Settings defective,	292	32
Furnaces out of shape,	446	10
Fractured plates,	216	51
Burned plates,	202	11
Blistered plates,	196	4
Cases of defective riveting,	1,149	82
Defective heads,	115	21
Serious leakage around tube ends,	2,086	206
Serious leakage at seams,	287	15
Defective water gauges,	371	58
Defective blow-offs,	170	48
Cases of deficiency of water,	12	10
Safety-valves overloaded,	52	20
Safety-valves defective in construction,	58	21
Pressure gauges defective,	553	26
Boilers without pressure gauges,	2	2
Unclassified defects,	111	1
Total,	11,255	842

The Locomotive.

HARTFORD, DECEMBER 15, 1896.

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

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

MR. William Paul Gerhard's little book on *Theater Fires and Panics*, contains much that is of interest to the general reader, and of importance to the architect and builder who may have to do with theatres and other public buildings devoted to like purposes. To show the importance of his subject, Mr. Gerhard presents statistics concerning 516 theaters that have been totally destroyed by fire, including 29 in New York city alone. One theater in Spain is notable for having been burned to the ground no less than seven times. The average number of such fires, for the past century and a half, has been 19 per annum. Twelve notable fires, resulting in the death of some 2,800 persons, are also described in some detail. The causes of such fires, and the best methods of avoiding and controlling them, and of preventing panics, are then discussed in a lucid and practical manner. A very good bibliography of the subject is also appended to the volume. (John Wiley & Sons, 53 East Tenth St., New York. 175 pp. ; cloth, $1.50.)

High vs. Low Water Explosions.

A correspondent in Texas writes as follows, "To settle a wager, will you kindly give your experience and opinion on the following proposition: A boiler with three gauges of water will do more damage, if it explodes, than a boiler with only one gauge of water, or with any other quantity less than the full three gauges. The damage to be directly from the explosion, and not from scalding water or scalding steam. In other words the force of the explosion is greater with a full boiler of water than with less. Have you, in your records, anything that would indicate at what stage of water the explosion would be worst?"

In reply we desire to say that we do not care to express an absolute, unqualified, hard-and-fast opinion on this point, because there are explosions and explosions. Sometimes a full boiler will burst and do wonderfully little damage; while at other times a boiler that is nearly empty will do an amount of damage apparently quite out of proportion to the heat energy stored up in it at the moment of explosion. As a general rule, however, it may be said that the most disastrous explosions are those in which the ruined boiler was plentifully supplied with water. The immediate cause of a low-water explosion usually is, that the plates become overheated to such a degree that they soften and lose their strength. The pressure then forces an opening in the shell, and the contained steam rushes out in great volume, throwing down the settings, and very likely shaking up the boiler-house to such an extent that it is considerably damaged. The damage is likely to be much greater when the boiler contains more water, because then the explosion takes place either because the pressure is abnormally high, or because there is some defect in the boiler itself that weakens it so that it cannot withstand the ordinary pressure. The result is apt to be that when the boiler gives way, it is torn apart so badly that the pressure within is liberated almost *instantly*, and the pressures and other forces exerted on the adjacent property are equally sudden, and correspondingly more effective. These general considerations are, as a rule, borne out by our experience. They are also borne out by the various attempts that have been made, from time to time, to make boilers explode, experimentally, from low water.

Assuming that our correspondent's interest in this matter goes beyond the mere decision of the ownership of the stake he has pledged, we shall give a few references that may aid him in looking into it further. There is a popular belief that a boiler whose sheets are dry and red-hot (or nearly so) is particularly liable to explosion; and as we suspect that this belief is what led to the dispute in hand, we shall consider it first.

Various experiments have been made for testing the liability of boilers to explosion under these conditions, but the results that have been reached do not agree among themselves as well as we could wish. For example, the interesting and exhaustive experiments carried out by the Franklin Institute in 1835, and reported in the *Journal of the Franklin Institute* for 1836 (Vol. XVII), indicate that a considerable increase of pressure may follow the injection of cold water into an overheated boiler. The way in which these experiments were carried out will be understood by reading the following extract from the committee's report: "The experimental boiler being arranged as already described, a small quantity of water was placed in it and boiled away; the heat being still applied, the temperature of the bottom was gradually raised. At different temperatures of the bottom, water was thrown in by the forcing pump, and the effect (on the gauge) of a given quantity was noted. . . . The water injected was at 70° Fahr. The course of the water injected could be distinctly marked after the bottom of the boiler had become heated to redness, and was examined through a glass window ($\frac{3}{8}''$ thick). The force of the pump carried it to the fire end, nearly; the boiler being slightly inclined to the back end, the water slid back in one or more dark masses, moving down the central line, or diverted up the sides, greatly agitated and frequently changing its shape. The water generally disappeared at the back end, though parts were retained by accidental spots of sediment, and disappeared upon them." In every case in which the cold water was injected, a material rise of pressure was observed; and in the last experiment this rise amounted to about twelve atmospheres, with the result that one of the glass observing windows was blown out. The steam that was produced was highly superheated in every case, the observed pressure never being more than about half of that due to the observed temperature.

Although the labors of the Franklin Institute Committee constitute a valuable contribution to our knowledge of steam-boiler explosions, yet we are of the opinion that they were not conclusive, so far as the effect of injecting cold water into an overheated boiler is concerned. Sir William Fairbairn considered the subject of boiler explosions in a lecture delivered about 1850, and reprinted in his *Useful Information for Engineers*,* but he throws no new light upon this particular question of low-water explosions, except that he very correctly denies that hydrogen gas is liberated in any considerable quantities when water is thrown upon red-hot boiler plates. So far as the sudden formation of steam is concerned, he says: "When a boiler becomes short of water, the

* First series, fourth edition, 1864, p. 54.

first and perhaps the most natural act is to run to the feed valve and pull it wide open. This certainly remedies the efficiency, but increases the danger, by suddenly pouring upon the incandescent plates a large body of water, which, coming in contact with a reservoir of intense heat, is calculated to produce highly elastic steam."

About 1860 we find another standard authority upon steam boiler explosions, in the person of Mr. Zerah Colburn. In his excellent little book on this subject he speaks as follows of low-water explosions: "Supposing extensive and severe overheating to have taken place, and water to be suddenly thrown upon the heated plates, it is doubtful if the quantity of steam disengaged would be sufficient to increase greatly the pressure already within the boiler. Whoever has observed a large mass of wrought-iron, when plunged at a high heat into twice or three times its weight of cold water, must have remarked how small a quantity of steam was disengaged. There is reason to believe that just as much and no more steam would be produced if the same weight of iron, heated to the same degree, were disposed in the form of a boiler, and the same quantity of cold water were suddenly thrown into it. If, however, the boiler already contained a considerable quantity of water, heated to from 212° to 400° Fahr., the injection of additional water upon any overheated surface of the furnace might be followed (as, indeed, it often is in such cases) by an explosion. . . . But there is, I think, sufficient reason to believe that an empty boiler, however much it may be overheated, may be filled, or partly filled, with water with no danger whatever of explosion. Red-hot boilers, I am told, have been occasionally filled in this way without any disturbance or consequences of any kind indicating a tendency to explosion. I have never tried such an experiment myself, nor can I, perhaps, furnish such authority as would, by itself, be sufficient to establish such a fact; but a brief consideration of some of the phenomena of heat has convinced me that it is a fact. The actual quantity of heat which the thin metallic sides of a steam boiler are capable of containing, is not sufficient to change a very large quantity of water into steam." Notwithstanding these remarks on the introduction of cold-water into a red-hot boiler, Mr. Colburn said that he "believed that under certain circumstances a boiler may be violently exploded by the steam thus formed," and that he thought that "the explanation by overheating possesses considerable probability." In a foot-note he quotes from the *Engineer* an account of an experiment made to test the theory on a larger scale than was possible with the Franklin Institute apparatus. "The boiler was 25 feet long and 6 feet in diameter," says the account, "and the safety-valve was loaded to 60 pounds per square inch. When empty and red-hot, the feed was let on and the boiler filled up. No explosion occurred, but the sudden contraction of the overheated iron caused the water to pour out in streams at every seam and rivet as far up as the fire-mark extended."

In April, 1868, the Pennsylvania Railroad Company made a series of experiments at Kittanning Point, which are thus described by Mr. J. M. Cains: "The object was to blow up a boiler by introducing cold water on a red-hot crown-sheet, the maximum steam-pressure being on the boiler at the time. In conducting the experiments the boilers were first fired up until 125 pounds of steam were obtained and the water was low, and then, through 1,000 feet of hose, cold water was forced into the boiler by means of a steam fire-engine; and every attempt at exploding a boiler in that manner failed. Two boilers were experimented on, the first one becoming leaky after several trials, and being of no further use in that way. The second boiler was tried a few times, and finally blew up when least expected, seemingly from excessive pressure and weakened fire-box. The crown-sheet blew down and the boiler turned a complete somersault, and then rebounded and fell down the side of a hill, the spectators scattering very fast and seeking shelter behind convenient trees. Nobody was hurt." *

In 1875 a commission appointed by the United States Government made a series of similar experiments at Sandy Hook, the general results of which are given in the following extract from the *Scientific American:* † "The boiler experimented upon was of the plain cylindrical type, set in brickwork in the usual manner. In each experiment the boiler was filled with water, a fire started, and, when the fire was in good order and the steam at the right point, all water was blown out; the boiler was allowed to become heated to the desired temperature, as indicated by a pyrometer inserted within it, and at the proper moment the feed water was introduced by a force pump. It was only on the second day that this severe usage produced the destruction of the boiler. At each occasion, on the introduction of the water, the steam pressure jumped up suddenly, the safety-valve opened, and, the water still continuing to enter, the boiler pressure dropped almost as rapidly as it had risen, and the boiler cooled down on each occasion (except the last) without apparent injury, and without having even started a seam, although the metal had been red-hot. The last experiment resulted in the explosion of the boiler and the destruction of its setting, and interrupted the work. The succession of phenomena in this case was precisely as already described; but the temperature of the boiler was higher, probably a bright red on the bottom, and the pressure of steam was about 60 pounds when the explosion occurred. It had fallen somewhat from the maximum, which had been attained the moment before. These experiments illustrate the facts which we have often presented to the readers of the *Scientific American*, in our remarks upon the methods by which low water in steam boilers becomes an element of danger. When the boiler is strong, of good, tough iron, and not too seriously overheated, it may not be exploded on the introduction of water. But there is invariably a development of steam immediately upon the entrance of the feed water, producing a rise of pressure which will be directly in proportion to the weight of iron overheated, and the excess of temperature attained; and the suddenness of this rise will be proportional to the promptitude with which the boiler iron discharges its heat into the water first entering. This rise may be sudden and so great that the safety-valve cannot relieve the pressure promptly, in which case the boiler, if not very strong, may be exploded."

Prof. R. H. Thurston, in his little book on *Steam Boiler Explosions* (page 64) says: "The author has taken part in many attempts to experimentally produce explosions by pumping feed-water into red-hot boilers, and has but once seen a successful experiment. The same operation in the regular working of boilers has been often by ignorant or reckless attendants without other disaster than injury to the boiler: but it has unquestionably, on other occasions, caused terrible loss of life and property."

In an elaborate series of experiments carried out in 1889 by the Manchester (Eng.) Steam Users' Association, negative results were obtained, as will be seen from the following extract from the chief engineer's report: "The results obtained showed that showering cold water on the furnace crowns when red-hot did not lead to their rending by sudden contraction, either transversely or longitudinally, nor did it lead to a violent generation of steam which the safety-valve could not control and the shell could not resist. . . . *There was no collapse; there was no rent, either in the furnace tubes or in the shell, and no movement of the boiler whatever.*" ‡ Nevertheless, the association does not by

* THE LOCOMOTIVE, December, 1893, p. 190.

† *Scientific American*, Aug. 21. 1875, p. 113.

‡ Manchester Steam Users' Association: *Report on a Series of Red-Hot Furnace Crown Experiments.* Manchester, Eng., 1889, p. 39.

any means recommend engineers or firemen to try these experiments on their own boilers; its final words to boiler attendants are: "Do not let shortness of water occur. Keep a sharp lookout on the water gauge." We may also quote the following words, which form the conclusion of the report: "These experiments clearly put to rout the generally entertained opinion, that showering cold water on to red-hot furnace crowns would cause the 'instantaneous disengagement of an immense volume of steam,' which would act 'like gunpowder,' overpowering the safety-valves, however efficient, tearing the outer shell of the boiler to pieces, and hurling the fragments to a considerable distance. Yet these opinions have been repeated again and again; the credence they have obtained has tended much to mystify the subject of steam-boiler explosions, and, by leading astray from the true cause, to perpetuate the recurrence of these disasters. Many a poor fireman has been blamed for an explosion of which he was perfectly innocent. It is trusted these experiments will be of public service, by helping to correct some of the mistaken views too generally entertained with regard to the cause of steam boiler explosions. It would have been well if they had been tried some fifty years ago, in the days when high pressure steam was young, when the cause of steam-boiler explosions was shrouded in mystery, and the easiest way out of the dilemma was to blame the stoker."

Our correspondent may also refer to an article by Alfredo Gilardi on "Leidenfrost's Phenomenon," a translation of which was given in The Locomotive for April, 1893, on page 54. In this article a calculation is presented, which shows that under the conditions there assumed, the introduction of the cold feed-water leads to an ultimate *reduction* of pressure.

We think that the difference of opinion that prevails among engineers concerning the danger of introducing cold feed-water into a red-hot boiler is due, in no small degree, to a confusion of ideas about the *amount* of water injected. It is evident, of course, that if several tons of water were suddenly introduced, the pressure would fall, and would probably disappear altogether. It is equally certain that if only a few *ounces* were introduced, the pressure would rise to some extent. Hence, there must be some intermediate point at which the maximum pressure would be produced. This intermediate point will be realized when the quantity of water injected is such that it can be entirely vaporized by the surplus heat stored up in the red-hot plates. Experiments or calculations in which a greater or less amount of water than this is used or assumed, will naturally show a less marked rise of pressure; and we apprehend that most of the prevailing disagreements among engineers, on the effect of cold-water in a hot boiler, hinge upon this point. After reviewing the evidence for and against the cold-water theory, we may fairly say that cold-water, when thrown on an overheated plate, is certain to give rise to enormous contraction strains in the shell, which, when added to the normal strain already present, may be sufficient to produce rupture. We may also say that when the pump is first started, a rise of steam pressure may be expected; but it is difficult, and in fact almost impossible, to state whether this rise of pressure will constitute an element of immediate danger or not. Certainly we do not advise the attendant to try the experiment. If, in spite of the vigilance which it is his duty to his employers and himself to exert, the water gets so low that he cannot find it (the fusible plug having meanwhile given no warning), then the proper thing for him to do is to cover the fire with ashes, and leave the damper and the fire doors open. The feed-valve, steam valve, and safety-valve should not be touched. If this course be followed, the boiler will soon cool down sufficiently to remove all danger of further overheating, or of explosion. Its condition should be carefully ascertained, however, before it is again put into service.

Having devoted considerable space to what we conceive to be the root of the controversy, we shall conclude with a few words on the specific point that our correspondent asks us to decide. As we said at the outset, it is not possible to state positively than an explosion at one given stage of the water-level will produce more or less destruction than at some other stage, because so much depends upon the precise way in which the failure takes place. In general, however, we may safely use *the quantity of heat energy stored in the boiler* as an index of the *probable* violence of a prospective explosion. If this be admitted, it follows that under conditions otherwise similar, an explosion will be more destructive when plenty of water is present, than it will be when the water is low. In illustration of this fact, let us consider the horizontal tubular boiler described by Thurston on page 28 of his book on steam-boiler explosions, to which we have previously referred. This boiler was 60″ in diameter and 15 feet long. Under usual running conditions, with the water-level at the usual height, it contained about 145 cubic feet of water, and about 100 cubic feet of steam. Now, under a gauge-pressure of, say, 90 pounds per square inch, and a corresponding temperature of 330.9° Fahr., a cubic foot of steam weighs 0.239 of a pound, and a cubic foot of water weighs something like 60 pounds. According to Thurston's tables, a pound of water at 330.9° Fahr. contains about 7,270 foot-pounds of energy, which may be liberated by explosion and consequent cooling to, say, 212°. A pound of steam, under the same conditions, contains about 109,300 foot-pounds of available energy. The tremendous difference between those figures has led, sometimes, to the erroneous conclusion that a boiler filled with steam possesses a vastly greater capacity for destruction than a boiler reasonably full of water; but this is not the case, because these figures are given *per pound* of steam and water, respectively, and if the same data are presented for the two substances so that the energy *per cubic foot* shall appear, the result is very different, as we shall show. With the data given above, it follows that the available energy in a cubic foot of *water* at 330.9° Fahr. is about 60 × 7,270=436,200 foot-pounds; while the available energy in a cubic foot of saturated steam, under like conditions, is only .239×109,300=26,123 foot-pounds. From these results we find that under proper working conditions, with 100 cubic feet of steam and 145 cubic feet of water, the available energy in the boiler is as follows:

Available energy in the steam=100× 26,123= 2,612,300 ft.-lbs.
" " " water=145×436,200=63,249,000 ft.-lbs.

Total available energy in the boiler, =65,861,300 ft.-lbs.

Now let us assume that the water-level is so low that there are only 35 cubic feet of water present, the remaining 210 cubic feet being filled with steam. We then have:

Available energy in the steam=210× 26,123= 5,486,000 ft.-lbs.
" " " water= 35×436,200=15,267,000 ft.-lbs.

Total available energy in the boiler, =20,753,000 ft.-lbs.

It appears from these figures that when the boiler contains the proper amount of water, its available energy is *more than three times as great* as it is when there is only about one-quarter of the proper quantity of water present. If the available energy be taken as a proper index of the probable destructiveness of an explosion, it therefore follows that when other conditions are the same, the greatest damage will be produced by the boiler that contains the most water.

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