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

The Locomotive.

PUBLISHED BY THE

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Heating Water by the Direct Injection of Steam.

The Locomotive for October, 1897, contained an article on heating water by steam, both by the direct injection of the steam, and by the use of submerged coils of pipe. As a result, we have received many inquiries concerning the amount of coil surface, the best size of pipe, and the time required to heat a given number of gallons of water through a given range of temperature. The present article is intended as a partial answer to these various queries, and we shall give further information of a similar nature in a subsequent issue.

When problems of this sort are sent in to us for solution, they are seldom accompanied by sufficient data to make an intelligent solution possible. When an estimate is wanted of the probable time that will be required to heat a given tankful of water, it is important to know the size and length of pipe to be used, the number of turns or elbows that it contains (counting from the main steam pipe), the initial pressure of steam that is available, and the size, material, and exposure of the tank. All these elements affect the solution of the problem in a marked degree. When these elements are correctly taken into account, it is possible to make a fairly correct estimate of the time required to heat a given amount of water through a given range of temperature, as we have repeatedly found in designing the steam machinery for dye-houses, bleacheries, and other similar works.

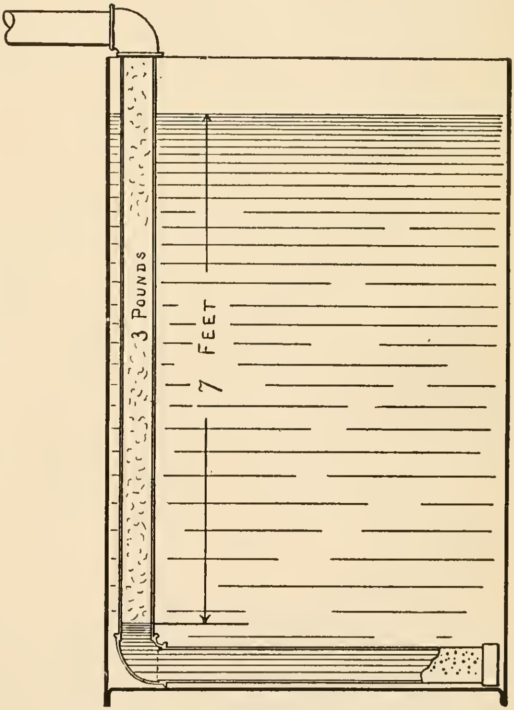

Fig. 1.—Effect of the Static Water Pressure.

To illustrate the method of calculation when the steam is discharged directly into the water of the tank, let us consider a case that was recently proposed for solution. The tank was of iron, and contains 1,080 gallons of water, which was to be heated from 82° to 170° by means of exhaust steam. We were informed that the pipe was 5″ in diameter, and that the initial pressure of the steam was five pounds per square inch, above the atmosphere. No other data were given. We have to assume the length of the pipe, and we will assume that the initial pressure of the steam is one pound above the static water pressure at the end of the pipe where the steam is delivered into the tank, and also (which was not definitely stated), that the available *volume* of steam is sufficient to make the flow constant under these conditions.

First, we have to find the weight of the water to be heated. A gallon of water at 82° weighs about 8.315 pounds; and hence 1,080 gallons will weigh 8,980 pounds. Each pound is to be raised from 82° to 170°, so that for each pound we shall require $170 - 82 = 88$ heat units. To heat the whole 8,980 pounds we shall therefore require $8{,}980 \times 88 = 790{,}240$ heat units. Now one pound of steam at a gauge pressure of 5 pounds per square inch will give out 971 units of heat in condensing into water at 212°, and 86 units more in cooling to 126° (which is the average temperature of the water in the tank). But inasmuch as there is an unknown amount of heat being continuously radiated from the tank into the surrounding air, we take no account of the heat given out by the condensed steam in cooling from water at 212° to water at 126°, considering that this will roughly compensate for the loss by radiation. In other words, we allow only 971 units of heat for each pound of steam condensed, as the amount actually available for raising the temperature of the water in the tank. So that to obtain the required 790,240 heat units, we should have to condense

$$790{,}240 \div 971 = 814 \text{ pounds of steam.}$$

Having found the number of pounds of steam that would be required to heat the water to the desired temperature, we have next to find out how long a time would be required for the supply pipe to deliver that quantity of steam, under the given conditions. This is the only uncertain element in the calculation; and its uncertainty is due to the fact that the discharge from a steam pipe is largely influenced by the length of the pipe and the number of elbows and valves it contains. A straight five-inch pipe, 100 feet long, may be expected to deliver about 77 pounds of steam per minute, under the conditions which are assumed in the problem under consideration, and we shall take this as the actual discharge of the pipe in question. If 77 pounds are discharged in one minute, the time required to discharge the 814 pounds required will be

$$814 \div 77 = 10.6 \text{ minutes,}$$

which is therefore the time that would be required to heat the given tankful of water from 82° up to 170° under the assumed conditions.

This calculation assumes, as we have already said, that the steam available for the purpose of heating is sufficient in volume to maintain a *steady flow* through a 5-inch pipe, under an initial pressure that is constantly one pound greater than the static pressure of the water in the tank at the discharge end of the steam pipe. If this condition is not fulfilled, the actual time required may be much greater than the time as calculated by this process; and the difference, in extreme cases, may amount to an hour or more, so that the calculation, at first thought, may appear false and illusory. A reference to Fig. 1 will make the importance of this point clear. A cylindrical tank, five feet in diameter, would have to be at least seven feet high to contain the 1,080 gallons of water postulated in our example. The steam pipe, in order to be effective in heating the water, would have to open near the bottom of the tank, where the static pressure of the water would be some 3 pounds (reckoning one pound for every 2.3 feet). A steam pressure of 3 pounds might therefore exist in the pipe without *any* discharge of steam into the tank. If the steam were the exhaust from an engine, this state of things might very easily be realized during a considerable part of every stroke, and we might be led to base our calculations on the assumption of a continuous flow of steam, when we really had nothing but an intermittent discharge. Such a proceeding would be manifestly wrong, and we could not expect to obtain a correct estimate of the time required, by applying the principles of calculation given above.

It takes a surprisingly large amount of heat to raise the temperature of half a ton of water through 80 or 90 degrees. We have seen that we should have to use 77 pounds of steam every minute, in order to raise the temperature of 8,980 pounds of water from 82° up to 170° in 10.6 minutes. This is at the rate of $77 \times 60 = 4,620$ pounds of steam per hour; and allowing 30 pounds per hour as the equivalent of a horse-power, we see that, in order to do the heating at this rate, we should have to have a boiler capacity of at least $4,620 \div 30 = 154$ horse-power.

With a smaller boiler capacity it would be impossible to do the heating in so short a time as 10.6 minutes, because it would be impossible to keep up the assumed flow of steam through the 5-inch pipe. A 50 horse-power boiler having about one-third of the capacity required to do the work in 10.6 minutes, might be able to do it in $3 \times 10.6 = 31.8$ minutes, though the loss by radiation from the tank would be much greater in half an hour, than it would be in ten minutes; and therefore some further allowance would have to be made on this account. A 25 horse-power boiler would have about one-sixth the capacity called for in our original example, and hence, if there were no extra radiation, it might do the work in $6 \times 10.6 = 63.6$ minutes, or something over an hour. But when the process is carried out as slowly as this, the radiation of heat from the tank would be so considerable that a materially longer time than the calculated hour and three minutes would be required, in order to compensate for it.

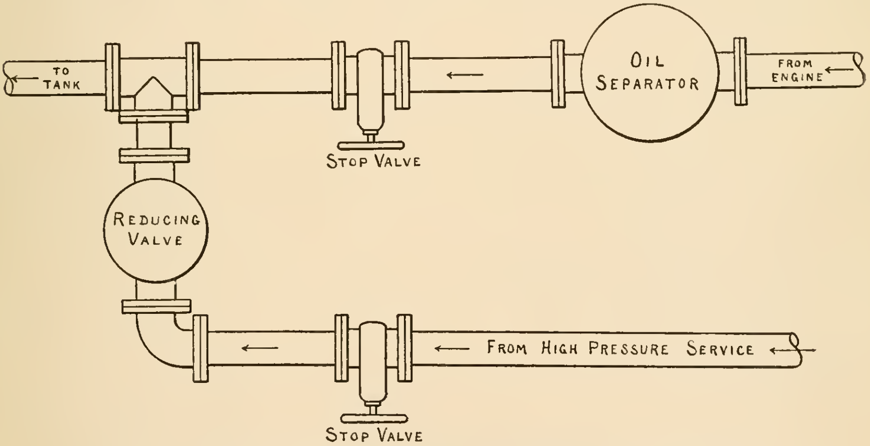

Fig. 2.—Connections for Using Live Steam with the Exhaust.

Exhaust steam is used very largely for heating water tanks such as we have described, and as the volume of the exhaust is often insufficient to maintain a flow of steam sufficient to effect the heating in the time desired, it is advisable to provide some means of drawing enough live steam from the boiler to supplement the exhaust, and keep the flow up to the necessary volume. An arrangement of this sort, which requires very little explanation, is shown in Fig. 2. The exhaust from the engine passes through an oil separator, to remove such greasy matter as it may contain. A side pipe from the live steam main then enters it, after passing through a reducing valve which is set so as to open automatically whenever the pressure in the exhaust pipe falls below the point at which the required flow of steam is obtained.

Inspectors' Report.

OCTOBER, 1897.

During this month our inspectors made 9,124 inspection trips, visited 18,529 boilers, inspected 6,427 both internally and externally, and subjected 779 to hydrostatic pressure. The whole number of defects reported reached 10,730, of which 919 were considered dangerous; 31 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	850	38
Cases of incrustation and scale,	1,986	47
Cases of internal grooving,	95	8
Cases of internal corrosion,	567	28
Cases of external corrosion,	662	36
Broken and loose braces and stays,	91	26
Settings defective,	270	19
Furnaces out of shape,	432	18
Fractured plates,	252	49
Burned plates,	220	16
Blistered plates,	201	2
Cases of defective riveting,	1,483	78
Defective heads,	102	25
Serious leakage around tube ends,	1,768	286
Serious leakage at seams,	413	22
Defective water-gauges,	360	47
Defective blow-offs,	189	54
Cases of deficiency of water,	20	6
Safety-valves overloaded,	97	40
Safety-valves defective in construction,	76	19
Pressure-gauges defective,	467	40
Boilers without pressure-gauges,	9	9
Unclassified defects,	120	6
Total,	10,730	919

Boiler Explosions.

NOVEMBER, 1897.

(282.) — A boiler exploded, on November 1st, in the Edmonds creamery, at Mina Center, near Maysville, N. Y. The boiler room and engine were wrecked, but nobody was injured, as none of the employes were in the building at the time.

(283.) — By the explosion of an upright boiler, on November 2d, at the jetty at Eureka, Cal., Engineer George R. Wilson was badly scalded about the hands and face, and Henry Garner was thrown into the bay. The explosion blew the machinery over the pier, and wrecked the pile driver.

(284.) — A boiler exploded at Quebec, Canada, on November 2d, while in use for unloading the bark *Corona*. Nazaire Cantin was fatally injured, so that at last accounts his death was hourly expected. Thomas Donnolly and Charles Holme were also severely injured, and three other persons received injuries of a less serious nature.

(285.) — On November 3d a boiler exploded in Fletcher Haggood's cotton gin, at Naples, Morris county, Texas. The engine room was entirely destroyed, and one end of the gin house was torn off. Joseph Phillips was badly cut and bruised, and also received internal injuries that are supposed to be fatal. Robert Dudley was also badly scalded, and Fletcher Haggood received some painful bruises.

(286.) — A boiler exploded, on November 3d, in a saw-mill at St. Mary's, Pa. Frederick Hawr was seriously injured.

(287.) — On November 3d, a boiler exploded in the Royal City Mills, at Vancouver, B. C. G. Sully, Charles Phillips, and a young man named Forbes were injured. The engine house and the blacksmith shop were wrecked.

(288.) — A boiler exploded in Isaac Weir's furniture factory, at Laurel, Ind., on November 4th. Hugh Smith, the fireman, was fatally scalded, and the proprietor of the factory was also painfully injured.

(289.) — On November 5th a boiler exploded at the Wildcat oil well, at Summerfield, near Bellaire, Ohio. Engineer William Finney was seriously injured. The explosion wrecked the whole outfit, and the boiler was blown 800 feet from its original position.

(290.) — On November 8th a boiler exploded at the No. 2 mine of the Moe Iron and Coal Company, of Stoneboro, Pa. David Love was instantly killed, and John Jackson and Joseph Dower were injured so badly that they died within a few hours. Charles Yeager, Albert Japtheimer, and Hayes Fry were also fatally injured, and Charles Fry received injuries of a less serious character. The boiler house was completely demolished, and a part of the boiler was blown to a distance of 2,000 feet, passing over two dwelling-houses on its way.

(291.) — James Simpson, engineer, and John Robinson, fireman, were instantly killed, on November 9th, by the explosion of a boiler of a freight engine on the Burlington & Missouri River railroad, near Crawford, Neb.

(292.) — The boiler of a locomotive on the West Pennsylvania Division of the Pennsylvania Railroad exploded, on November 16th, at the station at Springdale, Pa. Those upon the platform of the station were thrown to the ground. Miss Kate Kennedy and another young woman were painfully scalded. The engineer and fireman of the locomotive escaped injury.

(293.) — On November 9th a heating boiler, carrying three pounds of steam, exploded in the basement of the city hall at Charleston, S. C. There were no personal injuries, because nobody chanced to be near the boiler at the time. The setting of the boiler was blown down, and the boiler itself, to quote the Charleston *Critic*, "is a wreck, and to all appearance will soon have to be disposed of as old iron."

(294.) — A boiler exploded, on November 10th, in Miles Morton's cotton gin, at Morgan Mills, Erath county, Texas. John Hancock and Robert Simpson were instantly killed, and Benjamin Cook was injured so badly that he died almost immediately. Miles Morton and William Cook were also injured so badly that they died some two hours later.

(295.) — A boiler in W. H. Kimbrell's gin and grist mill, situated about 19 miles from Meridian, Miss., exploded, on November 12th, just at the close of the day's work. Fireman George Burns was severely injured. Considerable portions of the mill were destroyed.

(296.) — The boiler of a steam traction engine blew up, on November 12th, on the farm of Minshall Sharpless, at Birmingham, near Westchester, Pa. One man was injured, and the boiler was blown to atoms.

(297.) — A boiler exploded, on November 13th, in the MacKenty Hospital, at Waltham, Mass., badly wrecking the basement of the building and the operating room, which was directly over the boiler. The explosion occurred when there were nobody in the operating room except one physician, who was slightly hurt. Miss Mary MacKenty, who was in an adjoining room, was severely injured by flying bricks. Every window in the lower part of the building was blown out, and a large stock of surgical instruments in the operating room was destroyed.

(298.) — A boiler exploded, on November 16th, at the Cooper oil well, near St. Mary's, W. Va.

(299.) — A boiler exploded, on November 19th, in the Southern Pine company's big saw-mill at Offerman, Ga. Fragments of machinery were thrown to a distance of a quarter of a mile. Part of the roof of the mill was torn off, and a portion of one of the heavy brick walls was thrown down.

(300.) — On November 19th, a boiler exploded in Milton Artley's large wood working factory at Carleton, Mich., instantly killing the fireman, Edward Craft, and injuring Frederick Artley, Otis Baker, and Cyrus Burroughs. The explosion shook every building in town, and left the factory almost a total wreck. Portions of the boiler were blown 500 feet from the mill, and other parts several thousand feet.

(301.) — A boiler operating an oil-well drill near Huntington, Ind., exploded on November 20th, doing a great deal of damage. Albert Bell, the engineer, was killed and his body was blown to pieces. This is the third accident of the sort that has occurred within a radius of one mile of this place, within the past six months.

(302.) — On November 20th a boiler exploded in John Woodward's saw-mill at Louisville, some 16 miles south of Ackerman, Miss. Frank Woodward, James Hemphall and Fayette Norton were killed. John Woodward and his nephew, Mott, were badly scalded. Jefferson Hathron, John Coleman, and two little boys named Blair were also severely burned. Part of the boiler was hurled 200 feet into the air, landing finally some 300 feet from its original position.

(303.) — A heating boiler exploded, on November 22d, at the office of the *Chronicle*, of Binghamton, N. Y. The boiler was under the sidewalk, and when it exploded it demolished the stone flagging. Pieces of iron and brick were hurled in all directions, and there were many narrow escapes from severe injuries. The plate glass front of the building was smashed in, and the interior of the *Chronicle* office looked as though it had been through a fire. The boiler was carrying 13 pounds of steam at the time of the explosion.

(304.) — A mud drum exploded, on November 22d, in Liggett & Myers' tobacco factory, at St. Louis, Mo. Engineer William Etzes was thrown to the floor, but was not injured. The explosion occurred at half-past four in the morning, when nobody was in the building except the engineer and two watchmen.

(305.) — On November 22d a boiler exploded in the building owned and controlled by the Graves Elevator company, of Rochester, N. Y. Patrick Shields and Robert Henry were instantly killed. The boiler-house was destroyed, and considerable portions of the main building were damaged so badly that they will have to be torn down and rebuilt. A Corliss engine which stood beside the exploded boiler was badly wrecked, and the total property loss was probably in the neighborhood of $25,000. [We have issued an illustrated circular giving a full account of this explosion. Copies of it will be sent free to any address, upon application at any of our offices.]

(306.) — A boiler exploded, on November 22d, in the American Gas Company's plant, at Bakerstown, near Pittsburgh, Pa. Joseph Moore, the engineer, was killed.

(307.) — A boiler explosion occurred, on November 23d, in the power-house that supplies the electric lights and the street car service at Terre Haute, Ind. We have not learned further particulars.

(308.) — A boiler belonging to Anderson & Cameron, of Saron, near Groveton, Tex., exploded on November 24th, killing Augustus Thelander, and injuring four other persons.

(309.) — A boiler exploded, on November 24th, in Hatcher's mill, nine miles west of New Albany, Miss. Walter Taylor was fatally injured, and J. W. Bullock, Henry Rochester, Thomas Ford, Nicholas Taylor, and Thomas Adams were hurt seriously but not fatally.

(310.) — A steam-heating boiler exploded, on November 24th, on a passenger train on the Evansville division of the Illinois Central railroad, at Paducah, Ky. Nearly every person in the car was more or less injured. The most seriously wounded were R. C. Watkins and C. E. Cameron.

(311.) — A boiler exploded, on November 27th, at the Gold Lake mines, at East Halifax, N. S., causing the instant death of Daniel McPhail, James Hennessy, and John McIsaac. Mr. McPhail was the manager of the mines.

(312.) — On November 28th a boiler exploded in the Soho iron mill of Laughlin & Co., Limited, of Pittsburgh, Pa. John Mullen was scalded and burned so badly that he died four hours later. Seaford Armes, John Pierpont, John Karsey, William McCarthy and one other man whose name we could not learn were severely injured. Several others also received minor injuries. We have not learned the extent of the property loss.

WE desire to acknowledge the *Report*, for 1896, of the Associazione fra gli Utenti di Caldaie a Vapore, of Milan, Italy, and the *Report* for 1896, of the Naples association of the same name. We acknowledge, also, the *Report*, for 1897, of the Chief of the Bureau of Steam Engineering of the U. S. Navy.

THE Hartford Steam Boiler Inspection and Insurance Company has issued an illustrated circular, entitled *The Rochester Boiler Explosion*, which gives an account of the explosion in Messrs. Graves & Co.'s elevator, at Rochester, N. Y. Copies of this circular may be had upon application to any of our agents.

The Locomotive.

HARTFORD, JANUARY 15, 1898.

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.

IN the November issue of *The American Miller*, there is an article by Mr. James F. Hobart, on "Boiler Inspection for Safety." In the course of this article we find the following passage : "Some kind of a solvent should be used, and the best way is to put at least two quarts of the feed water in a clean jug, and send it to be analyzed. It is not a costly operation, if the water is sent to the right place; for the Hartford Steam Boiler Inspection and Insurance Company, of Hartford, Conn., will test the water for steam-making purposes, free of charge, *no matter whether your boilers are insured with that company, or not.* They will also advise what chemical to use, to get the scale loose, and to prevent further formation."

We desire to say that this statement is entirely unauthorized. We never make analyses for those who do not insure with us.

A NEW and very welcome and creditable technical journal comes to us from the Worcester Polytechnic Institute, of Worcester, Mass. It will be published five times a year, and if future issues sustain the high standard shown by this first one (and we have excellent reasons for believing that they will), it will prove itself a worthy exponent of the work that is doing at the Worcester "Tech.," and it will be sought for, on account of the intrinsic value of its articles, by those who have no specific interest in the institution from which it comes. The leading articles in the present issue are on "Greater Boston's Water Works," "Sewage Purification," "Wire Testing at Washburn & Moen's," "Resistance of Insulating Materials as affected by Temperature," "Modern Cupola Practice," and "The Crushing Strength of Concrete." Typographically the *Journal* leaves nothing to be desired; and we wish it every success.

WE acknowledge, with pleasure, Mr. C. W. McCord, Jr.'s, treatise on *Slide Valves*, which was recently issued by Messrs. John Wiley & Sons, of 53 East 10th street, New York. It is based on a series of articles contributed to *Power* during 1895 and 1896. Beginning with the general principles of the steam engine and the slide valve, the author proceeds, with his third chapter, to the consideration of the Zeuner valve diagram, and to the solution of the various problems that the slide valve presents. The Allen valve and double ported valves are next treated in a similar way, and in the eleventh chapter the setting of the valve is explained. The remaining portion of the book is devoted to the discussion of shaft governors of various types. The work is well done, and the treatment, so far as we have observed, is as simple as could be expected. The phenomena of the slide valve are more or less complicated, yet Mr. McCord has presented them in this book with commendable clearness and simplicity. (Cloth, $2.00.)

Literary Thievery.

We do not like to talk all the time about other papers stealing articles from The Locomotive, and we should have been spared that duty on the present occasion, if the *Engineers' List* had been more honest in its November issue. The article on "Reduction of Pressure in Shell Boilers," was taken from our pages without a word of credit. It *does* contain the name of this company, it is true, but it contains it in such a way as to make the offense against us even more flagrant. For the original article says that "President J. M. Allen of this company, . . . by means of lectures, and articles in The Locomotive . . . endeavored to elucidate the principles of boiler construction," etc. It would not suit the purposes of the *Engineers' List* to retain the words "of this company," as that would betray the source of the article; so the revised version was made to read, that "President J. M. Allen of the Hartford Steam Boiler Inspection and Insurance Co., . . . endeavored to elucidate the principles of boiler construction," etc. Even the indirect allusion to The Locomotive was stricken out, probably for greater security against detection. A similar animus is shown in another place in the article, where we said that a certain thing "is well shown by the following cases which are taken almost at random from measurements recently made by *our* inspectors upon boilers proposed for insurance." Of course it was necessary for the editor of the *Engineers' List* to strike out the word "our," if he was to succeed in duping his readers into the belief that he wrote the article himself. So he made the passage say, that the thing in question "is well shown by the following cases, which are taken almost at random from measurements recently made by *the Hartford* company's inspectors upon boilers proposed for insurance."

Let us have a square deal in this matter. It is a small thing to give credit for a borrowed article, but it is a serious breach of honesty and courtesy not to do so. We believe that no paper loses by making an honorable acknowledgment of the source of its articles. What do your readers care if your paper *is* a scrap-book, provided it is a good honest one, and worth the pittance that you charge for it? But an editor who steals his matter, and studiously avoids giving credit for it, is morally obtuse; and if, as might easily be the case, he is no more conscientious about the accuracy of his articles than he is about their source, what is his paper good for?

Intentional Boiler Explosions.

A correspondent writes as follows: "In looking over a recent issue of The Locomotive, I note that you have several times referred to intentional boiler explosions. Here is an experience that I had recently, which may have a bearing on the subject. I was called upon to go out into the country for a few miles, to look at a boiler which 'had not exactly burst,' but had pulled the flues out of one of the flue sheets. Upon examination, I found that the flue sheet in the firebox had bent outward so as to drop all the middle rows of tubes into the boiler, only the upper row and the bottom ones remaining in place. The crown sheet was blistered in several places, and showed four small cracks, from 2″ to 5″ long. The gauge cocks in the front of the boiler were in bad condition, and the lower one was useless. The water column on the side, was connected to the boiler, top and bottom, by pipes which were each fitted with a globe valve. The steam gauge was slow, and the safety valve had various monkey wrenches and plow bolts hung upon it. The boiler was fed by an inspirator, which appeared to be in good working order. Upon making inquiries, I found that the boiler had run all right the day before, and the fireman and sawyer (for it was a saw-mill), both asserted that there was plenty of water in the boiler when they quit work the night before. When the mill was well under way on the morning of the accident, the fireman approached the sawyer and said: 'I wish you'd look in here; the steam is right blue.' The sawyer did as requested. The water in the glass appeared to be all right, but upon looking into the firebox he said it 'looked red.' Feeling uncertain what was going to happen, the men shut off the steam, and precipitately 'took to the woods,' and the boiler soon gave way, in the manner indicated above. It seems that some one, whether maliciously or not, had shut off both the globe valves leading to the water column, so that although there was no water in the boiler, there was plenty of it in the glass gauge, and the shortage was not detected, because they did not use the gauge cocks. The boiler was repaired, and is now doing good service again."

While we thank our correspondent for the trouble he has taken in sending us this item, we think that he has hardly made out a good case. That is, we do not think there is sufficient evidence that the explosion was intentional. A fireman who would neglect his boiler as this one evidently was neglected, would be quite capable of shutting the valves on the water column, and then forgetting about them. And even if he *did* recall his careless behavior after the trouble had come, he would hardly be likely to fasten the blame upon himself, by owning up. It would be more to his interest to let the thing remain clouded in mystery.

Hibernation.

The phenomenon of hibernation in animals, fish, and reptiles, is something that from its very nature and surroundings cannot be investigated, and consequently little is known as to its cause, or as to what physiological changes occur to animals that habitually retire to concealed places and lie dormant, or in a lethargic sleep, for days, weeks, and even months. It is known that in the perfect hibernators the processes of nature are interrupted during the period of this long insensibility. Breathing is nearly and in some hibernators entirely suspended, and the temperature of the blood, even in the warmer-blooded animals, falls so low that how life can be maintained by it is a mystery of mysteries.

A variety of Rocky Mountain ground squirrel, when in perfect hibernation, has a temperature only three degrees above the freezing point of water, and when taken from their burrows in that condition these squirrels are as rigid as if they were not only dead, but frozen. But a few minutes in a warm room will show that they are not only alive, but full of life. This interesting fact in natural history was first demonstrated by the late Andrew Fuller of Ridgewood, N. J., to whom a friend in the West sent a pair of these squirrels. When the weather became cold, Mr. Fuller missed his pets one day. He supposed they had run away from his premises. Nearly a month later he found them by accident curled up beneath a pile of straw in one corner of an inclosure on his place. They were so cold and stiff that he supposed they were frozen to death. He carried them into the house to show his wife the fate that had befallen the poor little rodents in the harsh Eastern climate. While he and she were discussing the matter sorrowfully, the squirrels began to show signs of life, and shortly were frisking about the room as if they had not been apparently frozen stiff for weeks. Mr. Fuller then knew that the squirrels had been in a state of hibernation, and it was such an extraordinary one that he put them out of doors again to let them resume that condition if they might, so he might investigate it further. They had no sooner got into the cold air than the lethargic state began to assert itself, and Mr. Fuller covered them with the straw. A month later he took their temperature and found it to be as I have stated — only three degrees above the freezing point of water. Again they came back to life and activity when placed in the warm room, but after a few hours showed plainly that they were being bereft of their natural winter sleep. Mr. Fuller turned them loose to find it again. They found it as before, and they remained in that condition until the warm weather returned in the spring, when they came out as chipper as if they hadn't lost a day or a meal.

As to the suspension of breathing in hibernators, the fact is proved sufficiently in the instances of the raccoon and the woodchuck. When they have laid themselves away for their winter sleep they roll themselves up so comfortably and press their noses in such a peculiar position against their hinder parts that it would be an absolute impossibility for them to draw a breath. The popular backwoods belief is that the bear rolls itself up in this way and does not breathe, but, while the bear is classed as a perfect hibernator by naturalists, it breathes while in its lethargy, as its blow holes in the snow prove — holes melted in the snow beneath which the animal frequently stows itself away, under a covering of leaves, which holes frequently betray its presence to the woodsman.

The marmot family produces the soundest winter sleepers. When the marmot is in its peculiar state of hibernation the electric spark will not rouse it. The most noxious gases do not affect it in the slightest. If its temperature is raised above that at which the animal breathed in its natural state it will die almost immediately. This is on the authority of the late Prof. Peter A. Browne, who at one time was connected with Lafayette College, and investigated the subject of hibernation and estivation further than any other scientist that I know of.

The hamster, a rodent common in northern Germany, is another animal that has its peculiarities as a hibernator. Prof. Browne mentions a hamster that was put into a box which was closed with earth and straw and placed where the cold was intense, but the hamster did not show any sign of becoming torpid. The box was then buried in the ground and was dug up after some hours, when the animal was found in a state of the most profound lethargy. And this hamster was kept in a room where there was no fire. The animal rolled itself up in a corner, but presently woke up and came out. It was in the best of health, but died in a few days — "suffocated," Prof. Browne declared, "because it could not have confined air."

Our own familiar wild animals, the bear, the raccoon, and the woodchuck — the groundhog of colloquial nomenclature — are classed as perfect hibernators because they store no food for winter, but have acquired a thick, fatty secretion between the skin and flesh, which, it is supposed, supplies them with sustenance. As a matter of fact, although dormant animals absorb fat, it does not enter into their digestive organs. The same fat absorption occurs when the animal is dead. If you kill a rabbit, or any other animal, and leave the entrails in it, the fat will disappear in a short time. Remove the entrails and the fat will remain. Food introduced into the stomach of a hibernating animal or reptile will be found undigested at all stages of its lethargy. I say "introduced into the stomach," because it could get into the stomach of such a creature only by force or artificial means, for a hibernating animal invariably goes into its peculiar state on an empty stomach. Why? I do not know. That is one of the mysteries of the phenomenon. But the most mysterious of all things connected with hibernating animals is that, although bears and woodchucks are profound hibernators, they produce their young during their winter sleep.

The woodchuck is undoubtedly a perfect hibernator, and the female bear is, but the male bear is frequently roused from his winter sleep, and is found roaming about in midwinter. A bear hunt when the snow is deep and the cold intense is not an uncommon relief to the monotony of life in the backwoods, but the hunted bear is invariably a male. I have talked with scores of old and observant woodsmen, versed in the ways and haunts of wild beasts, but none has ever been able to say yet that he ever knew a female bear to be killed after the season for hibernation has come, and none has ever yet seen a gravid female bear. Where do the females go during that time, that they are never disturbed in their retreats? No one can say.

The raccoon is often gregarious in its hibernating, and it may be that for that reason it not infrequently comes forth from its snug quarters in the hollow tree and makes foraging trips about the country — the warmth engendered by the huddling colony arousing one or more of its members from their lethargy for the time. Woodchucks hibernate in pairs, but I never knew one of these proverbially sleepy creatures to leave its hole until warm weather came — in spite of the alleged practice it has of coming out invariably on the second day of February to fix the weather for the rest of the winter. I took the trouble once to dig into a woodchuck's burrow on a Candlemas Day — and a warm, cloudy day it was; just such a day when the groundhog is said to come out of his hole and stay out. I found two woodchucks in the burrow, with no more sign of life about them than if they had been shot and killed. From all outward appearances I could have taken them out and had a game of football with them without their knowing it.

Squirrels are only partial hibernators, from the fact that they work all summer and fall storing great quantities of food to supply them when hunger wakes them up during the winter, if, indeed, they spend much of their time in sleep. Squirrels are systematic and longheaded providers for the emergencies of a long winter, and not only stow away their favorite food in one grand storehouse, but also make deposits of it in other places, so that if one granary or nuttery is destroyed or becomes exhausted the caches can be depended upon. When the snow has lain on the ground late in the spring, holes may be seen in it at various places in the woods where squirrels have dug down through it to reach nuts or grain or acorns buried in the ground there months before for just such an emergency. The instinct with which these little animals locate such spots, covered as they are with maybe a foot or more of snow, is unerring and marvelous. If the snow should happen to be thickly covered with crust the squirrels are unable to dig through it, and it is no rare thing, toward the end of an unusually long winter, for woodsmen to find squirrels dead on the crust, where they had been digging desperately to uncover the cache below, the supplies at the main store having become exhausted.

A curious phenomenon of hibernation, according to Prof. Browne, is shown in an animal called the loir, a native of Senegal. This animal never hibernates in its native clime, but every specimen that was ever brought to Europe became torpid as soon as exposed to cold. The common land tortoise, no matter where it may be, and it is a voracious feeder, goes to sleep in November and does not wake up again until May. The hedgehog goes to sleep as soon as the weather gets cold and remains in unbroken slumber six months.

At the beginning of cold weather bats begin to huddle together in bunches in hollow trees, dark corners in deserted houses, and in caves and crevices in the rocks. They gradually lose all sensibility, and continue in a comatose state until the return of genuine warm weather. When you see the first bat of the season fluttering at nightfall you can be sure that warm weather has come to stay. The little hooks at the end of one of the joints of each wing are what the bat hangs itself up by when it goes to sleep, whether for a day or for months. When the bats are clustering for hibernation, one of the number hangs itself up by its hooks, head downward, and the others cling to it. It is on record that sixty bats have been found in one cluster, the entire weight of the lot being sustained by the one bat clinging with its hooks to whatever it had fastened them to at the start — a weight of at least ten pounds. The position of the central bat in such a cluster would be like that of a man hanging to something by his thumb nails, and supporting the weight of fifty-nine other men. So completely is animation suspended in the bat during the cold months that no test yet applied has induced it to show the least sign of life. Torpid bats have been inclosed by the hour in air-tight glass jars and not a particle of the oxygen in the jars has been exhausted when they were taken out, showing that the bats had not breathed.

As cold drives certain animals, insects, and reptiles to a state of torpidity, so heat and lack of water bring about the same condition in others. The animal or reptile that hibernates, or goes to sleep in cold weather, arranges its body so that it will conduce to the greatest warmth, while those that estivate, or become torpid in warm weather, place themselves in positions that show that they want all the coolness the climate will permit. The tenric, a tropical animal, carnivorous and insectivorous, becomes torpid during the greatest heat, and lies on its back with its body drawn to its greatest length, and its limbs spread wide apart. Snakes estivate in the South, all kinds together, just as snakes hibernate in the North, but instead of rolling themselves in great balls, as the Northern snakes do, they lie singly, and stretched to their full length.

Want of water will cause the common garden snail to go into a state of the most complete and curious lethargy. This is the snail of the genus *limax*, and not the larger one of the genus *helix*. In the latter the phenomenon of hibernation is especially remarkable. In November the snail forms just a soft, silky membrane across the external opening of its shell. On the inner surface of that it deposits a coating of carbonate of lime, which immediately hardens like gypsum. This partition is again lined with a silky membrane. The snail then retires a little further into the shell and forms a second membraneous partition, retiring again and again until there are six of these partitions between the snail and the lime-coated door at the entrance of the shell. In the recess behind all these partitions the snail lies torpid until May. All this time it lives without motion, without heat, without food, without air, and without circulation; without the exercise of any of its functions. If this snail is prevented from hibernating for several seasons, by keeping it in a warm room, it will gradually waste away and die. Prof. Browne mentions a case where several snails of this genus were shut in a perforated box without food or water. They retired into their shells and closed them with a thin membrane. They remained so for three years. They revived when put into tepid water. They had been driven into torpidity by drought. The blood of this snail is white.

Another curious thing about hibernating animals is that the bile of all other animals is the bitterest of substances, while the bile of hibernating animals is sweet.— *New York Sun.*

Railroading as a Profession.

Dr. Chauncey M. Depew has prepared an article under this heading for *Railroad Men*, a periodical issued by the railroad branch of the Young Men's Christian Association, of 361 Madison Avenue, New York. As it contains numerous suggestions that cannot fail to be useful to young men who think of entering the railway service, or who are engaged in it already, we reproduce the article below:

"In the early days of railroading it was a vocation; now it is a profession. The railroad in its beginning had evoluted from the stage coach. It required for its operation and management little more than had been needed for the stage lines. As the railway systems expanded and the railway mileage increased, the railway companies found it necessary to organize departments.

"The enormous business of each company and its competition with its rivals compelled traffic departments, including both freight and passenger. The magnitude of its transactions made it necessary for each company to have an auditor and a large number of accountants and clerks. The office of the treasurer became very important, and he required the assistance of a large staff. Construction, roadbed, and bridges made necessary the employment of skilled and educated engineers. The operations of the road called for general managers, superintendents, and assistant superintendents, who were equal to handling, in safety and on time, the freight and passenger trains. The terminals called for special skill in their administration. The stations constantly demanded a higher grade of ability. A lawyer of distinction, supported by a large number of assistants, who should devote themselves entirely to the legal business of the company, became everywhere common.

"Thus the management of railways grew rapidly into a complex organization, requiring the highest ability, the largest experience, and the best training. There are now nearly two hundred thousand miles of railroad in the United States. They are capitalized at about ten billion dollars. They earn $1,125,000,000 annually. They disburse for material and wages $793,000,000, and have a system of rates for the carriage of freight which is one-third less than that of the railroads of Europe.

"The American companies have made possible the internal commerce of the United States. This commerce is larger, by many times, than the foreign commerce of all the world upon all seas and oceans. There are directly in the service of the railways of the United States about 800,000 men, and about 2,000,000 members in the families of employes.

"The railway profession presents more attractions for a young man than any other line of business. It has greater opportunities for advancement, and its employment is more permanent. To succeed in it in any department requires health, brains, honesty, and equipment. The young man must make up his mind that, if he would rise in the profession, he must never question the kind of work that is put upon him, the hours which are required of him, or the places, agreeable or disagreeable, to which he is assigned.

"Railway organization is essentially military, because upon the ability, vitality, and integrity of the vast number of men in the various positions working harmoniously together depend most of the internal commerce of the country, the prosperity of business, the activities of communities, great and small, the funds of investors, and the safety of hundreds of millions of passengers.

"The young man who proposes to enter railway service should first decide whether he will take his chances for a career in outdoor or indoor work. If outdoor work, which is in the operating department, he will be immensely assisted if he has had the opportunities which are offered in the technical schools. In these days of thorough training it is almost impossible for a young man of ordinary education to get on in competition with the graduates of the Sheffield Scientific School at Yale, the scientific schools of Columbia, the special education of Cornell, the big advantages of the Troy Polytechnic and the Stevens Institute, and the instruction given in many other of the schools and colleges of the United States.

"If he selects indoor work, he must make up his mind that much more will be required of him, at first, than in commercial lines. If he is in the treasurer's department, and shows special efficiency and intelligence, when a vacancy occurs in the freight department, in any discussion that should happen between the heads of these departments, he is almost certain to be drafted for a better position by the traffic manager, and *vice versa*.

"Railroading differs from no other business or profession in its beginnings. The salary is small. The work is hard. It is only the few who, by cheerful readiness at all times to perform their own tasks and to stay several hours — and, if necessary, all night — to meet the requirements of the office, or to do the work of the lame, lazy, and incompetent, attract the attention of their superiors, and are marked for promotion.

"When once, in any department, the young man has impressed upon the head of it his usefulness and fidelity, his career is made. With the rarest exceptions, the heads of all departments in the railway service of the United States have come up from the ranks. The presidents of all the railroads have known the day of small things, and been many years reaching their positions. The superintendents have all come from the brakes or from carrying the rod and chain in the engineering service. The superintendents of motive power have come from the footboard. The master mechanics have all come from the bench. Traffic managers and treasurers have all begun as clerks. There are but few heads of departments on our own road who have not risen from the ranks. In the operating department the general manager began as a brakeman, the general superintendent and two of the superintendents as telegraph operators, one superintendent as agent, and one as a clerk in the superintendent's office.

"Where the employment is so vast and the requirements so great, the men at the top are constantly breaking down. The railway army is ever in the field, on the march, and in the battle. Vacancies have to be filled, and filled at once. These vacancies are the inspiration and hope of those who desire and work for promotion. Sometimes a young man will do very well at first, but, as soon as he reaches a place of some importance, he overestimates the hold which he has and the strength which he has attained in the confidence of his superiors. He will be often absent from the office. He will take frequent vacations. He becomes restive under rigid hours and over-time. His superior discovers that he often takes advantage of the necessary absence of his chief to be absent himself.

"In the service everyone's eye is on everyone else. There is a generous appreciation of comradeship; at the same time there is severe criticism of the conduct and character of fellow employes and officers. The moment an officer becomes careless of his duties, inattentive, and out of reach when wanted, his chances for promotion are over; and the accident of a discharge or displacement are imminent. The chief mistake of the ambitious young man is in regarding the necessity for extra effort, care, and attention lessened because he has been promoted to better and more important positions.

"It is in these stages of conspicuousness that many a promising railway officer loses all the advantages of his previous hard work, incurs the displeasure or distrust of his superiors, and makes it impossible, even if he reforms, to advance him. There is but one rule of success in railway service, and that is, no matter how high you get, once a hustler, always a hustler, a hustler until you die or resign."

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Heating Water by Steam Coils.

In the October issue of The Locomotive we printed an article on "Heating Water by Steam," in which the general principles of the subject were considered. This was followed, in our January issue, by an article on "Heating Water by the Direct Injection of Steam," in which, as the title indicates, we gave especial attention to the case in which the steam is discharged from an open pipe, so that it mingles with the contents of the tank. We shall now take up in a similar way, a more detailed discussion of the second form of the problem, in which the steam is not allowed to mingle with the water in the tank, its heat being transmitted to the contents of the tank indirectly, by passing through a conducting surface of metal (such as the walls of a steam pipe), which serves to keep the steam and water separate. For the sake of greater clearness, we shall first consider the form of apparatus shown in Fig. 1, where the steam and the water to be heated are separated by a flat horizontal plate of metal.

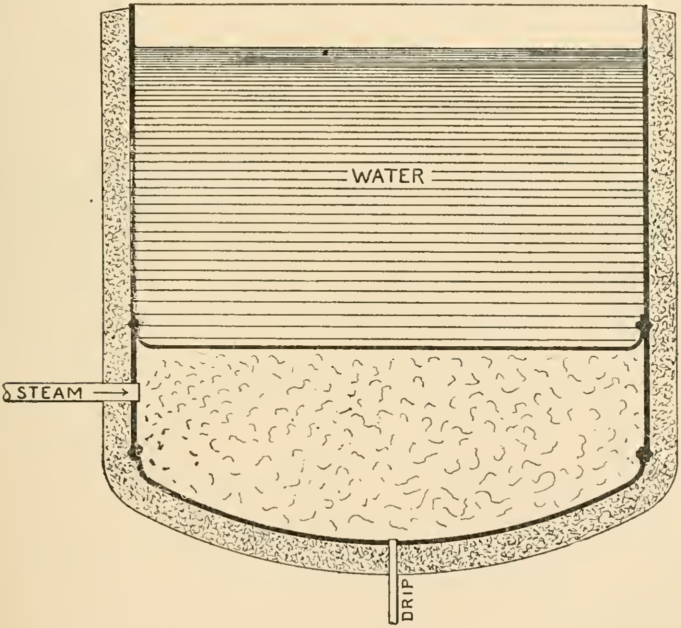

Fig. 1.— Heating through a Flat Horizontal Plate.

The theory of this indirect method of heating water is given in a fairly complete manner in Rankine's *Steam Engine;* but we do not find that the discussion there given is of much practical importance, because although the theory as he gives it is not difficult to understand, yet it involves constants that are not known with any precision, and makes assumptions that are rarely, if ever, realized in practice. In fact, although the problem, as it is suggested in Fig. 1, appears simple enough, it nevertheless contains a sufficient number of unknown elements to make a rigorous solution impracticable; and we therefore have to be content with an approximate method of treatment, which experience shows to be close enough for practical purposes.

If the conducting plate which separates the steam from the water were precisely as hot as the steam on one of its surfaces, and precisely as cold as the water on its other surface, we should have a reasonable basis for calculation; for we could find out, experimentally, just how much heat such a plate would have to give out to the water, every minute, to prevent its cold side from being warmed by conduction from the hot side. But this rational solution of the problem is unfortunately impossible, because we have every reason for believing that the lower surface of the conducting plate is always materially colder than the steam, and that its upper surface is, at the same time, materially hotter than the water. If we knew just what these differences of temperature were, we could take them into account, and could probably deduce, from Rankine's equations, a serviceable rule for the time required to heat a given tankful of water through a given range of temperature. But unfortunately we know little or nothing about them, except that they probably vary widely with the temperature of the water, and the condition of the surfaces of the conducting plate.

In practice, the best that we can do, is to assume that the heat transmitted through the conducting plate in any given time is simply proportional to the difference in temperature between the water and the steam. This assumption gives results that are near enough to the facts, in actual work. The *thickness* of the conducting plate is an important element in the abstract theory of the subject, but in the practical application the effect of varying the thickness of the plate (at least within the limits of thickness that are actually employed) is almost indistinguishable; so that we shall not need to take account of this thickness in formulating our rule.

The average of numerous experiments indicates that when the conducting plate which separates the steam from the water is *horizontal*, as in Fig. 1, we may expect that the heat transmitted from the steam to the water, by one square foot of plate in one minute, will be about 5.71 heat units for every degree of temperature-difference between the steam and the water. A few examples will make this statement clear.

(1) The conducting plate being one foot square, we wish to know how much heat will be transmitted in one minute, the steam being at 220°, and the water at 61°. The difference in temperature between the steam and the water being $220^\circ - 61^\circ = 159^\circ$, we may expect that the heat transmitted in one minute by a plate one foot square will be $159 \times 5.71 = 907.89$ heat units.

(2) The conducting plate being 2 feet wide and 3 feet long, we wish to know how much heat will be transmitted in one minute from steam at 218° to water at 43°. The difference in temperature being $218^\circ - 43^\circ = 175^\circ$, the heat transmitted in one minute will be $175 \times 5.71 = 999.25$ heat units, for every square foot of plate. The plate contains $2 \times 3 = 6$ square feet, and hence it will transmit, in one minute, $6 \times 999.25 = 5{,}995.5$ heat units.

(3) The conducting plate contains 2.18 square feet, and we wish to know how much heat it will transmit, in 3.5 minutes, from steam at 212° to water at 160°. The temperature-difference being $212^\circ - 160^\circ = 52^\circ$, one square foot of plate will transmit

52 × 5.71 = 296.92 heat units in one minute. Hence 2.18 square feet of plate will transmit 296.92 × 2.18 = 647.3 heat units in one minute (keeping only one place of decimals). In 3.5 minutes the plate will therefore transmit 3.5 × 647.3 = 2,265.55 heat units.

Having learned to calculate the amount of heat that will be transmitted by a given plate in a given time, from steam at one definite temperature to water at another definite temperature, we are ready to take up the second part of the problem, which is, to calculate by how much this heat will raise the temperature of the water in the tank, from the known fact that one heat unit will raise the temperature of one pound of water by one degree. For this purpose we must first know how many pounds of water there are in the tank. It may be that the number of pounds of water is given in the problem, and in that case we shall need no calculation for determining it. If the amount of water is given in *gallons*, we obtain its weight in pounds by multiplying by 8.33; and if the amount is given in *cubic feet*, we obtain the weight in pounds by multiplying by 62.37. Assuming, therefore, that the weight of the water is known, we proceed to investigate the rise in temperature of the water in the tank; and for this purpose we shall take a numerical example, after which we shall give a general rule which will apply to any other example of the same kind.

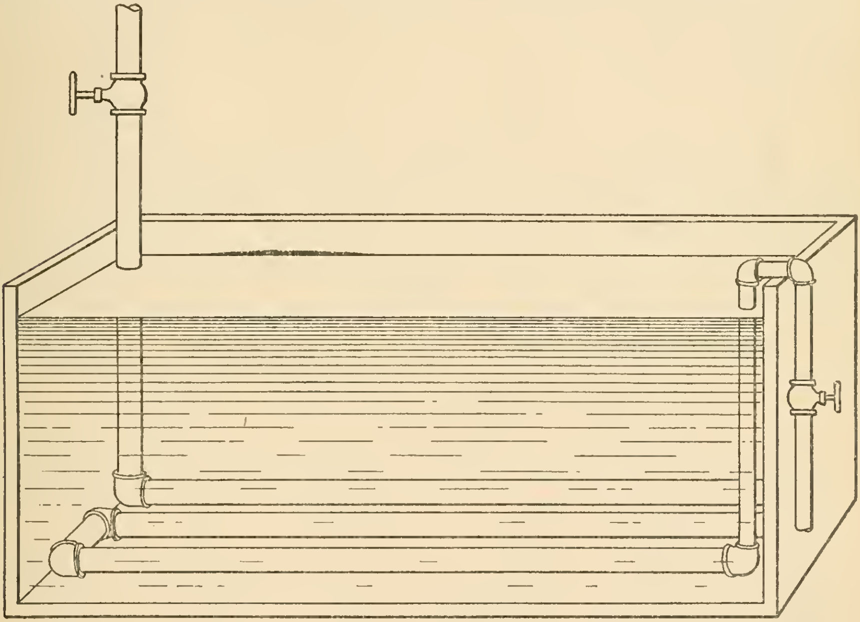

Fig. 2.—Heating by a Coil of Pipe.

Let us suppose that the heating tank is of the form shown in Fig. 1, and that the horizontal plate through which the heat passes contains 13 square feet, and that the tank contains 1,000 pounds of water. We will suppose that the temperature of the steam is 220° Fahr., and that the temperature of the water, at the beginning of the experiment, is 140°, and that we wish to find out how long it will take to raise the temperature of the water to 180° Fahr. The usual method of figuring the heat transmitted through the plate per minute in a problem of this kind, is to base the calculation upon the *average* temperature of the water during the whole time. Thus the average temperature in this case is (140° + 180°) ÷ 2 = 160°. The calculation would then be as follows: The temperature of the steam being 220°, and the average temperature of the water being 160°, the average difference in temperature between the steam and the water is 220° — 160° = 60°. Applying the rule given above, we find that the conducting plate will transmit 5.71 × 60 = 342.6 heat units to the water per minute, for each square foot of plate surface. The area of the plate being 13 square feet in the present case, the total number of heat units transferred to the water in one minute will be 13 × 342.6 = 4,453.8. This quantity of heat would be sufficient to raise the temperature of 4,453.8 pounds of water by 1°; and as there are 1,000 pounds of water in the tank, it would raise the temperature of these one thousand pounds by 4,453.8 ÷ 1,000 = 4.4538 degrees, or, preserving only two decimals, the water in the tank would have its temperature raised by 4.45° in one minute. We wish to raise the temperature of this water by 40° (that is, from 140° up to 180°); and therefore, since we heat it 4.45° every minute, the time required to heat it 40° would be 40° ÷ 4.45 = 8.99 minutes, or almost exactly 9 minutes.

As we have said, the calculation is usually performed in the way just indicated; but we may refine this process of calculation a little, so as to obtain results a little nearer to the actual facts. In cases where the range of temperature of the water is small, as in the foregoing example, the ordinary mode of calculating the time required to do the heating is good enough; but when the water is to be heated through a very *wide* range of temperature, it is better to make use of a method of calculation that we shall give below. Suppose, by way of illustration, that the water in the tank in the last example were to be heated from 40° up to 196°, with steam at 212°. The calculation, according to the principles already given, would be as follows:

Average temperature of water = (40° + 196°) ÷ 2 =	118°
Temperature of steam =	212°
Average difference between steam and water =	94°

Then 94 × 5.71 = 536.74 heat units, which is the heat transmitted to the water each minute, through each square foot of plate. There being 13 square feet of plate,

536.74 × 13 = 6,978 heat units,

which is the amount of heat given up to the water by the entire plate in one minute. Since there are 1,000 pounds of water present, this quantity of heat would raise the temperature of the entire mass of water by

6,978 ÷ 1,000 = 6.978 degrees.

Continuing the calculation, we have

Range through which water is to be heated = 196° — 40° = 156°.
Rise in temperature of water in one minute = 6.978°.
∴ Time required to do the heating = 156° ÷ 6.978° = 22.3 minutes.

The weak point in this process lies in the assumption that we can treat the problem as though the heat was being constantly given up to the water *at the average temperature of the water*. When the temperature range through which the water is to be heated is small, we do not commit any material error by making this assumption; but, when this range is large, the assumption in question may easily lead to an error of more than 50 per cent. in the estimated time required.

To illustrate this point, let us divide the foregoing problem up into six stages, so as to consider the times required to heat the water through six equal ranges of 26° each

We shall not need to set down all the work, as it is done precisely as indicated above. The results are as follows :

Time required to heat the water from 40° to 66° = 2.20 minutes.
" " " " 66° " 92° = 2.63 "
" " " " 92° " 118° = 3.27 "
" " " " 118° " 144° = 4.32 "
" " " " 144° " 170° = 6.37 "
" " " " 170° " 196° = 12.08 "

Hence the time required to heat the water from 40° to 196° is 30.87 minutes.

The estimated time obtained by considering the process in its separate parts in this way exceeds the estimate obtained when we apply the same rule to the whole process by more than 38 per cent.; and this fact is alone sufficient to show the imperfection of a rule based merely on the *average* temperature of the water in the tank. To obtain a good approximation to the actual time, in cases in which the water is heated through a wide range of temperature, we should divide the temperature-interval up into a great number of equal parts, just as we did in the last paragraph, and we should calculate every interval separately. The finer we divide up the problem, the closer to the actual result will our computation be. If we should divide it into a hundred, or a thousand, stages, we should practically eliminate the imperfection of the rule already given, and obtain a result which would come as close to the actual facts as the uncertainties of the problem will allow. Of course, we cannot go to all this trouble every time we want to work out one of these questions, for the labor of it would be prohibitory. We append, therefore, a table in which the thing is done once for all, and it only remains to explain how the table is to be used.

TABLE OF VALUES OF THE MULTIPLIER, *K*.

Temperature Ratio.	*K*.	Temperature Ratio.	*K*.	Temperature Ratio.	*K*.
1.00	.000	2.10	.130	5.25	.291
1.05	.009	2.20	.138	5.50	.299
1.10	.017	2.30	.146	5.75	.306
1.15	.024	2.40	.153	6.00	.314
1.20	.032	2.50	.160	6.25	.321
1.25	.039	2.60	.167	6.50	.328
1.30	.046	2.70	.174	6.75	.334
1.35	.053	2.80	.180	7.00	.341
1.40	.059	2.90	.186	7.25	.347
1.45	.065	3.00	.192	7.50	.353
1.50	.071	3.10	.198	7.75	.359
1.55	.077	3.20	.204	8.00	.364
1.60	.082	3.30	.209	8.25	.370
1.65	.088	3.40	.214	8.50	.375
1.70	.093	3.50	.219	8.75	.380
1.75	.098	3.75	.231	9.00	.385
1.80	.103	4.00	.243	9.50	.394
1.85	.108	4.25	.253	10.00	.403
1.90	.112	4.50	.263	10.50	.412
1.95	.117	4.75	.273	11.00	.420
2.00	.121	5.00	.282	11.50	.428

Rule: To find the time required to heat a given tankful of water through a given range of temperature, proceed as follows: (1) Subtract the *initial* temperature of the water from the temperature of the steam; (2) subtract, also, the *final* temperature of the water from the temperature of the steam; (3) divide the greater of these by the less, and call the quotient the "temperature ratio"; (4) find this "temperature ratio" in the table, and take out the corresponding value of the constant, K; (5) multiply this constant by the number of pounds of water in the tank, and divide the product by the number of square feet of heating surface. The result is the number of minutes that will be required to heat the water through the desired range of temperature.

We have thus far supposed, for the sake of simplicity, that the tank is arranged as shown in Fig. 1. It is more usual, in practice, to use a coil of steam pipes in the bottom of the tank, somewhat as suggested in Fig. 2. The rule in this case is the same as before, except that the question now arises whether the *inside* or *outside* of the pipe is to be used in reckoning the heating surface. In computing the heating surface of ordinary horizontal tubular boilers, it is our custom to use the *outer* surface of the tubes, because we are satisfied that by so doing the horse power of the boiler, as estimated by the method given in The Locomotive for December, 1895, comes nearer to the actual power developed in practice. But, in the heating of water by coils of steam pipe, we are of the opinion that better results are obtained by using the *average* of the inner and outer surfaces. To facilitate the calculation of problems in which pipe coils are used, we append a table giving the average of the inside and outside surfaces of pipes of various sizes, assuming them to be of the standard thicknesses given in The Locomotive for September, 1896.

Average Surface of Steam Pipes, Per Foot of Length.

Nominal inside diameter.	Average surface per foot of length.	Nominal inside diameter.	Average surface per foot of length.	Nominal inside diameter.	Average surface per foot of length
½"	0.191 sq. ft.	1½"	0.460 sq. ft.	3½"	0.988 sq. ft.
¾	0 245	2	0.582	4	1.116
1	0.309	2½	0.700	4½	1.245
1¼	0.398	3	0 860	5	1.389

To illustrate the complete calculation of the time required to heat a given tankful of water through a given range of temperature by means of a coil of pipe arranged as suggested in Fig. 2, let us take the following example: A tank contains 500 gallons of water at 60° Fahr., which is to be heated to 180° by means of steam at 220°. What time will be required to do the work, with a coil composed of 50 feet of two-inch pipe? We first find the weight of the water, by multiplying the number of gallons by 8.33. We have 8.33 × 500 = 4,165 pounds. We next find the total heating surface by multiplying the length of pipe by 0.582, which is the average surface of a one-foot length of 2-inch pipe. We have 0.582 × 50 = 29.10 square feet, which is the total heating surface. We then apply our improved rule as follows:

Temperature of steam *minus* initial temperature of water = 220° — 60° = 160°
Temperature of steam *minus* final temperature of water = 220° — 180° = 40°.

Hence the "temperature ratio" is 160° ÷ 40 = 4.00, and for this value of the "temperature ratio" the first table gives us .243 as the constant to be used. Then

.243 × 4,165 = 1,012; and 1,012 ÷ 29.10 = 34.8 (nearly).

Therefore, the heating ought to require a trifle less than 35 minutes.

We have assumed throughout that the heating surface is disposed *horizontally*. If it is *vertical*, the time required to heat the water through the desired range will be at least 50 per cent. greater than that calculated by the foregoing rule. This is because the average temperature of the water in contact with the heating surface is higher when the surface is vertical than when it is horizontal. The water that is warmed by the lower part of a vertical heating surface expands and flows up in practical contact with that surface, so that the water that is taking up the heat at any given instant, in this case, is warmer than the average temperature of the water in the tank. Hence, the heating process is slower than it is when the heating surface is horizontal and at the bottom of the tank, where the circulation continually brings the coldest water in contact with it.

Inspectors' Report.

November, 1897.

During this month our inspectors made 10,035 inspection trips, visited 17,284 boilers, inspected 5,956 both internally and externally, and subjected 705 to hydrostatic pressure. The whole number of defects reported reached 10,978, of which 980 were considered dangerous; 37 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	871	38
Cases of incrustation and scale,	2,075	74
Cases of internal grooving,	164	19
Cases of internal corrosion,	520	19
Cases of external corrosion,	525	32
Broken and loose braces and stays,	121	30
Settings defective,	288	21
Furnaces out of shape,	358	16
Fractured plates,	426	61
Burned plates,	284	25
Blistered plates,	168	12
Cases of defective riveting,	1,603	20
Defective heads,	145	22
Serious leakage around tube ends,	1,870	337
Serious leakage at seams,	440	33
Defective water-gauges,	278	38
Defective blow-offs,	124	33
Cases of deficiency of water,	20	6
Safety-valves overloaded,	87	24
Safety-valves defective in construction,	71	35
Pressure-gauges defective,	343	28
Boilers without pressure-gauges,	47	47
Unclassified defects,	150	10
Total,	10,978	980

December, 1897.

During this month our inspectors made 9,414 inspection trips, visited 19,589 boilers, inspected 5,716 both internally and externally, and subjected 736 to hydrostatic pressure. The whole number of defects reported reached 10,023, of which 1,137 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,	640	38
Cases of incrustation and scale,	1,932	51
Cases of internal grooving,	95	10
Cases of internal corrosion,	461	26
Cases of external corrosion,	487	25
Defective braces and stays,	80	21
Settings defective,	274	31
Furnaces out of shape,	343	16
Fractured plates,	334	63
Burned plates,	261	18
Blistered plates,	123	8
Cases of defective riveting,	1,429	224
Defective heads,	84	8
Serious leakage around tube ends,	1,878	390
Serious leakage at seams,	366	29
Defective water-gauges,	267	38
Defective blow-offs,	107	48
Cases of deficiency of water,	7	0
Safety-valves overloaded,	65	25
Safety-valves defective in construction,	84	31
Pressure-gauges defective,	376	25
Boilers without pressure-gauges,	6	6
Unclassified defects,	324	6
Total,	10,023	1,137

Summary of Inspectors' Reports for the Year 1897.

During the year 1897 our inspectors made 105,062 visits of inspection, examined 206,657 boilers, inspected 76,770 boilers both internally and externally, subjected 7,870 to hydrostatic pressure, and found 588 unsafe for further use. The whole number of defects reported was 131,192, of which 11,775 were considered dangerous. A summary of the work by months is given below, and the usual classification by defects is likewise given :

Summary, by Defects, for the Year 1897.

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	10,516	509
Cases of incrustation and scale,	24,797	780
Cases of internal grooving,	1,272	138
Cases of internal corrosion,	8,171	380

Nature of Defects.	Whole Number.	Dangerous.
Cases of external corrosion,	7,981	444
Defective braces and stays,	1,797	598
Settings defective,	3,824	356
Furnaces out of shape,	5,072	248
Fractured plates,	3,372	541
Burned plates,	2,847	338
Blistered plates,	2,407	94
Defective rivets,	14,358	956
Defective heads,	1,439	320
Leakage around tubes,	21,924	3,280
Leakage at seams,	4,754	321
Water-gauges defective,	3,990	598
Blow-outs defective,	1,932	515
Cases of deficiency of water,	189	77
Safety-valves overloaded,	764	292
Safety-valves defective,	1,066	317
Pressure-gauges defective,	5,969	460
Boilers without pressure-gauges,	140	140
Unclassified defects,	2,611	73
Total,	131,192	11,775

SUMMARY BY MONTHS, FOR 1897.

MONTH.	Visits of inspection.	Number of boilers examined.	No. inspected internally and externally.	No. tested hydro-statically.	No. condemned.	Number of defects found.	Number of dangerous defects found.
January,	8,687	17,486	5,651	379	34	10,844	1,222
February,	7,779	15,650	5,025	431	39	8,404	751
March,	8,906	17,025	5,467	574	54	10,500	982
April,	8,774	17,924	6,915	663	64	11,373	920
May,	8,156	16,079	7,171	687	55	11,518	1,318
June,	8,410	16,123	6,953	797	43	11,594	1,179
July,	8,047	16,009	8,559	706	73	13,202	915
August,	8,253	16,677	6,220	715	62	11,115	782
September,	9,477	18,282	6,710	698	56	10,911	670
October,	9,124	18,529	6,427	779	31	10,730	919
November,	10,035	17,284	5,956	705	37	10,978	980
December,	9,414	19,589	5,716	736	40	10,023	1,137
Totals,	105,062	206,657	76,770	7,870	588	131,192	11,775

On December 31, 1897, the Hartford Steam Boiler Inspection and Insurance Company had 63,578 boilers covered by its policies of insurance. The total amount at risk upon these boilers was $274,330,707.00. The total amount returned to our patrons up to that date, in losses paid and in inspections, was $4,748,819.

We append, also, a summary of the work of the inspectors of this company from 1870 to 1897 inclusive. The years 1876 and 1878 are omitted, because the data that we have at hand for those years is not complete. The figures, so far as we have them, indicate that the work during those years was in good accordance with the general progression observable in other years. Previous to 1875 it was the custom of the company to publish its reports on the first of September, but in that year the custom was changed and the summaries were made out up to January 1st, so as to agree with the calendar year. The figures given opposite 1875, therefore, are for sixteen months, beginning September 1, 1874, and ending December 31, 1875.

SUMMARY OF INSPECTORS' WORK SINCE 1870.

Year.	Visits of inspection made.	Whole number of boilers inspected.	Complete internal inspections.	Boilers tested by hydrostatic pressure.	Total number of defects discovered.	Total number of dangerous defects discovered.	Boilers condemned.
1870	5,439	10,569	2,585	882	4,686	485	45
1871	6,826	13,476	3,889	1,484	6,253	954	60
1872	10,447	21,066	6,533	2,102	11,176	2,260	155
1873	12,824	24,998	8,511	2,175	11,998	2,892	178
1874	14,368	29,200	9,451	2,078	14,256	3,486	163
1875	22,612	44,763	14,181	3,149	24,040	6,149	216
1877	....	32,975	11,629	2,367	15,964	3,690	133
1879	17,179	36,169	13,045	2,540	16,238	3,816	246
1880	20,939	41,166	16,010	3,490	21,033	5,444	377
1881	22,412	47,245	17,590	4,286	21,110	5,801	363
1882	25,742	55,679	21,428	4,564	33,690	6,867	478
1883	29,324	60,142	24,403	4,275	40,953	7,472	545
1884	34,048	66,695	24,855	4,180	44,900	7,449	493
1885	37,018	71,334	26,637	4,809	47,230	7,325	449
1886	39,777	77,275	30,868	5,252	71,983	9,960	509
1887	46,761	89,994	36,166	5,741	99,642	11,522	622
1888	51,483	102,314	40,240	6,536	91,567	8,967	426
1889	56,752	110,394	44,563	7,187	105,187	8,420	478
1890	61,750	118,098	49,983	7,207	115,821	9,387	402
1891	71,227	137,741	57,312	7,859	127,609	10,858	526
1892	74,830	148,603	59,883	7,585	120,659	11,705	681
1893	81,904	163,328	66,698	7,861	122,893	12,390	597
1894	94,982	191,932	79,000	7,686	135,021	13,753	595
1895	98,349	199,096	76,744	8,373	144,857	14,556	799
1896	102,911	205,957	78,118	8,187	143,217	12,988	663
1897	105,062	206,657	76,770	7,870	131,192	11,775	588

COMPARISON OF INSPECTORS' WORK DURING THE YEARS 1896 AND 1897.

	1896.	1897.
Visits of inspection made,	102,911	105,062
Whole number of boilers inspected,	205,957	206,657
Complete internal inspections,	78,118	76,770
Boilers tested by hydrostatic pressure,	8,187	7,870
Total number of defects discovered,	143,217	131,192
" " of dangerous defects,	12,988	11,775
" " of boilers condemned,	663	588

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

GRAND TOTAL OF THE INSPECTORS' WORK SINCE THE COMPANY BEGAN BUSINESS, TO JANUARY 1, 1898.

Visits of inspection made,	1,198,029
Whole number of boilers inspected,	2,383,702
Complete internal inspections,	919,418
Boilers tested by hydrostatic pressure,	134,311
Total number of defects discovered.	1,760,596
" " of dangerous defects,	207,821
" " of boilers condemned,	11,051

Boiler Explosions.

DECEMBER, 1897.

(313.) — On October 24th a heating boiler exploded in the basement of Engine House No. 2, on Bush street, San Francisco, Cal., setting fire to the building. The boiler was used to keep the fire engine supplied with hot water.

(314.) — A boiler exploded, on November 24th, in a cheese factory near Potsdam, N. Y. The fires had only been started, and there were but a few pounds of steam on. If the explosion had taken place when the full head of 80 pounds was up the plant would have been blown to atoms.

(315.) — On November 30th the boiler at the power house on the Ford farm, which furnished power to pump the Akron Oil Company's wells, two miles north of Dundee, Ohio, exploded. The boiler house was blown down. [This explosion and the two preceding ones were reported to us too late for insertion in their proper places.]

(316.) — A heating boiler exploded, on December 1st, in a hotel at Leiperville, near Chester, Pa. We have not learned the amount of damages, except that a new boiler will be required.

(317.) — Customers in Tiffany's store, in New York city, were startled, on December 1st, by a loud report, which sounded like a blast of dynamite, and was followed by a perceptible vibration of the building. The store was crowded at the time, and it was first thought that an elevator had fallen. Inquiry showed that one of the sections in a heating boiler in the basement had burst. Fortunately, nobody was injured.

(318.) — On December 1st a boiler exploded in the basement of the Lutheran church at Cairo, Ill., damaging it to the extent of about $1,000.

(319.) — The boiler in T. J. McKenzie's mustard factory at Freeport, Ill., exploded on December 1st.

(320.) — On December 1st a boiler exploded at the Glenwood Coal & Mining Company's plant, at Sevastopol, near Des Moines, Iowa. The building was wrecked, and Reece Griffiths was scalded so badly that he died three days later. Daniel Williams, Aaron Hayden, John Hayden, Robert Marsh, and Henry Calbert were also injured more or less severely.

(321.) — The office occupied by Drs. G. W. Willard, Edward Reinert, and W. L. Dick, at Columbus, Ohio, was badly damaged, on December 1st, by the explosion of a heating boiler. Large pine joists and hard-wood flooring were splintered by the force of the explosion, and the place was drenched by dirty, boiling water. The total loss will probably amount to about $4,000.

(322.) — The boiler of a locomotive on the Titusville & Pleasantville Railroad exploded, on December 1st, at East Titusville, Pa. Engineer Jacob Miller, Fireman Charles Miller, Mr. M. B. Dunham, and Edward Neeley were badly hurt, and it is believed that the engineer and fireman cannot recover.

(323.) — A terrific boiler explosion occurred, on December 2d, in the mammoth new Penwell dry goods and department store at Pana, Ill. The damage was heavy, but cannot yet be estimated. The entire east end of the building was blown out, and the side walls were damaged so badly that they will have to be torn down and rebuilt. The large plate glass front of the structure, 160 feet distant from the boiler, was wrecked. A number of workmen had narrow escapes from death. The building was one of the largest in central Illinois.

(324.) — A tube failed, on December 2d, in a boiler in the Falcon mill at Niles, near Warren, Ohio. William Stevenson, who was working near by, was badly and perhaps fatally burned.

(325.) — On December 3d, as the first section of east-bound freight No. 84, on the Chicago & Erie railroad, was pulling up the hill east of Westminster, Ohio, the crown-sheet of the locomotive (No. 708) gave way. The fireman, J. C. Beiber, who was in the act of throwing in coal, was blown from the cab and was dangerously hurt. He was picked up in a field, unconscious, some 100 feet from the track. Engineer Joseph Doolittle and Brakeman S. B. Planck were pinioned beneath the wreckage and seriously hurt. Doolittle and Planck will recover, but Beiber is believed to be fatally injured.

(326.)—A tube failed, on December 3d, in the power plant of the Essex County Electric Company, at Orange, N. J. James Gallagher, John Bruen, and Thomas Houlihan were seriously scalded. The plant was brought to a standstill, and with it all the cars on the Suburban Traction Company's line, the South Orange and Maplewood line, and the Caldwell electric line.

(327.) —A big boiler used for boiling sugar exploded, on December 3d, in the candy factory of D. Auerbach & Son, in New York city. John Cheroghino, John Zenolsky, Joseph Auerbach, Caesar Donidero, and Leo Schaushauer were frightfully scalded about the head, arms, and body. The property loss was over $5,000.

(328.) — On December 4th a boiler exploded at an oil well at Nine Mile, near Olean, N. Y. Nobody was injured.

(329.) — The floating grain elevator *Columbia*, while working alongside the big Hamburg-American steamer *Pennsylvania*, at Hoboken, N. J., was discovered to be on fire on December 4th. During the course of the fire the *Columbia's* boilers exploded, and she was almost completely wrecked. She was towed to Castle Point and beached.

(330.) —A boiler exploded, on December 4th, in the planing mill and saddle-tree factory owned by Horwedge Bros., of Petaluma, Cal. The roof was torn from the building, and two men were injured.

(331.) —A boiler exploded, on December 5th, at Wrayswood, near Greensboro, Ga., killing Sydney Pyron and another man, and injuring several others.

(332.) — On December 6th a boiler exploded in Grover's stone-crushing plant at Ingalls, near Goshen, Ind. The roof of the boiler house was blown off, one side wall was carried away, and the entire building was almost wrecked. One man was injured.

(333.) —A boiler exploded, on December 7th, in the power house of the Citizens' Light, Heat & Power Company, at Portsmouth, near Norfolk, Va. Fireman Benjamin Dennis was instantly killed. His half brother, Joseph Johnson, who was assistant fireman, was injured so badly that it is doubtful if he can recover. The power house, which was one of the largest in the State, was completely wrecked, together with the machinery contained in it. The boiler was hurled 100 feet. Bricks were thrown through adjacent houses, and there were many narrow escapes from serious injuries.

(334.) — One of the flues of the tug-boat *Ira O. Smith* collapsed, on December 9th, at the Lake street bridge in Chicago, Ill., while the *Smith* was engaged in pulling another vessel off of a pile upon which she had lodged.

(335.) —A heating boiler exploded, on December 10th, in the schoolhouse at Randolph, near Fremont, Neb. Nobody was hurt.

(336.) —A boiler exploded, on December 11th, in Stobaugh & Jennings' mill at Choctaw, six miles south of Clinton, Ark. Thomas Treadaway was killed. John Huggin received injuries from which he will probably die, and Fireman Presley and Samuel Burnett were painfully bruised and scalded.

(337.) —A boiler exploded, on December 11th, in William Haley's saw-mill, on Rifle River, near Standish, Mich. William Haley, Jr., a son of the proprietor, was killed, and several others were injured.

(338.) — On December 11th, a boiler exploded in the Lagrange, Ill., electric light plant, temporarily crippling the light service in Lagrange, Grossdale, and East and West Grossdale. Fireman David Putts had a narrow escape from death, as he had been standing directly in front of the exploded boiler only a moment before the accident.

(339.) — On December 13th a boiler exploded in the yards of the South Broadway Coal and Feed Company, at Lexington, Ky. William Drake was killed, and Jefferson Gardner, David Green, and William Lewis were seriously injured.

(340.) — At Beatrice, in Pike county, near Sergent, Ky., a boiler belonging to Mullins & Son exploded on December 14th. Engineer George Honycout was killed, two other men were fatally injured, and two more received lesser injuries, from which they will recover. Parts of the wreckage were thrown into a schoolhouse 200 yards away, causing a panic among the pupils. The property loss was about $2,000.

(341.) — A boiler exploded, on December 14th, in C. W. Townsend's woodyard on Tradd street, Charleston, S. C. Dallis Whitfield was instantly killed and Brown Chisholm and one other man were fatally injured. The woodyard was wrecked and considerable damage was done to neighboring property.

(342.) — A tube failed, on December 15th, in a locomotive on the Northwestern railway, near Plymouth, Wis. Head brakeman Sylvester M. Schwartz was severely burned by steam and live coals.

(343.) — On December 17th a boiler belonging to W. R. Stafford exploded at Port Hope, Mich. Engineer James Watson was thrown about 60 feet, and injured so badly that he died on the following day.

(344.) — On December 18th a locomotive boiler exploded on the Bear Creek road, near Repton, Ala., killing Morris Sullivan, John Clepper, John Johnson, and Henry Vickery. The engineer and three other men were severely injured.

(345.) — A boiler exploded, on December 18th, in John Grant's saw-mill at Cross Hill, S. C. Michael Moore and Philip Frederick were killed and Henry Simpson was fatally injured.

(346.) — A locomotive boiler exploded on the Union Pacific railroad, on December 18th, at Medicine Bow, Wyo. Barney Flannagan was injured so badly that he died on the following day.

(347.) — On December 19th a small boiler exploded in the Mt. Carmel Hospital, at Columbus, Ohio. Nicholas Neary, the fireman, was severely bruised and scalded, but will recover.

(348.) — A boiler flue failed on December 20th, in the electric light plant at Ravenna, Ohio. We have not received further particulars.

(349.) — A heating boiler exploded, on December 20th, in the National Bank building at Fishkill Landing, N. Y. The damage was small and nobody was hurt.

(350.) — Three boilers exploded, on December 20th, in the Choctaw Coal Company's plant, at Hartshorne, I. T. The fireman was killed, and the engineer received painful injuries.

(351.) — On December 21st a boiler exploded in Fisher Bros.' mill at Pentwater, Mich. Albert Reese was severely, and perhaps fatally, scalded.

(352.) — A boiler exploded, on December 23d, at Helena, near Tiffin, Ohio, fatally injuring Henry Lancaster, George Robbins, and Philip Goodrich. Robbins died shortly after his removal from the ruins. Lancaster was scalded, and Goodrich was crushed by falling timbers. We have seen no estimate of the property loss.

(353.) — A tube failed, on December 24th, in one of the boilers in the New London Gas and Electric Company's plant at New London, Conn. The boiler was put out of use, and the dynamos and the usual electric service were running again in about half an hour.

(354.)—A collision took place, on December 24th, in the Communipaw, N. J., freight yard of the Central Railroad of New Jersey, causing the explosion of the boiler of drill engine No. 1. Brakeman Hollis A. Haycock was blown literally to pieces, and Engineer William Murtag and Fireman John Higgins were fatally injured. Six other persons also received lesser injuries.

(355.)—James Davidson of Moorestown, N. J., was severely scalded, on December 25th, by the explosion of a kitchen boiler in his residence.

(356.)—A boiler exploded, on December 26th, in William J. Strahlman's saw-mill at Weaver, near Winona, Minn. The roof of the mill was torn to pieces. Nobody was injured, as there was no one in the building at the time.

(357.)—William McGuirt was fatally scalded, on December 26th, in the works of the Cleveland Rolling Mill Company, of Cleveland, Ohio. A small locomotive that he was operating became unmanageable and ran into an obstruction. The boiler burst, and McGuirt was fearfully burned over the entire body.

(358.)—On December 27th, a boiler exploded at the Sanford Carpet Mills, Amsterdam, N. Y. The boiler-house was almost entirely destroyed. Nobody was hurt, but the property loss was about $10,000. As often happens in such cases, a story was put in circulation to the effect that the building had been blown up with dynamite; but investigation proved that the damage was due to the explosion of one of the boilers.

(359.)—A tube failed, on December 29th, in the Champion Coated Paper Company's plant, at Hamilton, Ohio. Engineer John Cope was fearfully scalded about the hands, face, neck, and breast. Mr. Cope was similarly injured one year ago.

(360.)—A boiler exploded, on December 29th, in the No. 2 mill of the Griswoldville Manufacturing Company, at Griswoldville, near Greenfield, Mass. Night Watchman Frederick Scheiffler was killed. The explosion practically demolished the boiler room, blacksmith shop, and machine room, and the property loss was upwards of $12,000.

(361.)—A small boiler exploded, on December 30th, in the residence of Mr. John Rowe of Chester, Pa. The explosion did considerable damage to the furniture and carpets, but nobody was injured.

(362.)—On December 30th, a boiler exploded at Thompson Bros.' coal mine, ten miles south of Clinton, near Sedalia, Mo. The miners had just left, and nobody was hurt.

(363.)—An oil well boiler exploded, on December 30th, on the Henry Owens farm at Hume, near Wapakmeta, Ohio. The engine house was demolished, but nobody was seriously injured.

(364.)—On December 31st, a boiler exploded in Llewellen's cotton gin, six miles north of Oakwoods, Leon Co., Texas. James Adams and Hilliard Jackson were killed. Christopher Durham's leg was cut off, and it is believed that he cannot recover. Henry Jordan was also badly scalded.

(365.)—Albert E. Simms, second engineer of the tugboat *Elsie*, was severely scalded, on December 31st, by the explosion of the *Elsie's* boiler, while the boat was lying at Lewis Wharf, Boston, Mass. He was removed to the emergency Hospital, where he died, later in the day. The *Elsie* was damaged to the extent of about $3,000.

The Locomotive.

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Bracing Boiler Heads.

Tables were given, in the issue of THE LOCOMOTIVE for September, 1893, for calculating the number of braces required in staying boiler heads. The braces were assumed to be of round iron, one inch in diameter. We have had numerous calls for similar tables for braces that are *an inch and one-eighth* in diameter; and in compliance with these requests we have prepared the present article.

We have shown, in past issues of THE LOCOMOTIVE, that boiler tubes that are correctly expanded and beaded possess great holding power, so that they can not only sustain the pressure that falls upon the inter-tubular segments of the head, but can also be relied upon to support a certain portion of the load that comes upon the upper part of the head. It is difficult to estimate the precise measure of stiffness that the tubes communicate to the head, but experience shows that it is safe to assume that the tubes will take care of the head for say *two* inches above their upper surfaces. The flanges of the heads being securely united to the shell, and being also curved or dished, it may likewise be safely assumed that no braces need be provided for that part of the head which lies within *three* inches of the shell. The part of the head that requires bracing, therefore, consists of a segment of a circle whose circumference lies three inches within

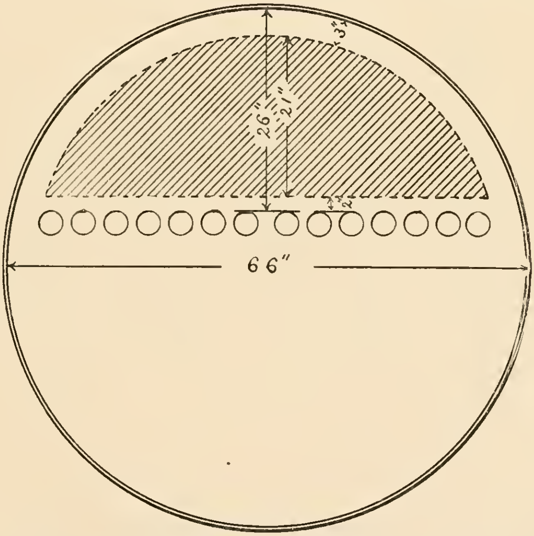

DIAGRAM SHOWING THE "AREA TO BE BRACED."

the circle of the shell, and whose base is two inches above the upper row of tubes. Thus in a 66-inch boiler, whose upper row of tubes is 26 inches below the top of the shell, the part of the head that requires bracing consists in a segment, twenty-one inches high, of a circle that is sixty inches in diameter. This segment is indicated by the shaded area in the engraving, and its area can be easily found by means of the table given in The Locomotive for June, 1891, on page 94. Thus the circle of which the shaded area is a part, is evidently 60 inches in diameter, and the height of the segment is 21 inches; so that to find this area by means of the table just referred to, we proceed as follows: 21÷60=.350, and

TABLE I. AREAS TO BE BRACED (Square Inches).

Height from Tubes to Shell.	Diameter of Boiler in Inches.							Height from Tubes to Shell.
	36″	42″	48″	54″	60″	66″	72″	
15″	206	....	....	....	....	....	....	15″
16	235	...	....	....	....	....	....	16
17	264	297	....	....	....	....	....	17
18	...	331	365	396	....	....	....	18
19	....	366	404	439	....	....	....	19
20	....	401	444	483	519	....	....	20
21	....	....	485	528	568	....	....	21
22	....	....	526	574	618	....	....	22
23	....	....	....	620	668	714	....	23
24	...	. ..	....	667	720	769	....	24
25	...	....	....	714	772	825	....	25
26	....	....	....	761	824	882	937	26
27	....	....	....	809	877	940	998	27
28	....	....	....	....	930	998	1,061	28
29	....	....	....	....	983	1,056	1,124	29
30	....	....	....	....	1,037	1,115	1,187	30
31	....	....	....	....	....	1,174	1,252	31
32	....	....	....	....	....	1,234	1,317	32
33	....	....	....	....	....	....	1,382	33
34	....	....	....	....	....	....	1,447	34

60×60×0.24498=882 square inches, the area in question. In Table I of the present article, this calculation has been made for all the sizes of boilers that are ordinarily met with. The area to braced has been calculated as above in each case, the two-inch strip above the tubes and the three-inch strip around the shell being taken into account. As an example of its use, let us suppose that upon measuring a boiler we find that its diameter is 54 inches, and that the distance from the upper tubes to the top of the shell is 25 inches. Then by looking in the table under 54″ and opposite 25″ we find 714, which is the number of square inches that requires staying on each head.

In case the measured height from the tubes to the shell is not an exact number of inches we may either call it the nearest even inch and take out the area as before, or we may proceed as in the following example. *Ex.* What is the area to be braced in a boiler 72 inches in diameter, the distance from the top of the shell down to the upper row of tubes being 31¼ inches? For 31 inches the table gives 1,252, and for 32 inches it gives 1,317. The difference between these is 65, and one-quarter of 65 is 16, which is the amount to be added to 1,252, on account of the measured height being 31¼ inches instead of 31 inches. Then 1,252+16=1,268 square inches, which is the area to be braced in this case.

The iron that is used in making braces is rarely of the best quality, and we cannot assume its ultimate strength to exceed 45,000 pounds to the square inch. As it is customary to use a factor of safety of at least 6, in designing boiler braces, it follows that the strain on such a brace must not exceed 7,500 pounds to the sectional square inch. In fact, the Rules and Regulations of the Board of Supervising Inspectors of Steam Vessels (as amended in January, 1892,) require that "no braces or stays hereafter employed in the construction of [marine] boilers shall be allowed a greater strain than 6,000 pounds per square inch of section"; but, in the construction of land boilers it is not usual to require such a large margin of safety as the United States rule just quoted implies, and in land boilers the strain on braces will nearly always run nearer to 7,500 lbs. per square inch than to 6,000 lbs. If we allow 7,500 lbs. as the safe working strain per square inch, we shall find that a round brace, 1⅛ inches in diameter, will safely bear 7,455 pounds. (For the sectional area of such a brace is 1⅛×1⅛×.7854=0.9940 sq. in., and 7,500×0.9940=7,455 lbs.) From this it is easy to calculate how many such braces a given boiler-head should have. Thus we see from Table I that in a 60-inch boiler whose upper tubes are 28 inches below the shell, the area to be braced is 930

TABLE II. NUMBER OF 1⅛″ BRACES REQUIRED, AT 100 LBS. PRESSURE.

Height from Tubes to Shell.	DIAMETER OF BOILER IN INCHES.							Height from Tubes to Shell.
	36″	42″	48″	54″	60″	66″	72″	
15″	2.8	....	....	....	....	....	....	**15″**
16	3.2	....	....	....	....	....	....	**16**
17	3.5	4.0	....	....	....	....	....	**17**
18	....	4.4	4.9	5.3	....	....	....	**18**
19	....	4.9	5.4	5.9	....	....	....	**19**
20	....	5.4	6.0	6.5	7.0	....	....	**20**
21	....	....	6.5	7 1	7.6	....	....	**21**
22	....	....	7.1	7.7	8.3	....	....	**22**
23	....	....	....	8.3	9.0	9.6	...	**23**
24	....	....	....	8.9	9.7	10.3	....	**24**
25	....	....	....	9.6	10.4	11.1	....	**25**
26	....	....	....	10.2	11.1	11.8	12.6	**26**
27	....	...	....	10.8	11.8	12.6	13.4	**27**
28	....	....	....	....	12.5	13.4	14.2	**28**
29	...	...	....	....	13.2	14.2	15 1	**29**
30	....	....	....	....	13.9	15.0	15.9	**30**
31	....	....	....	....	....	15 8	16.8	**31**
32	....	....	....	....	....	16.6	17.7	**32**
33	....	....	....	....	....	....	18.5	**33**
34	....	....	....	....	....	....	19.4	**34**

square inches. If the boiler is to carry a pressure of 100 lbs. to the square inch, the braces must withstand a total strain of 930×100=93,000 pounds; and as each single brace of 1⅛-inch round iron will safely bear only 7,455 pounds, we find how many braces will be required by dividing 93,000 lbs., the total load, by 7,455 lbs., the load that one brace can carry. We find that 93,000÷7,455=12.5; so that the proposed boiler will require 13 braces. We have performed this calculation for every boiler included in Table I, and the results are contained in Table II, which gives the requisite number of round iron braces, 1⅛″ in diameter, for boilers carrying 100 lbs. pressure. As an example in the use of Table II, let us take the following: How many braces of 1⅛-inch round iron are required to stay the head of a 72-inch boiler, the distance from the top of the shell down to the tubes being 29 inches; the maximum steam pressure to be carried being 100 pounds to the square inch? Under 72 and opposite 29 we find 15.1; so that the number of braces required is 16. As a further example of the use of the table, let us take the following: A boiler is 66″ in diameter, and the height from the tubes to the shell is 26½″. How many 1⅛″ braces will be necessary to stay the head of this boiler properly at 150 pounds pressure? Under 66″ and opposite 26″ we find 11.8; and under 66″ and opposite 27″ we find 12.6. The given height of the shell above the tubes being half way between 26″ and 27″, the number of braces required (at 100 lbs.) will be half way between 11.8 and 12.6; 11.8+12.6=24.4, and 24.4÷2=12.2, which is the number of 1⅛″ braces required, if the boiler is to carry 100 pounds pressure. For a boiler on which 150 pounds are to be allowed, the number of braces must be increased in proportion to the increased pressure. Hence, since 150 is 50 per cent. greater than 100, the required number of braces will be 50 per cent. greater than 12.2. Now 50 per cent. of 12.2 is 6.1; and adding this to 12.2, we have 12.2+6.1=18.3; so that we conclude that 19 braces, each 1⅛″ in diameter, will be sufficient for staying the head of the proposed boiler, at 150 pounds pressure. Other examples may be worked out in a similar manner.

Inspectors' Report.

JANUARY, 1898.

During this month our inspectors made 9,605 inspection trips, visited 18,888 boilers, inspected 6,130 both internally and externally, and subjected 497 to hydrostatic pressure. The whole number of defects reported reached 10,119, of which 1,053 were considered dangerous; 74 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	723	51
Cases of incrustation and scale,	2,155	72
Cases of internal grooving,	116	15
Cases of internal corrosion,	565	44
Cases of external corrosion,	505	45
Defective braces and stays,	235	20
Settings defective,	229	23
Furnaces out of shape,	335	21
Fractured plates,	292	46
Burned plates,	288	29
Blistered plates,	163	3
Cases of defective riveting,	1,316	80

Nature of Defects.	Whole Number.	Dangerous.
Defective heads,	94	34
Serious leakage around tube ends,	1,669	322
Serious leakage at seams,	466	38
Defective water-gauges,	241	59
Defective blow-offs,	153	56
Cases of deficiency of water,	13	7
Safety-valves overloaded,	67	32
Safety-valves defective in construction,	73	20
Pressure-gauges defective,	398	23
Boilers without pressure gauges,	11	11
Unclassified defects,	12	2
Total,	10,119	1,053

Boiler Explosions.

January, 1898.

(1.) — A heating boiler exploded on January 3d, in the basement of the Intermediate public school, No. 41, in Brooklyn, N. Y., shortly before the time for the noonday recess. The building was not much injured, but the explosion shook the floors and walls and caused a panic among 1,100 children ranging in age from 6 to 15 years. In the rush for the doors and stairways many of the children were slightly bruised, but only three required medical attention.

(2.) — On January 4th, the boiler of a locomotive drawing a fast freight train on the Cincinnati & Chattanooga railroad, exploded near Somerset, Ky. Fireman John Denham and Engineer Thomas Lenehan were killed, and several trainmen were injured. Twelve cars of freight were destroyed.

(3.) — A boiler exploded, on January 4th, on the Chatsworth dairy farm, at Richmond, Va. W. B. Crump, who was at work in the boiler room, was badly scalded about the face, arms, and feet, but will probably recover.

(4.) — A small boiler exploded, on January 4th, on Nathan Bush's farm, near Sterling, Ill. Nobody was injured.

(5.) — A heating boiler exploded in a club-house at Irving Park, Ill., on January 4th. We have not learned further particulars.

(6.) — On January 6th, a boiler exploded near Tallahassee, Fla. Three men were killed, two were fatally injured, and two others received severe injuries, from which they are expected to recover. Two of the men were thrown 80 yards. The property loss was about $2,000.

(7.) — The tow-boat, *Percy Kelsey*, owned by W. H. Brown's Sons of Pittsburgh, Pa., exploded her boiler, on January 8th, near Glenfield, Pa., while going down the Ohio river with seven barges and two flats, loaded with coal. Thomas Flynn, Lee Webster, Milton Wood, and an unknown man were instantly killed. Lee Brehtold, William Richards, Jacob Sellers, and Thomas Smith were stunned and thrown into the river, so that they were drowned before assistance could be had. William Alexander, David Walker, and Percy Wood were injured so badly that they cannot recover; and Daniel Gamble, Frederick Gohbol, Henry Hemmerlich, Leslie Jones, and Adolph Wendol also received severe injuries, from which, however, they will probably recover. The boat was literally blown to pieces, and the tow was scattered and lost. The *Kelsey* was valued at $25,000.

(8.) — On January 10th, a boiler exploded in a cheese factory at Vinton, Ia.

(9.) — A boiler exploded, on January 12th, in the plant of the Sheridan Brick Works, at Sheridan, Ind. Theodore Scott, Henry Anderson, and Daniel Harmon were seriously injured. The property loss was about $2,000.

(10.) — A safety boiler exploded, on January 14th, in the power house of the electric railway company, at Youngstown, O. Nobody was badly injured, although there were several narrow escapes. We have not received further particulars.

(11.) — A slight boiler explosion occurred, on January 14th, in August Torke's grist mill, at Adell, near Superior, Wis. Mr. Torke was badly scalded.

(12.) — A mud drum gave way, on January 15th, in the Valley Desk Company's factory, at Grand Rapids, Mich.

(13.) — A flue failed, on January 17th, in the Ferncliffe Distillery, Louisville, Ky. Fireman Charles Dickson was badly burned about the head, hands, and upper part of the body. It is thought that he cannot recover. John Thompson, Philip Kolf, William Witran, and John Kenney, were also injured. The property loss is estimated at $1,000.

(14.) — The following picturesque account is taken from the Chicago *Inter-Ocean*: "Half a dozen men were sitting at the lunch counter in Charles W. King's restaurant, on Fifth avenue, Chicago, on January 17th, when the long table, on which sat four huge coffee urns, began to rear and plunge about like a bucking broncho. A ton of dishes tumbled to the floor, and five big plate-glass windows made a hasty exit for the street. The cause was the explosion of a boiler in the basement. William Carter, Herbert Jackson, Jacob Lessak, John King, Arthur Newman, Frances Peonta, Mary Wtoisiejewski, and J. C. Blackwell were slightly injured. Though the men were tossed over the counter and rolled about on their stools, no one was seriously hurt, except one young man who was struck on the back of the head with a square yard of plastering. He had a lump on his cranium the size of a fried egg, but his only complaint was, that he had a meal check and no money, and had lost his lamb chop. His friend, sitting beside him, made a hasty lunge for a plate of cakes that was coming towards him, and then made a break for the door." The tone of levity which the reporter assumes, would suggest that the explosion was of small account. This, however, is not the fact. The loss was quite heavy, and is variously estimated at from $5,000 to $12,000.

(15.) — A west-bound passenger train on the Central Pacific railroad jumped the track on January 18th, about half a mile east of Colfax, Cal. It was drawn by two locomotives. When the train left the track, the boiler of one of the locomotives exploded, scalding Engineer Hackett so severely that he died soon afterward. Hackett's fireman, G. F. Brown, was also badly crushed and scalded. Fireman Leitner, on the second engine, was crushed to death, and Engineer C. C. Brown was cut and scalded about the head.

(16.) — On January 20th, a boiler exploded at Abingdon, near Galesburg, Ill., killing Oscar and Augustus Anderson, and severely injuring Lloyd and Willis Meadows.

(17.) — On January 21st, a boiler exploded in John R. Allen's saw-mill, five miles east of Bloomfield, Ind., instantly killing Engineer Thomas M. Nations, and seriously injuring Reese Adams. Joseph Shields and John R. Allen, the owner, were also injured, and the mill was totally wrecked.

(18.) — A boiler exploded, on January 24th, at Florence, near Kalamazoo, Mich. W. H. Benjamin, Herman Lane, and John Born were seriously injured, and Nelson Lane, William Coates, J. Herrine, J. Timmerman, and a Mr. Hardy received lesser injuries.

(19.) — On January 24th, a locomotive boiler exploded in the roundhouse of the Chicago & Northwestern railroad, at Madison, Wis. Frank Beck, Wesley Schelper, and Charles Young were killed, and Fred V. Baxter and Emil Olsen were seriously injured. The roundhouse and three locomotives were wrecked, and buildings were shaken in the business part of the city, a mile away.

(20.) — The crown-sheet of a locomotive on the Lehigh & Hudson railroad gave way, on January 26th, near Andover, Warren County, Pa. Fireman Robert Ferguson was blown from the cab and will probably die.

(21.) — A boiler exploded, on January 27th, at the Victor mine of the Coal Bluff Mining Company, at Fontanet, near Brazil, Ind. Fireman George Markle was injured so badly that he died shortly afterward. The explosion is attributed to the weakening of the shell plates of the boiler from corrosion.

(22.) — The boiler of a donkey engine exploded, on January 29th, on the deck of the sailing ship *Benjamin Sewell*, while she was lying at Johnson's coal wharf, at Baltimore, Md. Hugh King was killed, and Paul Schultz, Max Vogel, Samuel Bush, and Edward Kellum were injured.

(23.) — On January 19th a heating boiler exploded in the basement of Mortimer N. Judd's residence, at New Britain, Conn. Mr. Judd, who was in the basement at the time, was badly scalded and bruised, and the house was damaged to the extent of about $3,000.

(24.) — A boiler flue failed, on January 29th, in the factory of John Toler, Sons & Co., at Newark, N. J. The noise of the explosion and the sound and sight of the escaping steam caused the operatives in the factory to flee for their lives. Nobody was hurt, however, and the damage was small.

(25.) — A heating boiler exploded, on January 30th, in the Methodist Church, at Mystic, Conn. The damage was slight, and nobody was hurt.

(26.) — A locomotive drawing a freight train on the Norfolk & Western railroad exploded its boiler on January 31st, at Helena, near Welch, W. Va. Fireman William Jackson was killed, and Engineer O'Leary was fatally injured.

Mr. George W. Melville, engineer-in-chief of the U. S. Navy, has recently reported upon the experiments made with liquid fuel in the United States. He records the test made by the Pennsylvania Railroad Co., about ten years ago, which, while proving the practicability of using crude oil for fuel, demonstrated also that the railroad itself would consume more than one-third of the entire output of oil at that time, if used for fuel instead of coal. Mr. Melville considers that the balance of advantage is so greatly in favor of liquid fuel for small craft, that he strongly recommends the exclusive use of oil on torpedo boats.— *London Practical Engineer.*

The Locomotive.

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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.

A little booklet, entitled *Elementary Principles of Machine Design*, has been issued by the Industrial Publication Company, of 16 Thomas street, New York. It was prepared by Mr. J. G. A. Meyer, and is intended to give beginners some idea of the designing of various parts of the steam engine. As it is sold for twenty-five cents, it could not be expected to be at all exhaustive, but so far as it goes, it appears to be both accurate and intelligible, and well worth its price.

The Arlington Mills of Lawrence, Mass., have issued a remarkably attractive book, entitled *Tops*, which gives a great deal of highly interesting information about the manufacture of American worsteds. It contains more than 130 pages of matter, is beautifully illustrated, and is tastefully bound in cloth. The press-work was done at the Riverside Press, in Cambridge, Mass., and we are inclined to say, that if all advertising literature were prepared as elegantly as this specimen is, we should probably read nothing else.

The First Thermometers.

The thermometer, the Abbé Nollet writes, came for the first time from the hands of a peasant of North Holland. This peasant, whose name was Drebbel, was not, however, in fact, one of those coarse fellows who know of nothing but field work ; he seems to have been of a diligent nature, and had apparently some knowledge of the physics of the time. An ingenious inventor as well as an impudent pretender, and boasting that he had discovered perpetual motion, while he made great advances in the art of dyeing cloths, he secured favors from James I ; Rodolf II gave him liberal pensions and brought him to his court ; and Ferdinand II, who was himself interested in the thermometer, chose him as the tutor for his son.

Drebbel's thermometer — an invention which he may have borrowed from Porta, and in which Galileo doubtless preceded him — was composed of a vertical glass tube ending at the top in a bulb, while the lower end was plunged into a vessel filled with water or some colored liquid. When the bulb was warmed, a part of the air contained within it was driven back into the water and escaped without. When the air became cool again as the temperature around it, the external pressure caused the liquid to rise in the tube, the limit of its ascent being determined by the degree to which the air in the bulb had been heated, and the tension it had acquired.

This hardly practical apparatus was still used in Germany as late as 1621. The members of the Accademia del Cimento, with their active interest in all physical progress, soon substituted for it the more convenient instrument which we still use. Contained in a transparent bulb prolonged into a fine tube, a liquid more dilatable than the bulb rose in the tube when it was warmed, and descended when it was cooled. The Florentine Academy, moreover, never let any physical discovery pass without trying to apply it to the healing art. Galileo had hardly recognized the constancy of the time of the oscillations of the pendulum before the pendulum was used to determine the rapidity or the slowness of the pulses of patients. The thermometer, made convenient and portable, became in the hands of the Venetian physiologist, Santorio Santori, a sensitive and precise indicator of the progress of fever. Santori's writings made the instrument popular, and it was soon common in the enamelers' shops as the Florence or Santorius thermometer.

It is hard to imagine the interest that was excited by the indications of this instrument, which was declared to be "worthy of Archimedes." Everybody was curious to observe the ascent or descent of the colored spirit in the tube; for, Nollet wrote, "the physician, guided by the thermometer, can labor with more certainty and success; the good citizen is better informed regarding the variations that concern the health of men and the productions of the earth; and the individual who is trying to procure the conveniences of life is informed by it as to what he must do in order to live all the year in a nearly uniform temperature." According to Amontons, Colbert had a project for constructing a large number of thermometers and sending them to different parts of the earth for making observations on seasons and climates, but was obliged to give it up on account of the imperfect character of the spirit thermometer of the time. Different instruments would not agree.

The marking of the degrees on the thermometer stems was not controlled by any fixed rule, and they therefore did not express the same heat or the same cold by the same number of degrees. To remedy this defect, some physicists advised that the lowest point reached in the extreme cold of winter and the highest in summer be marked, and the space between be divided into a hundred equal parts. Such a thermometer would indeed permit its owner to compare the cold and heat of different years; but in communicating his observations to another he would give him data that would have no meaning unless he also sent him the instrument he had used, or one having identical graduations.

The problem was first solved in 1702 by Amontons; and his method, although it has been given up and resumed at intervals, has now become the normal one to which all others are subordinated. It is based upon two observations, both of which are of primary importance. We take two masses of air in two bulbs. Each of these masses is separated from the outer air by a curved tube filled with mercury, forming a manometer. Suppose that at a given temperature one of these masses supports a pressure of one, and the other of two atmospheres. Warm the two masses of air equally, and pour into both manometers enough mercury to maintain invariable the volume occupied by each of them. While the pressure supported by the first mass will increase to a certain amount, that sustained by the other mass will increase doubly. The pressure on the second will always be double that on the first. Thus, when we warm the two masses equally, while keeping invariable the volume of the recipients containing them, a constant relation will be maintained between the pressures supported by them. This is Amontons' first observation.

In the second observation, which can be made with an arbitrarily graduated thermometer, the temperature of boiling water is found to be invariable. Not only does the thermometer immersed in water keep for any number of hours of boiling the height it had reached when the first bubbles came up, but it ascends to the same point every time it is placed in boiling water. If Amontons had added the proviso that the pressure of the atmosphere should be the same in all the experiments, which we know now is indispensable, he would have been rigorously exact.

When we take a bulb of air connected with a manometer, mark carefully the pressure which it sustains when it is plunged into boiling water, and then the pressure at which, under other circumstances, it reaches the same volume, the ratio of that pressure to the former may be regarded as expressing the ratio between the temperature to which the air was raised under the latter condition to the fixed temperature of boiling water. This ratio will be the same, whatever thermometer, constructed in the same way, we may use. In this way we have a sure means of obtaining instruments that can be compared with one another.

Amontons proposed for a thermometer, as Drebbel did, a mass of air maintained at a constant volume under a variable pressure. The rule by which he attached a certain degree of temperature to each degree of heat and cold, or a larger number for more intense heat and a smaller for cold, is the same rule to which Desormes and Clément on the one hand, and Laplace on the other, returned a century afterward ; and is the rule proposed in the works of Sadi Carnot, Clausius, and Lord Kelvin as the measure of the absolute temperature.

The profound reasons which cause us to prefer the definition of temperature proposed by Amontons to every other could not be divined at the beginning of the eighteenth century. The large size and inconvenient shape of Amontons's instrument, and the necessity of taking account of the variations of atmospheric pressure in interpreting its indications, prevented its general adoption ; and the Florence thermometer was still preferred. Spirit thermometers, that could be compared with one another, were in demand. Réaumur furnished them.

Réaumur observed, in 1730, that a thermometer placed in freezing water went down to a certain degree, and remained fixed there as long as the water was not wholly solidified. The temperature of water in process of congelation was therefore always the same, and fixed. As physics has advanced, some corrections have been made to this law, and causes have been discovered that make the point of congelation of water vary; and physicists have been induced, in view of it, to take as their fixed temperature, instead of the freezing point of water, the melting point of it. But neither these corrections nor the incidental recognition by the Florentine Academicians of the invariability of the melting point of ice diminish the importance of Réaumur's discovery.

Having discovered a fixed temperature, Réaumur deduced a way of making spirit thermometers that could be compared with one another. If we plunge a glass bulb prolonged into a fine tube and filled with spirit into freezing water, and draw a line marked zero flush with the top of the liquid, then determine the volume occupied by the liquid under these conditions ; if we divide the tube into portions, the interior capacity of which represents at the temperature of the freezing of water aliquot parts of that volume — hundredths, for example — and number these divisions from the line marked zero : then if, in an experiment, we see the spirit rise to the level of the division marked five, we know that the spirit in the glass has suffered an apparent dilatation of five hundredths between the freezing temperature of water and the temperature of the experiment. If we always take care to use spirit of the same quality — Réaumur prescribed minute rules on this subject — and if we neglect the changes which the variable nature of the glass will introduce into the law of dilatation of the thermometric receptacle, we will obtain instruments of a kind that will always mark the same degree when they are equally heated or cooled.

For two instruments constructed according to the laws laid down by Réaumur to be rigorously comparable, it was essential that they be made of the same glass and filled with the same liquid. If the glass of which they are made has not exactly the same composition and tempering in both, and the alcohol has not the same degree of concentration, they will not agree. In order to diminish these variations, it is convenient to fix all thermometers, whatever they may be made of, so that they shall give the same indications for two fixed temperatures. The point reached by the liquid at the lower of these temperatures is marked on the instrument, and then it is raised to the higher temperature, and the point which it reaches then is marked. The interval is then divided into parts having the same interior volume, and the division is carried out beyond the fixed points. In such thermometers the liquid will stand at the same mark for an equal degree of heat, notwithstanding slight inequalities in the glass and the fluid.

It was some time before the two fixed temperatures at which the thermometric scale should be marked were determined upon. Dalencé, in 1688. took a mixture of water and ice for the zero, and the melting point of butter as the upper point. Renaldini, in 1694, recommended a mixture of water and ice and the boiling point of water, but his process was not applicable to the alcohol thermometers then in use, for the vapor of alcohol has a tension at the boiling point of water which would burst the reservoirs of the instruments. And Renaldini's method could not be adopted till after Musschenbroeck had introduced the use of mercury. In 1729, Delisle chose as graduating points the temperature of ice-water and the almost invariable temperature of the cellars of the Observatory at Paris.

About 1714 a skillful instrument-maker of Dantsic, Daniel Gabriel Fahrenheit, furnished chemists with alcohol thermometers, which he replaced in 1720 with mercury thermometers, the indications given by which all agree with one another. According to the chemist Woulfe, he boasted that he could make a thermometer that would agree with those he had already made in any place, and without seeing any of the instruments that had already gone out of his hands ; but he would not divulge the process by which he had been able to obtain such an agreement. This process, in establishing which he had been aided by the advice of the astronomer Roemer, was nothing else than the method devised by Dalencé ; but Fahrenheit took for his zero the temperature of a mixture of ice and muriate of ammonia (chloride of ammonium) — which, he thought, was the greatest cold that could be obtained — and for his higher degree the temperature of the human body.

Finally, in 1742, the Swede, Andrew Celsius, proposed to restore the method of Renaldini, and divided into a hundred degrees the interval which the mercury in the thermometer would traverse between the temperature of melting ice and that of boiling water. He marked the lower temperature 100, and the higher 0. Linnæus, reversing this order, gave the mercury thermometer (centigrade) the form under which it is now known. — M. P. Duhem, in the *Popular Science Monthly* (translated from the *Revue des deux mondes.*)

House-Heating in Europe.

House-heating practice in Great Britain, when compared with that current in America, exhibits great differences in style of apparatus employed, in the systems in favor, and in the extent to which the development itself has proceeded.

Some of the reasons, at least, are very apparent. In a large portion of the United

States and throughout Canada, the winter climate is such that some artificial heat, over and above that obtainable from an open fire, is absolutely necessary; in Great Britain, however, the old-fashioned open fireplace is, as a rule, sufficient, or, at least, has been so considered until very recently. Within the last few years there has been a growing appreciation, among the British people, of the comfort and advantage of maintaining an even temperature throughout an entire building, whether this be a dwelling or a school, church, office-building, or other *quasi*-public edifice. Indeed, even in private dwellings, where it is most attractive and most nearly adequate, the open fire, if depended on entirely, too often gives one the choice between being partly roasted, if he sits near, or shivering, if he moves to the further corners of the room or passes to the halls and staircases.

While the severity of the American climate has been of itself sufficient to cause the great demand for heating apparatus, there is at least a general belief that the climatic effect on the human system creates a greater dependence on artificial warmth among Americans than among Englishmen. The blood seems to become thinner. It was my own experience that, when I first went to America, I could well endure the cold, and the temperature of 70° usually maintained in buildings there was far too warm for me. As years went by, I grew more and more sensitive to the cold, and, on first returning to England, I felt the temperature of 60° maintained in English houses quite too low; but in a short time I became re-acclimated.

Again, the large blocks of buildings erected in America demand efficient adaptation of the heating apparatus, for it would be almost an impossibility to heat these large buildings (no matter what their use) by open fires. Fancy the large coal-storage space that would be necessary, and the work and labor of carrying coal to and ashes from all the different rooms, and of cleaning and attending to all these fires; the cost would be tremendous. In fact, one of the strongest economic principles in America is labor-saving; and an efficient heating apparatus is a labor-saver as well as a money-saver.

By a natural retroaction, the general introduction of improved house-heating systems, which primarily stimulated manufacturers to increased effort toward the production of efficient and economical apparatus, has itself received an impetus from the lowered cost and increased convenience of the many devices now offered in the market.

There is no doubt that America is now far in advance of Great Britain, in its systems of heating apparatus, and the materials and methods used in their installation. Many years ago the mode of heating was as crude in America as, I am sorry to say, it often is now in Great Britain; but as time went on and the demands became greater, natural competition proved to be, as always, the greatest producer of improvements; every keen competitor was anxious to have the latest device, style, system, or material, to assist him in obtaining a contract. For example, the hot-water or low-pressure steam boilers generally employed in America are, as a rule, far in advance of those in general use in Great Britain. This great advance has come about within the last fifteen or twenty years.

One of the principal points for which the manufacturers have striven was to produce a boiler that would give the maximum amount of heat for the minimum consumption of fuel, the cost of fuel being a great consideration in America. And as every manufacturer was anxious to produce the best boiler, it is natural that the questions of grate-surface, fire-surface, and rating of a boiler should have been carefully studied in America. Other points receiving especial attention have been the manner of constructing the surfaces in the boiler so they will absorb the utmost of the heat of the gases before they pass into the chimney; simplicity of construction; easiness of erection; getting them into the building required to be heated; cheapness and simplicity of repairs; and facilities for firing and keeping clean. From the combined results of all this study the modern American boiler has been developed. In Great Britain all these important factors in the construction of a boiler seem, as a rule, to be but little studied. The average English boiler seems to be constructed with but little consideration for the amount of fuel it will consume, and its grate and heating surfaces seem to be proportioned, not according to any set rules or ratios, but purely by guesswork. Many a boiler manufacturer of Great Britain, if asked the size of the grate-surface or fire-surface of his boiler, or its rating in proportion to its grate and fire-surfaces, would look in astonishment, and ask the purpose of the question. In many cases, indeed, he could not tell. With but very few exceptions, the boilers made in Great Britain are of wrought-iron, either welded or riveted, and are made in one piece, requiring to be brick-set. Almost invariably this setting is done according to the individual idea of each heating engineer or heating contractor. The boiler manufacturer does not have any particular design for setting the boiler bought from him. Thus it may be seen how vague are the statements of the rating of a boiler, as this depends a good deal on how it is set.

Nearly all the manufacturers make the same style of boiler, the only difference being that each has his own name. The only competition is in price. But within the last few years some manufacturers have begun to produce and push patent boilers of their own, using as strong arguments for their special type, its advantages in construction, style, and heating power in comparison to fuel-consumption. A few years will no doubt witness vast improvements in the boilers for heating systems in Great Britain. Most of the new boilers put on the market at present are of the American style, and do not require to be brick-set; they are called independent boilers, but they are made of wrought-iron.

The British people are somewhat prejudiced against the cast-iron boiler, for just what reason it is hard to tell; no doubt one reason is that cast-iron boilers so far produced in Britain have been cast in one piece, have been very heavy because of the thickness of metal, and may easily be broken because of unevenness of expansion and contraction, as well as unevenness of thickness. It is asserted, also, that if a boiler is of wrought-iron made in one piece, there is less likelihood of leakage than in a cast-iron sectional boiler which has to be put together with many joints. This is a point open to discussion. Although there is this prejudice in England against cast-iron boilers, it is no doubt dying; I have used a number of American cast-iron boilers in recent contracts, and several firms are using and selling American cast-iron sectional boilers to-day. In fact, there is one English firm that is putting on the English market a cast-iron boiler of American manufacture, though sold under another name. Although the larger number of boilers in use in Great Britain are of wrought-iron, either brick-set or independent, both classes show great variety in type, style, and mode of construction — especially in the arrangement of flues, cross tubes, and narrow flues. The greatest objection to the independent boiler is that, as a rule, it has no covering, and therefore is giving out a great deal of its heat where it should not. Indeed, the commonest fault with British boilers is that they are great fuel-consumers.

The low-pressure hot-water system is the one most largely used in Great Britain, but its chief application is to the heating of schools, churches, and public buildings; very few residences are heated in any way except by the open fireplace, although of late years far more of the owners of large residences and mansions are putting in some one of the newer heating devices, using it, as a rule, as an auxiliary to the open grate, which holds its own because it ministers to the natural love of the sight of an open fire and the maintenance of good ventilation. Low-pressure steam is but little used, as it is often considered to give too high a temperature for the heating of buildings. Another reason may be that its installation is not well understood, some very bad results having been produced. The two-pipe system is used, and the principal trouble has been that the returns have not been properly taken care of, with the result that water hammer has run riot. The one-pipe system is but little known, and the British architect is rather a difficult person to convert to new ideas. There are a few firms in Great Britain which are now doing considerable steam heating, using one-pipe work; and very good work indeed they are doing, for there is no question that, when the Briton goes in for good work, he does the very best. The fan system (or plenum, as it is called in Great Britain) has only of late come into use, and only in large public buildings, but it bids fair to become prominent. It is installed in Great Britain in a manner somewhat different from that prevailing in America; more often than not, low-pressure hot water is the heating agent, instead of steam. Instead, however, of making one large heating chamber, from which the warmed air is blown through tubes to the upright flues and thence to the different apartments in the building, the heating surface is subdivided, and the small units placed at the foot of each individual flue, and cased in. A brick tunnel leads from the fan around the building (under the ground floor), and from this tunnel the air is supplied to each stack of heating surface and regulated at the bottom of the separate flues. There are, of course, many ways of installing the fan system and of regulating the supply of warm fresh air and of taking out the foul air. Where low-pressure hot water is the heating power, a gas engine is used to drive the fan.

The high-pressure hot-water system (known as the Perkins system) was at one time very largely used in Great Britain, but of late is less often installed. In this system the boiler is simply a coil constructed of very heavy wrought-iron pipe and incased in brick work. From this coil are run strong inch pipes with $\frac{5}{8}$-inch or $\frac{7}{8}$-inch bore. The circuit is generally continuous, with no valves and no means of shutting off any part of the apparatus; the heat must be either on or off for the entire building. In some cases, however, there are several circuits with valves and by-passes to each circuit. The pipes are put together in a very strong manner, for they have to withstand a heavy pressure. The joints are connected by right and left hand couplings. The joint is not made by tightening on the threads. The ends of the pipes are made one convex and the other concave, and the process of tightening the couplings butts the two ends of the pipe together. The same kind of joint is made with all fittings, and the fittings are all made of wrought pipe of heavy gauge; where bends (or elbows) are required, the pipe has to be bent by the use of a fire. The system is run at a very high temperature, and, as it is entirely sealed up, with but a small air-chamber, or air-cushion, the pressure is very great. The principal objection is the unevenness of temperature, caused in the following way: When the fire is on, the water does not circulate slowly, as in a low-pressure system, but stands still until a high temperature is reached, and then goes through the pipes with a rush; as soon as the fire drops, the circulation stops, and the heat soon dies down.

The use of hot-air heating in Great Britain is very small; in fact, about the only system used is the Grundy, and that principally in churches and schools. It is different from the practice in America, which commonly involves the use of a furnace with tin flues.

The systems of low-pressure hot-water heating in use are much the same in both countries, the three principal being the rising system, the drop system, and the one-pipe system. In the first, the flow and return are duplicates, one of the other, and the mains run side by side, or one above the other, in the basement cellar or in trenches below the ground floor, branches rising from these mains. In the drop system a main riser is taken to the highest point of the building, and a main run around the top of the building, and from this main are taken drop pipes which supply the heating surface on their way down, the flow and return to the coil, or radiator, being from the one drop pipe; then all the different drop pipes are gathered into a main return pipe below the ground floor and returned to the boiler. The one-pipe system consists of one large main, in basement or cellar, which main is of the same size throughout. Its highest point is at its exit from the boiler, and it has a gradual fall all the way until it enters the return. This one pipe is used for both flow and return, the flow branches leaving the top and the return branches entering at its side.

Although the systems are much the same in both countries, they vary in detail; all three systems have been more fully developed in America. The rising system is most frequently used in Great Britain, the other two systems named being less often met, although I have put in several since my return to England. As to style of work, America is far in advance, but the large demand for heating and the great competition account for the superior quality of American work. The demand for heating systems has been comparatively small in Great Britain, as the country has been satisfied to go on in its old lines; but, as the demand increases, improvements are made, and some very fine systems are now being erected. Indirect heating, for example, which until very recently was hardly known, has been introduced in several large and handsome residences, the work being of the very best class. The indirect stacks are incased in chambers constructed of the finest glazed bricks, so arranged that access can be had for cleaning. The registers are of solid bronze metal of Tuttle & Bailey's best manufacture. Several strong principles which have been allowed to govern the erection of heating plants in Great Britain have prevented the work from presenting the most pleasing effect. One of the most prominent is the prevailing use of cast-iron pipe, heavy and clumsy in appearance; it has to be adopted in many cases for the reason that the water is so bad that it destroys or fills up the wrought iron pipes in a very short time. This has limited the demand for wrought-iron pipe, especially in sizes more than two inches in diameter; and, as a natural result, the prices of all the larger sizes are very high. No doubt to an American a very peculiar appearance would be presented by a heating job wherein the mains were of cast-iron pipe in lengths of nine feet, with spigot and socket joints caulked together with either rust joint, or red and white lead and spun yarn; nevertheless, a great part of the work in Great Britain is done in this manner; again, much of the heating surface is constructed of coils made of cast-iron pipe, two inches and upwards in diameter, put together in the manner described above. In greenhouse work cast-iron pipe is always used, and, as a rule, the joints are made with India-rubber rings, known as India-rubber expansion joints. Another point affecting heating plants in Great Britain is that comparatively few of the buildings have basements under the whole house; this makes it very difficult to get in mains, and the result is that the mains are made as short as possible, and the different rooms are heated by running long coils from room to room, making long circuits with short mains, to avoid very heavy expense in making channels, trenches, or tunnels below the ground floor. At one time there were but few radiators in use in Great Britain, the heating surface being usually of cast-iron pipe and cast-iron coils; but now the public is beginning to desire them and architects to specify them. But the Briton has little desire for decoration. It is generally his request that the radiators be put out of sight as much as possible. There is no doubt that the heating business in Great Britain is improving very much, and that the class of work is growing better every year and patterning more after American practice; but no doubt it will be some time before buildings are heated throughout, and each room controlled by a thermostat.—J. L. SAUNDERS, in the *Engineering Magazine.*

The Locomotive.

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The Horizontal Tubular Boiler.

The essentials of a good steam boiler may be enumerated somewhat as follows: The heating surface must be ample, and must be so arranged as to promote a free and rapid circulation of water and absorb the greatest possible amount of heat; the steam room and the evaporative surface must be large, so as to allow of an easy release of the steam from the water, and afford a steady supply, of uniformly dry quality; all parts of the boiler should be as accessible as possible for examination, repairs, and cleaning; the structure should expand as uniformly as possible, so that there shall be no severe strains produced when the temperature of the boiler varies from any cause; the boiler should be durable, and should possess an excess of strength, when new, in order to provide for wear and other deteriorating influences; it should not be liable to expensive repairs, and its first cost should be as low as is consistent with the other requisites, already mentioned.

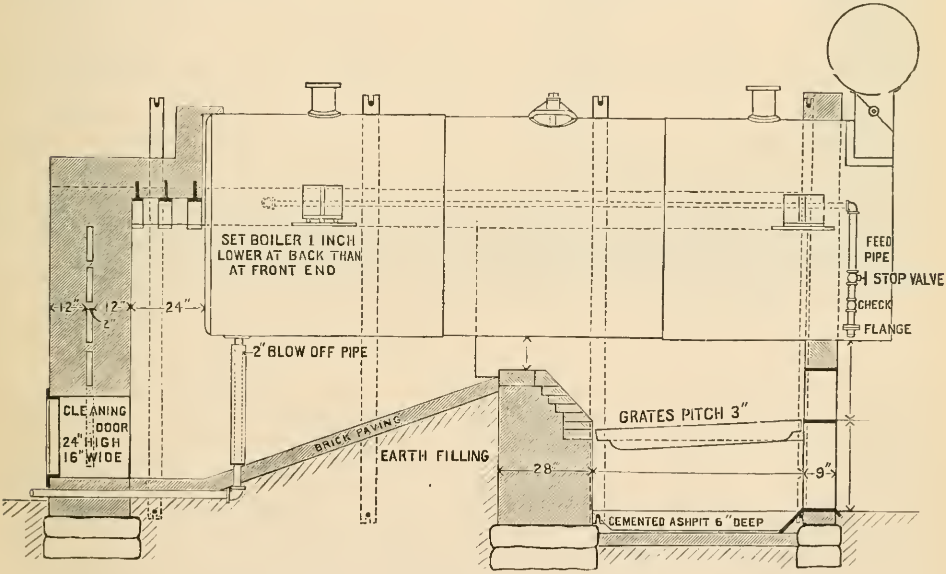

Fig. 1.— Side Elevation of Setting.

The horizontal tubular boiler has been considered to conform very closely to these requirements, and for this reason it came into very general use. It is unfortunately true that the best methods have not always prevailed, either in the design or in the erection of this type of boiler; but this is no fault of the type itself. The Locomotive has frequently called attention to prevailing faults in the construction of horizontal tubular boilers, ever since its first issue, and we are inclined to believe that a perceptible fraction of the improvement that has been manifested during these years has been due to our influence. We have particularly recommended, from the first, that fewer tubes be used than was formerly the custom; that ample space be left between the tubes and between the tubes and the shell; and that the feed pipe should be so disposed that the entering water might not cause severe strains in the shell plates. The evaporation of two pounds of water per hour per square foot of heating surface (or a duty of one nominal horse power for each fifteen square feet of heating surface) was undoubtedly realized as an average performance with this type of boiler, even before the more recent improvements in its design, and these data were used in computing the commercial rating of such boilers; but owing to the lack of uniformity in design, there was a corresponding variation in the economical results that were obtained. In the hope of improving the performance of the horizontal tubular boiler, the Hartford Steam Boiler Inspection and Insurance Company has prepared for its patrons, for many years past, drawings and specifications for the construction and erection of horizontal tubular boilers of approved design, taking into account the kind of fuel that is to be used, the quality of the feed water, and such other local conditions as might need to be considered. Several thousands of steam plants that have been installed in this way have given perfectly satisfactory results, giving a uniformly dry supply of steam, at a high efficiency.

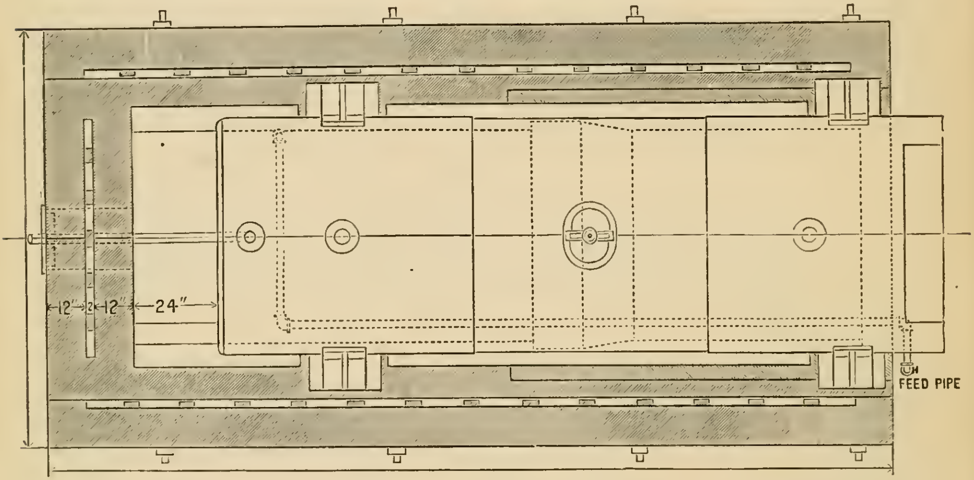

Fig. 2.— Plan View: Section through Center of Boiler.

The advent of high pressures has called for a stronger mode of construction, and thicker shell plates; and some engineers and boiler-makers have feared that the thicker plates would reduce the efficiency of the heating surfaces, by diminishing their power of absorbing heat in a marked degree. It has also been feared that the thick plates would deteriorate rapidly under the action of the high temperatures to which they are exposed. Many boilers constructed of half-inch plate have been in constant operation for the past ten years, however, showing good efficiency, and so little deterioration that not one dollar has been expended for repairs. While the thickness of the plate must necessarily have *some* influence on the heat-transmitting power, it is so small that it may be neglected in practical work. Chief Engineer Isherwood, experimenting with plates ranging in thickness from $\frac{1}{8}''$ to $\frac{3}{8}''$, found that when all other conditions are the same, the heat transmitted through a given plate in a given time is sensibly independent of the thickness. We do not know that these experiments have been extended to the thicker plates now met with in practice, but experience indicates that Mr. Isherwood's results are true for a considerable distance beyond the range indicated above. The resistance of a plate of metal to the passage of heat through it, appears to lie principally at the two surfaces of the plate, where the heat enters and leaves it. Rankine calls this skin-resistance the "external thermal resistance" of the plate, to distinguish it from the resistance opposed by the body of the plate, which he calls the "internal thermal resistance"; and he says, in his *Steam Engine*, Part 3, Chapter I, Section 3, that "the external thermal resistance of the metal plates of boiler flues and tubes and other apparatus used for heating and cooling fluids, is so much greater than the internal thermal resistance, that the latter is inappreciable in comparison; and, consequently, the nature and thickness of these plates has no appreciable effect on the rate of conduction through them." In fact, as we have already said in THE LOCOMOTIVE for February, 1898, the heat transmitted through a given heating surface may be considered to be independent of the nature and thickness of the plate through which it is to pass, and to be simply proportional to the difference in temperature between the water that touches the plate on the one side, and the hot furnace gases that touch it on the other. The temperatures of the gases and water in contact with the respective sides of the plate will vary with the circulation in the furnace and in the boiler; for with poor circulation on both sides, the gases in immediate contact with the plate are cooler than the average temperature of the combustion chamber, and the water in contact with the plate is warmer than the general mass of water in the boiler, so that the temperature-difference between the two surfaces of the plate is smaller than it would be if the circulation were good, and the heat transfer is correspondingly less. In well-proportioned boilers, having free circulation and large evaporative surfaces, the steam bubbles that form on the heating surface are rapidly disengaged or thrown off, and rise quickly to the surface. Where the circulation is poor, or the steam-bubbles have a long distance to travel before they can escape from the water, the steaming qualities of the boiler are necessarily impaired. The horizontal tubular boiler, when properly constructed, fulfils all these various desirable conditions admirably, and has proved itself to be as durable and economical as it is cheap (in comparison with other types).

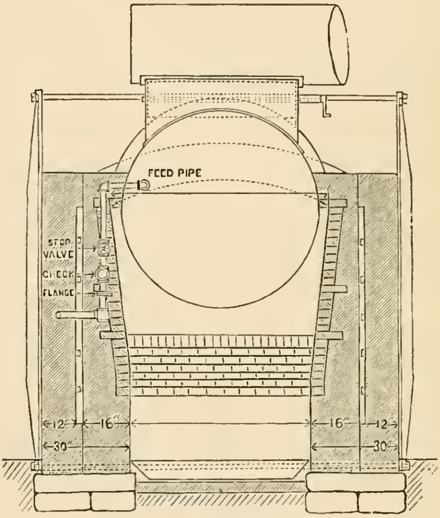

FIG. 3.— SECTION THROUGH FURNACE.

The *setting* of an externally fired boiler has an important influence on the efficiency of the boiler, and hence it is necessary to design and construct the setting intelligently. If the specific heat (at constant pressure) of the furnace gases be assumed to be sensibly constant, it follows that the maximum efficiency will be realized by securing the highest possible furnace temperature, simultaneously with the lowest admissible temperature of the gases that escape to the chimney. To secure this combination, the proportion of grate surface to heating surface must lie within certain limits, and the coal consumed per square foot of grate per hour must also be carefully considered. In certain experiments made by Mr. Isherwood, with a small horizontal tubular steam boiler, in which the ratio of the grate surface to the heating surface was as 1 to 25, the highest economy was obtained when 8 pounds of coal were burned per hour on each square foot of grate. With a more rapid rate of combustion, the capacity of the boiler was increased, but the economy was diminished. This result appears to be well substantiated by many boiler trials that have come under our observation. When the grate area stands to the heating surface in the ratio of 1 to 50, the rate of combustion can be increased to 15 or 16 pounds of coal per square foot of grate per hour, and the heating surfaces, if well arranged, will absorb and utilize the heat. By an increase in the ratio of heating surface to grate area, it is therefore possible to burn more coal, efficiently, on each square foot of grate area. This means that a greater intensity of combustion — or, in other words, a higher temperature — may be realized in the furnace, without a corresponding increase in the chimney temperature; and in accordance with the principle laid down at the beginning of this paragraph, this means that the efficiency of the boiler would be increased. We have made a considerable digression on this point, in order to illustrate the importance of a correct understanding of the principles of physics, in erecting the setting for a boiler.

The form of setting shown in the illustrations resembles ordinary settings in its external appearance, but examination will show that it embodies numerous distinctive and important features. One of these is the inclination of the grate, which is three inches lower at the bridge-wall end than it is at the furnace door, so that when the fires are kept level (as they always should be) they will be thicker at the back end, where the draft is strongest, and the consumption of fuel most rapid. The furnace is materially less in width than former practice required; and its side walls slope outward, from the grate up, with a batter that is sufficient to keep the walls three inches from the shell, at the center line of the boiler. When this construction is adopted, the furnace walls last much longer than straight or overhanging ones will, because the hot gases do not strike them so directly. The conduction of heat through the settings is checked by a two-inch air space in the outside walls. Walls that separate adjacent boilers are divided at the center by a space that is from $\frac{3}{8}''$ to $\frac{1}{2}''$ wide, so that the walls may not be injured by expansion strains when one boiler is put in service while its neighbor remains cold.

These are some of the minor features of a style of setting that our experience of some thirty years has shown to be eminently satisfactory and economical, when intelligently proportioned and constructed. Boilers that are set in this way may be expected to show a good efficiency in daily practice, and a capacity far above the conventional "nominal" rating. They should evaporate upwards of 10 pounds of water per pound of coal, counting the coal as it is run into the room from the pile, and the water as actually supplied to the boilers. When allowance is made for the incombustible matter in the fuel, and the results are reduced to the usual standard of "evaporation from and at 212°," they will, of course, make a still better showing.

The progress that has been made in recent years in the construction and erection of horizontal tubular boilers is well illustrated by the following data which came to our notice a short time ago. Ten boilers that were installed some 20 years ago were removed and replaced by three boilers of modern type, which were constructed and erected according to plans and specifications furnished by the Hartford Steam Boiler Inspection and Insurance Company. At the same time that the new boilers were installed, an additional 100-horse power engine was put in, and was thereafter operated 58 hours a week. The plant in question was a textile mill, and the old and new boilers were compared by the practical method of comparing the coal consumption and the product of the mills under the old conditions, with their corresponding values after the new boilers were introduced. For this purpose a careful record was kept, with the old boilers, for the six months ending with March 31st. When the change had been made, the same data were taken for the six months ending with the succeeding March 31st. The conditions being as nearly similar as possible, it was found that with the new boilers, the coal consumption was 209 tons *less*, and the cloth production was 107,000 pounds *more*, than they had been under the former condition of the plant.

Inspectors' Report.

FEBRUARY, 1898.

During this month our inspectors made 7,858 inspection trips, visited 15,545 boilers, inspected 4,720 both internally and externally, and subjected 494 to hydrostatic pressure. The whole number of defects reported reached 8,373, of which 834 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,	624	56
Cases of incrustation and scale,	1,651	65
Cases of internal grooving,	114	14
Cases of internal corrosion,	415	45
Cases of external corrosion,	408	47
Broken and loose braces and stays,	108	42
Settings defective,	206	28
Furnaces out of shape,	251	15
Fractured plates,	255	56
Burned plates,	211	28
Blistered plates,	104	4
Cases of defective riveting,	1,303	48
Defective heads,	75	9
Serious leakage around tube ends,	1,322	153
Serious leakage at seams,	367	32
Defective water-gauges,	222	58
Defective blow-offs,	121	37
Cases of deficiency of water,	9	2
Safety-valves overloaded,	60	22
Safety-valves defective in construction,	53	20
Pressure-gauges defective,	354	34
Boilers without pressure-gauges,	13	13
Unclassified defects,	127	6
Total,	8,373	834

Boiler Explosions.

February, 1898.

(27.) — On February 1st a pulp digester exploded in the Marinette & Menominee Paper Company's plant, at Marinette, Wis. Peter Borst was instantly killed, and Samuel Steffen and Louis Lefevre were seriously injured. The three-story brick building in which the digester stood was wrecked. The property loss is estimated variously, at from $50,000 to $75,000.

(28.) — A heating boiler burst, on February 2d, in the Lincoln school at Danville, Ill. Fortunately, nobody was injured.

(29.) — William A. Hawkins, Edwin J. Connors, John J. Ryan, and Thomas Cleary were fearfully burned and scalded, on February 2d, by the explosion of a boiler on the tug *Isabella Wilber*, while she was moored at the Lehigh Valley railroad docks, in Jersey City, N. J. The damage done to the tug was about $40,000.

(30.) — A tube failed, on February 3d, in one of the boilers in the oil mill at Sherman, Tex. Harvey McDuffie and W. H. Greer were fearfully scalded, and Greer may not recover.

(31.) — On February 4th, a boiler exploded in Carey & Son's saw-mill, at Plum Run Station, near Newport, Ohio. The mill was destroyed. Homer Carey was severely scalded, and John Simmons was painfully bruised.

(32.) — A boiler used for heating the shoe factories of Bragg & Morris and Jones & Shields, of Montpelier, Vt., exploded on February 4th. We have not learned further particulars.

(33.) — On February 5th, the head blew out of a steam dome on one of the boilers in the Samuel Allen Lumber Company's plant, at Corrigan, Tex. Henry Baker was badly scalded and bruised, but it is thought that he will recover.

(34.) — Edward Gillam's mill, at Mellville, near Stockbridge, Mich., was destroyed by a boiler explosion on February 7th. Melvin Siegfried and Richard Stevens were putting on a belt at the time. Siegfried was pinned against a post and his arm was broken in two places. Stevens was buried beneath the debris and severely injured. Both will probably recover.

(35.) — A boiler exploded, on February 8th, in the laundry of Wood's Hotel, at Clinton, Mo. The front half of the hotel building was blown out, and the walls were badly damaged. Two men were slightly hurt, and there were many narrow escapes.

(36.) — On February 9th, a heating boiler exploded in Walters' greenhouses, at Kenneth Square, in Philadelphia, Pa. Nobody was hurt.

(37.) — Several men had narrow escapes from death, on February 11th, when a boiler exploded in A. F. Underwood's saw-mill at North Crandon, Forest County, Mich. The mill and machinery were wrecked.

(38.) — A new safety boiler gave way during a "test," on February 14th, in the Pennsylvania Bolt and Nut Works at Lebanon, Pa. Several workmen were slightly injured.

(39.) — A man named Samson was instantly killed, on February 15th, by the explosion of a boiler in Carter Smith's mill, situated some five or six miles northeast of Madison, Fla.

(40.) — A safety boiler exploded, on February 16th, in the Wampanoag Mill, at Fall River, Mass. Fireman Richard O'Brien was badly scalded about the arms and legs, and a coal wheeler, whose name we have not learned, was also injured.

(41.) — On February 17th a traction engine boiler exploded at White Pigeon, near Mt. Pleasant, Mich., severely scalding eight men.

(42.) — A blow-off pipe burst, on February 20th, in the Tobias mill, at Omaha, Neb. The rear walls of the setting were blown down, the boiler-house windows were broken, and considerable other damage was done.

(43.) — A domestic boiler exploded, on February 20th, at Brooklyn, N. Y., in the residence of the Rev. John Fitzgerald, pastor of St. Patrick's Roman Catholic Church. Considerable damage was done, but we have not learned of any personal injuries.

(44.) — On February 21st a boiler exploded in an ice-cutter's camp at Bent's pond, in the town of Hubbardston, Mass., near the Gardner line. John L. Jones and Felix T. LeBlanc were injured so badly that they died in the course of the following night. George H. Lawrence also died from his injuries, five days later. Lucius Farrar was badly burned about the head and arms, but it is now believed that he will recover.

(45.) — On February 24th William Ehrig's mill, at St. Croix Falls, Wis., was totally destroyed by a boiler explosion. Engineer Campbell and one other man were somewhat injured, but there were no serious results.

(46.) — A boiler exploded, on February 25th, in Bunch's mill at Fyan, twenty-five miles southeast of Lebanon, Mo. The owner of the mill was scalded so badly that he died some ten hours later.

(47.) — A boiler exploded, on February 25th, in R. G. Dennis' mill at Suffolk, Va., near the Suffolk and Carolina railroad depot. The brickwork about the boiler was thrown down, but the damage was not great, and no person was injured.

(48.) — On February 25th a boiler exploded at Hancock's mill in Montgomery county, just across the river from Eastman, Ga. Engineer J. M. Arrington was killed, and the fireman, whose name we have not learned, was scalded badly and perhaps fatally.

(49.) — On February 26th a boiler exploded in Jacob Vauble's grist-mill at Atalissa, near Muscatine, Iowa. The end of the building was blown out, but nobody was injured.

(50.) — A blow-off pipe burst on February 28th, at the F. & P. M. shops at Saginaw, Mich. One end of the building was blown out, and two workmen were injured, though it is believed that both will recover.

(51.) — A boiler exploded, on February 28th, in Strickland Bros.' saw-mill, some eight miles east of Buford, Ga. Walter Strickland was killed, and Pern Mauldin was mortally injured. Two other men were badly burned, but it is believed that they will recover.

(52.) — On February 28th a boiler exploded near Brewton, Ala., killing six men. We have not learned particulars.

The Locomotive.

HARTFORD, APRIL 15, 1898.

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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WE desire to acknowledge the *Report* for 1896 of the Milan Associazione fra gli Utenti di Caldaie a Vapore; the *Report* for 1897 of the Naples association of the same name; the *Report* for 1896 of the Badische Gesellschaft zur Ueberwachung von Dampfkesseln (of Mannheim); and the *Report* for 1897 of the Manchester Steam Users' Association, of Manchester, Eng. We are also pleased to acknowledge a valuable memoir by Professor Francis E. Nipher, of Washington University, entitled "A Method of Measuring the Pressure at any Point of a Structure, due to Wind blowing against that Structure." We hope to present a review of this paper at an early date. An interesting illustrated report by Mr. John Waugh, addressed to the coroner of Bradford, Eng., and relating to the cause of a boiler explosion which occurred on February 22, 1898, is also at hand.

The Electric Telegraph.*

The telegraph, being one of the earliest of the practical developments of electricity, naturally had a great effect in stimulating the advance of the science.

The discovery by Stephen Gray, in 1729, that the electrical influence could be conveyed to a distance by means of an insulated wire, is probably the first of direct influence in connection with telegraphy. As a result of this discovery, and of the investigations which followed it, a considerable number of proposals were made as to the use of the electrical force for the transmission of intelligence. The first of these of which I have found any record was made in 1753 by Charles Morrison, a Scotchman, and then followed other proposals for electrostatic telegraphs by Bozolus in 1767, by Le Sage in 1774, by Lomond in 1787, by Betancourt in the same year, by Reizen in 1794, by Cavalla in 1795, and by Ronalds in 1816.

The discovery of voltaic electricity, and most directly the discovery by Nicholson and Carlisle of electrolysis, give rise to another group of proposals for the application of this discovery to the production of telegraphy. Among those may be mentioned that of Sömmering in 1809, of Coxe in 1810, and of Sharpe in 1813. In more recent years, of course, the same application appears in the chemical telegraphs, some of which are capable of giving very satisfactory results and great speed.

The discovery which had the greatest influence on the development of telegraphy was that of Oersted, supplemented by the work of Schweigger and Ampere. Ampere proposed a multiple wire telegraph with galvanoscope indicators in 1820, and a modification was proposed by Ritchie. A single-circuit telegraph of this character was invented by Tribaoillet, but it didn't come into use. In 1832 Schilling's five-needle

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* Extract from an address on *The Development of Electrical Science*, delivered before the Indiana Academy of Sciences, by its President, Prof. Thomas Gray.

telegraph appeared, and he also used a single-needle instrument, but his early death stopped further progress. In 1833 Schilling's telegraph was developed, to some extent, by Gauss and Weber, who used it for experimental purposes. The following quotation, referring to Gauss and Weber's telegraph, from *Poggendorff's Annalen*, is of considerable historical interest:

"There is, in connection with these arrangements, a great, and until now a novel project, for which we are indebted to Professor Weber. This gentleman erected, during the past year, a double-wire line over the houses of the town [Göttingen, Germany], from the Physical Cabinet to the Observatory, and lately a continuation from the latter building to the Magnetic Observatory. Thus an immense galvanic chain is formed, in which the galvanic current (the two multipliers at the ends being included) has to travel a distance of nearly 9,000 Prussian feet [9,270 English feet]. The line wire is mostly of copper, of that known as 'No. 3' [about equivalent to No. 18 of the American Wire Gauge], of which one meter weighs eight grammes. The wire of the multipliers in the Magnetic Observatory is of copper, 'No. 14' [about No. 22, A. W. G.] silvered, and of which one meter weighs 2.6 grammes. This arrangement promises to offer opportunities for a number of interesting experiments. We regard, not without admiration, how a single pair of plates, brought into contact at the farther end, instantaneously communicate a movement to the magnetic bar, which is deflected at once for over a thousand divisions of the scale." Further on in the same article we read : "The ease with which the manipulator has the magnetic needle in his command, by means of the communicator, had a year ago suggested experiments of an application to telegraphic signaling, which, with whole words and even short sentences, completely succeeded. There is no doubt that it would be possible to arrange an uninterrupted telegraphic communication in the same way between two places at a considerable number of miles distance from each other."

The method of producing the currents in Gauss and Weber's experiments was an application of the important discoveries of Faraday and Henry, in the induction of currents by currents and by magnets.

On the recommendation of Gauss, this telegraph was taken up by Steinheil, who, following their example, also used induced currents. The important contributions of Steinheil were the discovery of the earth return circuit, the invention of a telegraphic alphabet, and a recording telegraph. Steinheil contributes an account of his telegraph to Sturgeon's *Annals of Electricity*, in which he compares and discusses the relative merits of eye-reading, ear-reading, and automatically recording receivers, and points out the advantages, which experience has since brought into prominence, of reading by the ear.

Schiller's telegraph was exhibited at a meeting of German naturalists held at Bonn in 1835, and was there seen by Professor Muncke of Heidelberg, who, after his return to Heidelberg, made models of the telegraph and exhibited them in his class-room. These models were seen by Cooke, in the early part of 1836, and gave him the idea of introducing the electric telegraph in England. Cooke afterwards became associated with Wheatstone, and a large number of ingenious arrangements for telegraphing was the result. Many of the later developments by Wheatstone are still in use and are hard to beat.

Steinheil appears to have been anticipated in the idea of making the telegraph self-recording by Morse, who, according to evidence brought forward by himself, thought out some arrangements as early as 1832. Exactly what Morse's first ideas were seems somewhat doubtful, and he did nothing till 1835, when he made a rough model of an electro-magnetic recording telegraph. Morse's mechanical arrangements were of little merit, and his alphabet and method of interpretation by a dictionary were clumsy and inconvenient. The chief point of interest in connection with the early history of the Morse telegraph was the proposal to make use of Sturgeon's discovery of the electro-magnetism of soft iron. Morse, however, seems to have known practically nothing of the subject except that iron could be magnetized by a current, and in consulting his colleague, Dr. Gale, he was unwittingly led to use the discoveries of Henry, who had previously practically solved the whole problem. Much of the subsequent improvement in the mechanical arrangements was due to Vail, who became associated with Morse, and the Morse code as we now know it was almost, if not entirely, worked out by Vail. Considerable dispute and some litigation arose over Morse's claims, but that is outside our present subject. There is no doubt that the electric telegraph was a slow-growth invention, with a view to pecuniary and other advantage, its inventors being ever ready to lay hold of each scientific discovery and try to turn it to account. The question of who first conceived the idea can never be satisfactorily answered.— *Science.*

[Concerning Dr. Alter's connection with the invention of the telegraph, see The Locomotive for May, 1896, page 75.]

Henry Bessemer and Alexander Lyman Holley.

By Samuel Nott, C. E.

The death of Henry Bessemer, on March 14, brings to mind the name of Alexander Lyman Holley, a son of Connecticut, who died on January 29, 1882, distinguished, with Bessemer, in connection with the marvelous improvements, made within the last forty years, in the manufacture of steel.

A valuable article on the "Iron and Steel Industries of Troy," printed in the Troy, N. Y., *Daily Times* for July 3, 1879, gives a very good general idea of the improvements made by Bessemer and Holley in steel production. "In 1855," it says, "Henry Bessemer of London solved the metallurgic problem that had long vexed the minds of certain men, regarding the manufacture of steel. He knew that pig iron contains iron and much carbon, while steel consists of iron and but little carbon. His practical mind turned to the discovery of a process by which to entirely eliminate the carbon of the pig iron, and then to add to the pure iron so obtained the precise quantity of carbon that would be required to form steel. In this undertaking he expended his fortune, and the added money of his supporting friends. His experiments resulted in bitter disappointments and expensive failures." Further on, the article adds, "Nevertheless, Henry Bessemer gave to the world a process to convert iron into steel, that has not yet been surpassed." It then goes on to show the important part played by Mr. Holley in steel making at Troy, and gives some account of the building of the two-and-a-half-ton experimental Bessemer plant, which was followed, in 1867, by a five-ton plant. "Like all enterprising Americans," it continues, "A. L. Holley, after experimenting with the methods and appliances adopted in England, soon began making additions and improvements in the Bessemer plant, and it is no doubt due to him to say, that his inventions and modifications have enabled American manufacturers of steel to excel those of other countries, in producing a larger amount of steel in a working day."

The labors of these two men, Bessemer in England and Holley in America, have reduced the cost of steel rails and all other steel materials to about one-eighth of their former cost per ton.

The *Hartford Times* of October 2, 1890, contained an account of the unveiling, on that day, of the bronze bust of Mr. Holley in Washington Square, New York. We quote from this article as follows: "There was unveiled this afternoon in Washington Square, under the auspices of the American Institute of Mining Engineers and the British Iron and Steel Institute (now in session in Chickering Hall), the striking colossal bronze bust of the late Alexander L. Holley, who was the second president of the former organization. Mr. Holley, who died in Brooklyn, eight years ago, was a distinguished metallurgist and engineer, and was born in Connecticut, of which state his father was Governor in 1857–58. Mr. Holley edited and conducted railway magazines for many years. In 1857, he went abroad to study railway practice, with a view of reporting at home what he saw. He wrote, on his return, hundreds of newspaper articles on railroads, and published his *American and European Railway Practice.* In 1862 he was sent abroad by Edwin A. Stevens to study the subject of ordnance and armor, which resulted in a treatise on the subject. He purchased the American rights of the Bessemer patents, and put up the first plant at Troy, N. Y. The bust of Mr. Holley and its elegantly ornate Greek pedestal of sand-finished Indiana limestone cost some $10,000, and was erected by the contributions from engineers of both hemispheres. The bust is excellent as a portrait." The inscription on the front of the pedestal is in raised letters, and reads as follows:

HOLLEY.

Born in Lakeville, Conn., July 20, 1832.
Died in Brooklyn, N. Y., January 29, 1882.

In Honor of

Alexander Lyman Holley

Foremost among those
Whose Genius and Energy
Established in America
And Improved Throughout the World
The Manufacture of Bessemer Steel,
This Memorial is Erected
By Engineers
Of Two Hemispheres.

Mr. Holley was present, in one of his later years, at a meeting of a professional society in which he was interested, in Pittsburgh, Pa. His friends presented him with a handsome testimonial of their esteem, and in reply he made a memorable extemporaneous speech, of which these were the closing words: "Among all of us who are working hard in our noble profession and keeping the fires of metallurgy aglow, such occasions as this should also kindle a flame of good fellowship and affection which will burn to the end. Burn to the end! Perhaps some of us should think of that, who are burning the candle at both ends. Ah! well, may it so happen to us, that when at last this vital spark is oxidized, when this combustible has put on incombustibility, when this living fire flutters thin and pale at the lips, some kindly hand may turn us down, not underblown — and by all means not overblown; — some loving hand may turn us down, that we may perhaps be cast in a better mold."

A New Use for Ants.

Prof. Lafayette Bernard has returned from Florida with some artistically mounted snake skeletons and lots of stories about ants. His attention was first attracted toward ants by the discovery that they could be useful to him in his capacity as a collector of specimens. He had lamented the want of some method of preparing the skeletons of small animals for his private museum without wasting time that might be devoted to field work. One day while roaming in the pine woods of Florida he killed a fox squirrel, and as his specimen box was full he left the animal on the ground, intending to return for it later in the day. When he got back the flesh of the squirrel was gone, but a well-cleaned skeleton remained. A million ants scurried away as he approached, and he found that the little creatures had done his work for him. This labor-saving hint was not lost on him, and to the idea he put into execution are due the wonderful specimens of skeleton mounting for which he is noted.

As one enters the Professor's little museum one sees the skeleton of a rattlesnake coiled in the position assumed just before springing, the fangs protruding, the rattles slightly raised from the ground, as if sounding their alarm. This specimen is said to be the first ever mounted in the natural coil, the bony structure still held together by the real cartilage. Again, one sees the skeleton of a black snake coiled about the trunk of a small sapling, or that of a squirrel crouching on the limb of a tree, as if trying to shield itself from the eye of the sportsman, or that of a rabbit sitting on its haunches. Had it not been for Mr. Bernard's little friends, the ants, these groupings would have been impossible. The method is simple enough, when one knows how to apply it. The Professor's plan is to kill his specimen, bind it with wire in the position in which he wishes the skeleton to remain, and then place it near a group of ant-hills. The voracious insects do the rest. The operation requires careful watching, else the entomological dissectors might devour the cartilage that holds the bones together, as well as the flesh. At the proper moment the Professor removes the specimen from the region of the ant hills, applies a preservative and hardening chemical to the cartilage, and when the bones have set removes the binding wires.

The innumerable ant hills that infest the neighborhood of De Land, Fla., were the scene of many experiments. It is well known that certain species of ants keep slaves that labor for the good of the commonwealth; that they even have their milch cows, a species of the aphis or tree louse. Prof. Bernard wanted to learn the relations the slaves bear to their masters, the method of enslaving, whether slavery among ants demoralizes the will and degrades the spirit as it does among men, and he set himself at work to find out all these things. One day he stood over a community composed of black ants, which were working industriously away polishing off the bones of a quail which some sportsman had shot and failed to find in the long wire grass. Suddenly, he observed a dozen red ants, smaller than the black ones. They seemed to be some kind of advance guard, for after reconnoitering the black ant hill they scurried away to their own community, about 100 yards distant. The Professor followed and was rewarded by seeing a wonderful sight. The advance guard stopped every few minutes, apparently consulting squads of their fellows who were out foraging for food. The squads stopped in their tracks while the advance guard went on home and entered their hill. The sandy cone became alive. From all points red ants poured out and hurried to the black ant hill, the squads that had stopped when encountered by the advance guard joining the ranks of the invaders. As the army pushed forward the right and left (wings advanced ahead of the main column, the whole body forming the concave side of a crescent.

The horns of the crescent gradually closed, moved toward each other, until the enemy's camp was reached, when the crescent became a circle and the camp was surrounded. Then followed a battle. Hundreds of dead ants strewed the ground, red and black engaging in deadly combat. The red were superior in numbers and finally vanquished the black, looted their stores, and compelled their prisoners to bear the stolen goods to the city of their conquerors. Twelve fat and sleek aphides were part of the booty that rewarded the prowess of the victors.

On another occasion Prof. Bernard dropped a dozen red ants among a colony of black ones and the intruders were promptly killed. He placed a few black ones in a colony of red ants and the new arrivals were promptly surrounded, marched out of the camp, compelled to load themselves with food and then were brought back enslaved. The black ants seem to have no propensity for making slaves of their enemies, but prefer to kill them, while the red ants never waste an enemy by destroying him. Although slaveholders, they are never idle, Prof. Bernard says. They keep slaves to increase their own store of food, but they themselves work as hard as the slaves.—*N. Y. Sun.*

The Unexpected, Which Often Happens.

Professor John E. Sweet delivered an address on this subject before the American Society of Mechanical Engineers some ten or twelve years ago. It was full of suggestiveness, and as it is as timely to-day as it was when it was first read, we reproduce it, in part, below:

"If we had no experience or knowledge, or no knowledge of the experience of others, everything which happens would be unexpected. It is not so much the unexplainable as the unexpected which attracts our attention, excites our astonishment, or disturbs our mental equilibrium. The man who devotes his life to experimenting with practical mechanics, is sure to meet with the unexpected, or else to be too wise for his generation. Some of us do not care to admit that we were ever caught with the unexpected, but I beg to expose a few of the many things that have come upon me unexpectedly, in the belief that they may be of use to others, and in the hope that others will explain their experiences, so that we may profit in return.

"Things perfectly familiar to mechanics engaged in one branch of industry, are often matters of great wonder to workers in another branch. Men may work a lifetime in cast-iron as applied to tools and machinery, and yet know nothing of what it will do in the heating stove of a blast furnace. To such a man the discovery that cast-iron heating pipes grow from six inches to a foot in length by use would be unexpected. To tell the blast-furnace man that certain core bars, used for casting pipes, changed their length by three inches in casting twenty or thirty pieces, would be no surprise, until you supplemented the statement with the fact, strange to him, that they grew *shorter*, rather than longer.

"The unexpected sometimes comes from causes that are perfectly self-evident after the thing has happened (as was the case in my experience by the clogging of a nail machine by the scale from the nail plate), and at other times from causes utterly unexplainable, or from causes which are difficult to fathom. In practice, we use with a fair degree of success, for a piston rod packing, simply an easy fitting Babbitt bushing. When these bushes become worn so as to leak, we close them up by compressing them in the water cylinder of a sort of hydraulic press. In this operation a mandrel somewhat smaller than the piston rod is put inside, and with all the pressure we can bring to bear, we have never been able to compress the bush so as to make it grasp the mandrel tightly, and yet in two or three cases, or, perhaps, in half a dozen, we have had these bushes (one of them after running a year) shut down while the engine was running, so as to grasp the piston rod as if it were gripped in a vice — in fact, so strongly as to break the bushes asunder, or so that we had to destroy them to get them off.

"The unexpected comes upon us both by things not working when we think they ought, and by their working when common reasoning would indicate that they ought not. The man who first invented or constructed a lawn-mower must have been considered an idiot, or at least a man not familiar with the common laws of mechanics, to have imagined that he could, with two light wheels, get traction enough to rotate a cylinder of six times their own weight, at six times their own velocity, and cut the grass in addition. The worm that drives the bed of a Sellers' planer does not wear out half so fast as it ought, and I fancy there is something unexpected about it, even to the makers themselves.

"An engine with a 12″ × 18″ cylinder had been running a year at 185 revolutions a minute, standing quietly on a cut stone foundation. One day, without any apparent cause, it began to shake endwise, and before night had shaken itself loose so that it had a movement of three-sixteenths of an inch at every turn. The engine being self-contained, no harm came to it, except the loosening of the foundation, and, as the work was of more consequence than the foundation, it was allowed to go on with a view to repairing it at vacation time, a month ahead. But before vacation time came the shaking stopped without any more apparent cause for its stopping than for its beginning, and the engine continues to run quietly, to this day, notwithstanding the shattered foundation.

"The unexpected often happens to the scientist as well as to the practical man, and this must have been the case with Crookes, when he invented the radiometer. The story goes that he first invented the thing, and then made it; but it turned out, as tradition says the ship did, when some genius blew into the sails with a bellows. *It went the wrong way.* We laugh at the stupidity of the man with the bellows, and the next generation may laugh at Crookes.

"An engineer put in charge of our electric light station found them using oil of 26 gravity for lubricating the engines and dynamos. Even when the oil was used freely, the bearings would warm up, and sometimes get hot. It was the practice to increase the quantity of oil as the journals got warmer, and to turn on water when oil would do no longer. To the engineer's surprise, he discovered, one night, that one of the bearings kept cool; and he noticed also that the oil-cup was feeding only about one-quarter as fast as had been the practice. The happy idea of 'letting well enough alone' occurred to him, and he found that the bearing continued to run cool; and by experimenting he proved that by feeding little enough oil he could make the other bearings run cool, also.

"For casting a chilled die, to be used under a drop hammer, old chilled car wheels were used, to which fourteen per cent. of spiegelsen was added with the expectation that a good chill would be produced, as this had been our previous experience. The *first* surprise was to find that the die showed no evidence of chill whatever, but that it could be filed easily. Some pieces of work were required at once, and the die was put in with the expectation that it would serve only for a short time; but the *second* surprise came when its endurance proved to exceed the best of the chilled dies in the proportion of two to one.

"A large percentage of the unexpected comes in the development of original inventions. When these are in the experimental stages it is easy to brand the inventors fools or lunatics; but when predicted failures succeed, it is also easy to forget that we ever expected anything else. It is not always the ignorant who are wrong, or the best informed who are never in error. If ten [now twenty] years ago the possibility of conversing with people fifty miles away had been publicly suggested, it would have been accepted only by the ignorant, who, remembering the marvels that have been accomplished, would, in their blind faith, admit of its possibility, while the best informed would have been staggered at the thought. Less than ten [twenty] years have now rolled away, and it is an every-day occurrence.

"It is not always the uneducated, the insane, or the stupid who produce failures, nor the best educated, most thoughtful, or most experienced who bring out everything according to the original intention. The unexpected comes to the good and bad alike, and so, in our teachings to the young and our planning for ourselves, is it not well to have our statements and our speculations pretty well saturated with the elements of uncertainty ?

"It is an old and common custom to use the statement that 'two and two are four' as an example of the certainty of certainties, and another, that 'like causes produce like effects'; while as a simple matter of statement, the first can easily be shown to be twenty-five per cent. off, and the latter to hold along all the way from like results to results diametrically opposite."

A Problem in Mute Lovemaking. — Paul Miliken, who is quite an expert in the language of deaf mutes, says that one morning last week he was coming down on the Avondale car, when he became interested in a discussion between two mutes.

"Say, I want your advice," said one of them, using his hands as vocal organs. "I shall be happy to oblige you," said the other.

"Are you up on the tricks of women ?" inquired the first one. The second man modestly admitted that he knew something of the gentler sex, although he disclaimed being an oracle.

"Well," resumed the one who wanted advice, "you know, I am in love with Mabel. That pretty little blonde, you know. At last I made up my mind to propose to her. Last night I made the attempt." "And she turned you down !" eagerly inquired his friend, his hands trembling so with excitement that he stuttered badly.

"That is what I am coming to," said the first. "I don't know whether she did or not. You see, I was somewhat embarrassed, and the words seemed to stick on my hands. And there she sat, as demure as a dove. Finally my fingers clove together, and I could not say a word. Then Mabel got up and turned the gas down." "Well?"

"Well, what is bothering me is this. Did she do that to encourage me and relieve my embarrassment, or did she do it so we could not see to talk in the dark, and so stop my proposal !" — *Cincinnati Enquirer.*

Incorporated 1866.

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The Locomotive.

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Test of an Experimental Boiler.

There has been some difference of opinion among engineers concerning the strength of the water legs of upright, internally fired boilers, the main question being, whether the action of the stay-bolting is, or is not, substantially the same as it is in a *flat* water leg. In former years, when vertical boilers were all comparatively small, this question was not of so much import; but when the sizes were increased so that the water legs were six or eight feet in diameter, the problem became much more serious.

The mathematical discussion of a structure such as a curved water leg is somewhat involved, and the methods of calculation are not suited for publication in THE LOCOMOTIVE. In our issue for March, 1892, however, we published the general results of such an investigation, in which we found that for water legs that actually occur in practice, the following conclusions are true: (1) The stresses in the plates of a curved water leg are never *greatly* different (at the usual working pressures) from those that prevail in a similarly designed *flat* stayed surface; (2) The curved form of the leg does, however, cause the tension on the outer sheet to be somewhat greater than it would be in a flat leg; (3) The stress on the inner sheet is never a compression, but always a *tension*; (4) This tension on the inner sheet will differ (usually by a small amount) from the tension on a similar *flat* stay-bolted sheet, being sometimes greater and sometimes less, according to the design and proportions of the water leg; and (5), The curvature of the leg causes the stress on the stay-bolts to be somewhat *less* than it would be

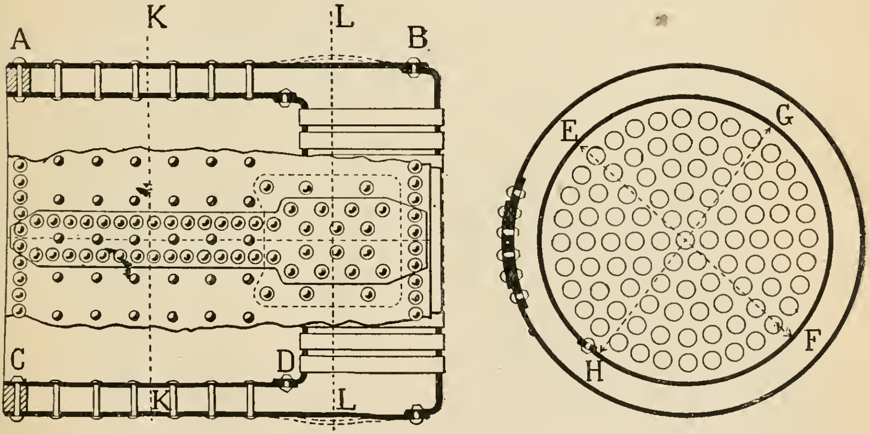

FIG. 1.— SHOWING THE CONSTRUCTION OF THE EXPERIMENTAL BOILER.

on a similar flat leg. Formulæ were given for calculating the effect of the curvature of the plates, both upon the shell tensions, and upon the stay-bolt tension; and it was concluded that within the range of pressures and proportions that are met with in practice, "the strains in a curved stay-bolted structure are not materially different from those in flat surfaces, similarly designed."

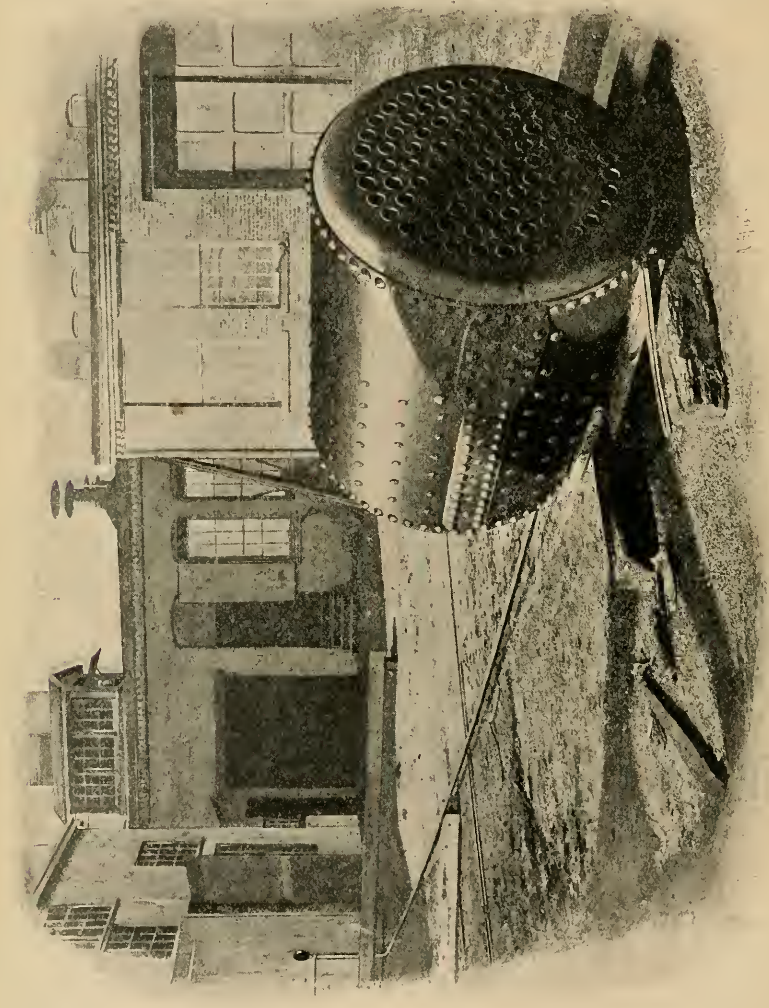

Fig. 2.—Showing the Boiler, Supply Pipe, and Pressure Gauge.

If this general conclusion were correct, it is evident that the shell joints of the water leg would be amply strong if they were simply double riveted, or even if they were single riveted, *provided* they were carefully designed and constructed. Our experience has shown, however, that in boiler practice it is not always safe to trust too implicitly in the indications of an abstract mathematical formula, no matter how carefully that formula may have been prepared. This is particularly true when the structure under consideration is at all complicated ; for it cannot be denied that the actual iron and steel of the shop are different things from the fictitious materials whose properties we assume in our mathematical equations. So far as we are aware, no actual *tests* have heretofore been made upon curved water legs ; and in the absence of such tests, we have frequently insisted upon triple-riveted butt joints being used for the outside shell, in cases where large boilers are to carry heavy pressures. The Bigelow Company, of New Haven, Conn., has taken a special interest in this matter, owing to the fact that it is difficult, when using a triple-riveted butt joint, to space the stay-bolts properly, in the vicinity of the joint. This difficulty is a very real and serious one, as all boiler makers and designers are aware. If the attempt is made to space the stay-bolts along a triple-riveted butt joint precisely as they are spaced along the rest of the water leg, it will be found that even with the most ingenious arrangement, it is not possible to prevent the stay-bolts and rivets from coming too closely together, in many places. To obviate this difficulty, it is common to make some of the stay-bolts fulfil the functions both of stay-bolts and of rivets; but this almost invariably requires the pitch of the stay-bolts to be modified along the joint. An example of this kind, taken from actual practice, is shown in Fig. 7, where the stay-bolts are shown with black centers. We have long been sensible of the desirability of an experimental investigation into this matter, and about three months ago President J. M. Allen, of the Hartford Steam Boiler Inspection and Insurance Company, and Mr. Geo. S. Barnum, Treasurer of the Bigelow Company, held a conference at Hartford, and arranged for a careful test of this kind, to be carried out at the works of the Bigelow Company, at New Haven. An

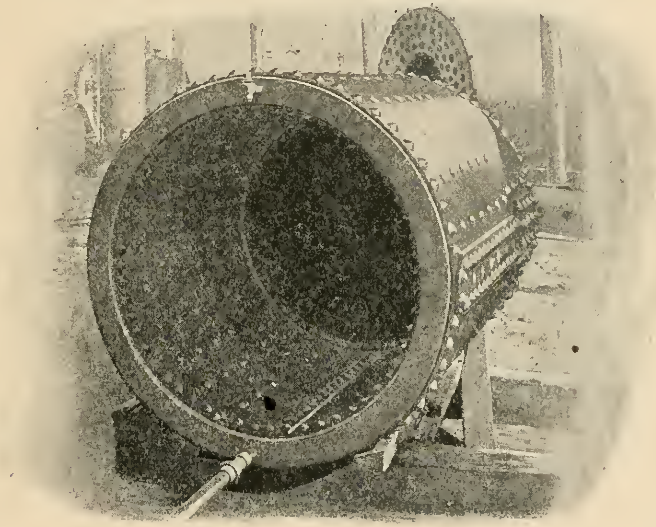

Fig. 3.—Showing the Furnace End of the Boiler.

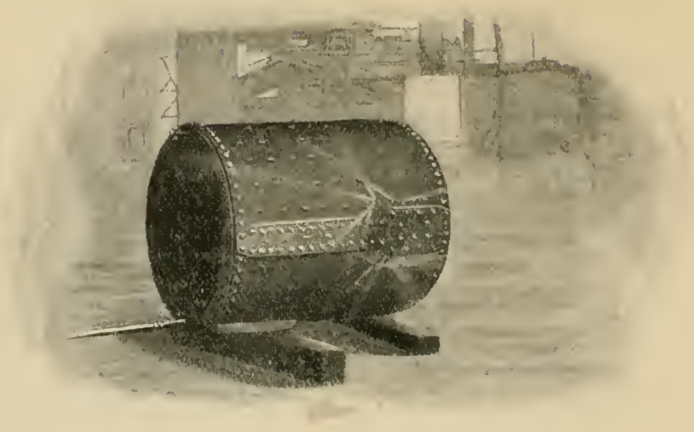

FIG. 4. — SHOWING THE FIRST LEAKS.

experimental boiler was then built by the Bigelow Company, and the test was made on February 26, 1898.

The boiler that was tested is shown in the accompanying engravings. Its general dimensions were as follows :

Shell plate, Park Bros. fire-box steel,	$\frac{7}{16}''$ thick.
Furnace plate, Worth Bros. fire-box steel,	$\frac{3}{8}''$ "
Upper head, Lukens fire-box steel,	$\frac{1}{2}''$ "
Lower head, Park Bros. flange steel,	$\frac{1}{2}''$ "
Bottom ring, forged wrought-iron,	$2\frac{3}{4}''$
Length between girth seams (*A* to *B* in Fig. 1),	$48\frac{1}{2}''$
Diameter outside of shell,	$42\frac{5}{8}''$
Length of fire-box between rivets (*C* to *D* in Fig. 1),	$33\frac{1}{4}''$
Internal diameter of furnace, right angles to joint (*EF*),	$35\frac{7}{16}''$
Internal diameter of furnace, close to joint, outside lap (*GH*).	$35\frac{5}{8}''$
Number of tubes,	93
Diameter of tubes,	2″
Length of tubes,	$15\frac{1}{4}''$
Circumference of shell at *KK* before test,	11′ 4.80″
Circumference of shell at *LL* before test,	11′ 4.81″

The stay-bolts were pitched $4\frac{3}{4}''$ from center to center, circumferentially, and $4\frac{11}{16}''$ lengthwise of the boiler. They were cut from stock $1\frac{1}{8}''$ in diameter, and were threaded with ten threads to the inch. The diameter of each stay-bolt at the bottom of the thread was therefore about $\frac{61}{64}''$, or 0.953″. The joint in the furnace sheet was lapped. and single riveted with $\frac{3}{4}$-inch rivets, pitched $1\frac{15}{16}''$ from center to center, the rivet holes being $\frac{13}{16}''$ in diameter. The joint on the shell plate is shown clearly in Fig. 1, The ends of the sheet were butted together, and each was secured to an outside strap, $\frac{7}{16}''$ thick and 7″ wide, by means of a single row of rivets, which were pitched $2\frac{3}{8}''$ apart, and driven in holes that were $\frac{29}{32}''$ in diameter. Beyond the stay-bolted part of the shell, the outer strap was increased in width, and an inner strap, $\frac{3}{8}''$ thick (shown dotted in Fig. 1) was added. A triple-riveted butt strap joint was then put in at this part,

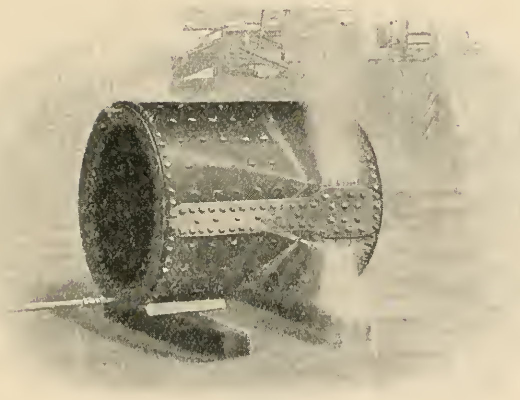

FIG. 5. — LEAKAGE AT THE TRIPLE RIVETED JOINT.

the pitches being $3\frac{3}{8}''$ and $6\frac{3}{4}''$, while the holes were $\frac{29}{32}''$ in diameter, as before. Owing to the short space allotted to the triple-riveted section of the joint, there was only one full space of $6\frac{3}{4}''$ on the outside row of rivets, the pitch between the two outside rivets nearest the furnace end of the boiler being reduced of necessity to $4\frac{3}{4}''$, as indicated in the engravings. One row of stay-bolts, it will be seen, was tapped into the covering strap, passing through holes drilled in the abutting edges of the outside sheet.

The boiler was supplied with water from a powerful hydraulic apparatus, through

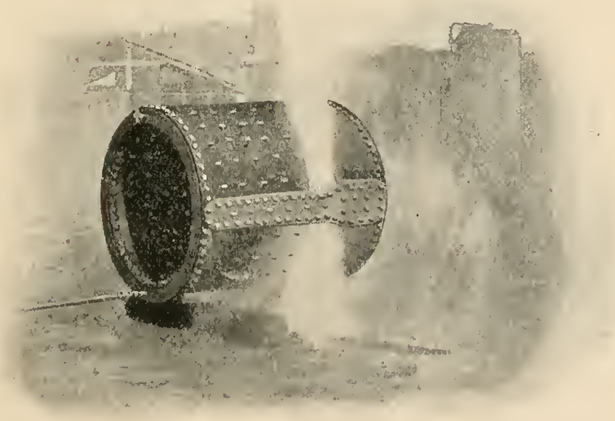

FIG. 6. — LEAKAGE AT THE END OF THE TEST.

50 feet of 1¼-inch pipe, which entered the wrought-iron ring at the bottom of the furnace, as may be seen in the engravings. Just as it entered the boiler, the pipe was reduced to ½ inch, in order that the ring might not be materially weakened. The pressure gauge was near the pump; it is shown in the background in Fig. 2.

When the test began, nothing was noted until the pressure exceeded 800 pounds to the square inch. Between this pressure and 1,000 pounds, the shell began to show signs of distress, and the triple-riveted butt joint began to leak. The appearance of the boiler at this stage is shown in Fig. 4. The rise of pressure was so rapid between 800 and 1,000 pounds that it was impossible to say at precisely what point the distortion and leakage began. The pressure was maintained at 1,000 pounds while the boiler was examined. The shell had bulged at the section *LL* around the entire circle of the boiler except at the joint, where the straps had sufficient stiffness to prevent serious distortion. The circumference at this point was now 11′ 7.22″, or 2.41″ greater than the original

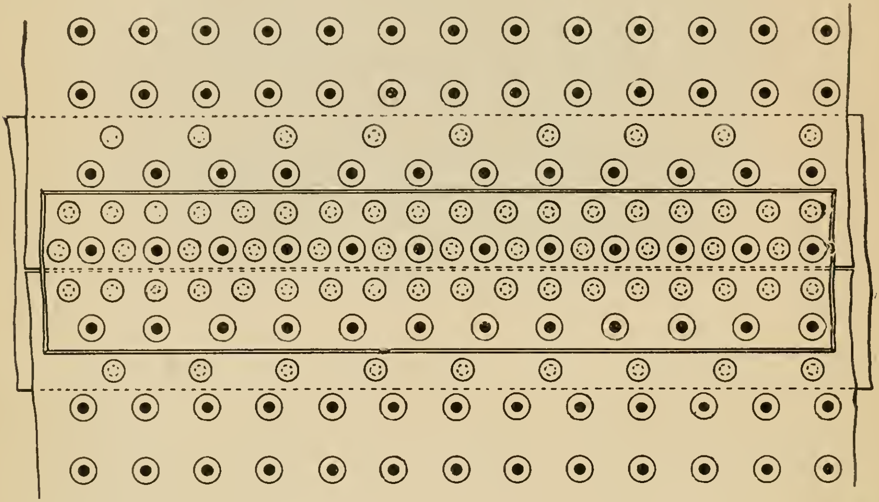

FIG. 7.—A TRIPLE-RIVETED JOINT, WITH STAY-BOLTS.

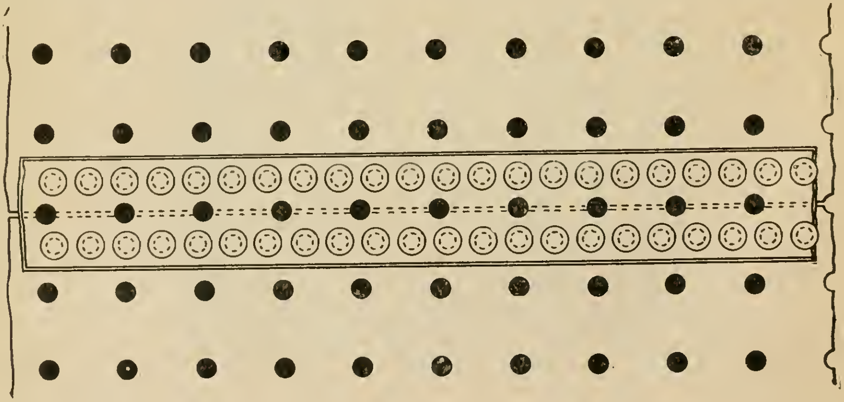

FIG. 8.—STYLE OF JOINT ADOPTED IN THE BIGELOW BOILER.

measure. It was noted that about one-half of this extension occurred while the pressure was stationary, and the measuring tape was in position. The circumference was also taken at *KK*, and found to have identically the same value as at the beginning of the test. No leakage was observed, except along the triple-riveted butt joint.

The pressure was then raised until the gauge showed 1,100 pounds per square inch, though the leakage had meanwhile become so serious that it is doubtful if there was any actual increase in the pressure in the boiler. The circumference at *KK* still remained unchanged, but that at *LL* showed a further increase to 11′ 7.72″. The appearance of the boiler at this time was again photographed, and is represented in Fig. 5. The triple-riveted butt joint was leaking badly at several of the rivets and along the outer strap, so that the pressure could not be longer maintained with any approach to steadiness. The pump was therefore stopped and the pressure removed, and the leaks were thoroughly calked. The pressure was then run up once more, till the gauge read 1,250 pounds. Leakage began again at about 1,000 pounds, and at 1,250 pounds it was so severe that the pressure could not be increased, even with the pump running at full capacity. At this point the shell still showed the same circumference at *KK*, but at *LL* it had stretched further, to 11′ 9.00″, recovering, after the release of the pressure, to a permanent value of 11′ 8.50″. The photograph shown in Fig. 6 was then taken, and the test was discontinued.

No severe leakage was noted either at the tube ends, nor along the furnace seam, either inside or outside, during the test. The furnace sheet had bulged slightly between the staybolts, so as to take a permanent set, in the center of each square, of about $\frac{1}{16}$″.

Allowing 85 per cent. as the efficiency of the triple-riveted butt joint, the calculated bursting pressure of the bulged part of the shell may be shown, by the usual rule, to be about 1,050 pounds per square inch. It is doubtful if the actual pressure in the boiler exceeded this value by any considerable amount, on account of the severe leakage which occurred when the gauge pressure was 1,200 pounds or so. The triple-riveted section was so short, too, that it was undoubtedly stiffened and sustained, to an appreciable extent, by the upper head at one end, and by the stay-bolting at the other. The stress on the stay-bolts, per square inch of sectional area at the base of the threads, was about 31,200 pounds when the test pressure was 1,000 pounds per square inch, when reckoned in the usual way — that is, by treating the curved leg as though it were flat. The formula in the issue of The Locomotive for March, 1892, gives about 28,000 pounds as the actual stress per square inch of sectional area under these conditions, when the curvature of the leg is taken fully into account.

The general conclusion to be drawn from this experiment, we think, is that our mathematical analysis, whose results were printed in the issue just quoted, was in substantial agreement with the actual facts; and that it is not necessary, except, perhaps, in special cases, to provide a triple-riveted butt joint on the outer sheet of a curved and properly stay-bolted water leg.

Fly-wheel Accident. — On January 13th, a small fly-wheel burst in J. S. Hunt's sawmill at Athol, Mass., while the engine was running at full speed. A portion of the wheel crashed into the boiler, causing a terrific explosion. Mr. Hunt, who was standing near, a distance of twenty feet, fortunately escaped with a few bruises. Another part of the wheel flew up through the roof, tearing out a large hole and cutting the heavy timbers like a knife. The engine was a complete wreck, but as none of the employes were near the machinery at the time, Mr. Hunt was the only man injured.

The Locomotive.

HARTFORD, MAY 15, 1898.

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

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

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

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

A man named J. H. Bess (or Best), who is believed to have lived in Rock street, Indianapolis, Ind., is said to have been killed, about ten years ago, in a boiler explosion. If any of our readers have definite knowledge of Mr. Bess, they will confer a great favor on his friends by notifying Rev. Geo. W. Grube, 2917 Vine street, Kansas City, Mo.

Steam Boiler Insurance.

Formerly there was a chance to argue the case as to whether it was desirable to have a steam boiler inspected and insured by a company doing this kind of business, or to let the state or city inspector examine it and then run it according to his recommendation; but the former plan possesses so many advantages that any comparison of the two must result in its favor. An idea prevails in some quarters, however, that so long as a boiler is insured by a company doing that kind of business, it matters but little what company it is or how its business is conducted, provided it has sufficient capital to meet its obligations. Now, we are firmly convinced that the first business of the company that takes risks on a steam boiler, is to prevent that boiler from exploding ; and its second obligation is to pay the loss, if it does explode after all ordinary precautions have been taken for its safety. Viewing the matter from this standpoint, it becomes plain that the company that possesses the best equipment for preventing the evil, as well as the ability to cure it when it does come (so far as money will effect a cure), is more worthy of patronage than some other company which only possesses the ability to pay the damage after it is done. Furthermore, it is only reasonable to suppose, and investigation shows the truth of the supposition, that a company that devotes its whole energies to steam boiler insurance, will give the matter more attention than another company will, which make the steam boiler part of its business only a side issue. The latter may have issued policies on the building comprising a plant, while the boiler or boilers may be insured by another company, or perhaps not be protected at all until some day, when the policies are to be renewed, or some change is to be made, it is suggested by someone that the boilers be included in the new deal, and so the thing is done, the same as another building would be added to the list, or the chimney insured against damage by an earthquake. Such insurance is far from being what it should be, and what its patrons have a right to expect when they pay their money and take their choice.

It is true that such a company may go through the form of inspecting the boilers, but who does the inspecting ? Is it a qualified inspector, appointed to the position because he has had a term of experience that eminently fits him for the place ? Or is it someone who has brought himself to the front in other ways, and makes the duties of a boiler inspector but a side issue to which he gives little or no attention, except to occasionally view a boiler and make his charge for the same? The company that insures boilers exclusively has a corps of trained inspectors who devote their whole time to this line of work, and from long practice become very efficient in it. They profit not only by their own experience, but by constantly comparing notes with their associates, so that a large fund of information is at their disposal at all times. Furthermore, such a company will have a laboratory where waters that give trouble by causing corrosion, or producing excessive deposits of scale and sediment, may be analyzed, and proper remedies applied. They will have facilities for making tests of iron and steel used in boiler work for the benefit of their patrons, and they will investigate causes of disasters when they do come, in order that the knowledge so gained may be applied in preventing similar catastrophes in other places.

It is an old saying that to be a Jack-of-all-trades is to be a master of none; and this axiom applies in boiler insurance with exceeding patness.— W. H. Wakeman, in *American Engineering.*

Boiler Explosions during 1897.

We present, in the accompanying table, a summary of the boiler explosions that occurred in the United States during the year 1897, together with the number of persons killed and injured by them.

It is difficult to make out accurate lists of explosions, because the accounts of them that we receive are often unsatisfactory. We have spared no pains, however, to make this summary as nearly correct as possible. In making out the monthly lists from which it is extracted (and which are published from month to month in The Locomotive) it is our custom to obtain a large number of accounts of each explosion, and to compare these different accounts diligently, in order that the general facts may be stated with some considerable degree of accuracy. It may be well to add, too, that this

Summary of Boiler Explosions for 1897.

MONTH.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January, ...	27	25	27	52
February, ...	31	24	59	83
March, ...	24	28	29	57
April, ...	16	10	28	38
May, ...	28	32	43	75
June, ...	25	43	23	66
July, ...	31	42	64	106
August, ...	37	63	51	114
September, ...	40	41	48	89
October, ...	27	21	54	75
November, ...	32	31	48	79
December, ...	51	38	54	92
Totals, ...	369	398	528	926

summary does not pretend to include *all* the explosions of 1897. 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 1897 was 369, against 346 in 1896, 355 in 1895, and 361 in 1894. 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 1897 was 398, against 382 in 1896, 374 in 1895, and 331 in 1894, and the number of persons injured (but not killed) in 1897 was 528, against 529 in 1896, 519 in 1895, and 472 in 1894.

It will be seen from these figures that during the year just elapsed there was, on an average, over one boiler explosion a day. The figures in the table show that the average of the deaths and injuries during 1897, when compared with the number of explosions, was as follows: The number of persons killed per explosion was 1.08; the number of persons injured (but not killed), per explosion, was 1.43; and the total number of killed *and* injured, per explosion, was 2.51.

The year of 1897 was not marked by any single explosion comparable with those of the Gumry Hotel at Denver, and the Detroit *Evening Journal*, which we recorded two years ago; but the total number of explosions, and the number of persons killed, was greater than ever, and while we have no means of knowing the total property loss, we believe that the list published each month in The Locomotive indicates that it was at least as great as it has been during the past few years.

Inspectors' Report.

March, 1898.

During this month our inspectors made 10,208 inspection trips, visited 19,297 boilers, inspected 6,369 both internally and externally, and subjected 955 to hydrostatic pressure. The whole number of defects reported reached 12,539, of which 945 were considered dangerous; 53 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	905	46
Cases of incrustation and scale,	2,263	61
Cases of internal grooving,	93	3
Cases of internal corrosion,	647	37
Cases of external corrosion,	537	39
Broken and loose braces and stays,	975	68
Settings defective,	259	18
Furnaces out of shape,	344	12
Fractured plates,	254	45
Burned plates,	248	25
Blistered plates,	171	6
Cases of defective riveting,	2,150	90
Defective heads,	116	21
Serious leakage around tube ends,	2,056	232

Nature of Defects.	Whole Number.	Dangerous.
Serious leakage at seams,	442	26
Defective water-gauges,	218	36
Defective blow-offs,	189	44
Cases of deficiency of water,	22	19
Safety-valves overloaded,	66	32
Safety-valves defective in construction,	74	24
Pressure-gauges defective,	464	59
Boilers without pressure-gauges,	0	0
Unclassified defects,	46	2
Total,	12,539	945

Boiler Explosions.

March, 1898.

(53.) — The boiler of shifting engine No. 18, of the Boston & Albany railroad, exploded, on March 1st, at North Brighton, Mass., while delivering its freight in front of A. Brackett's coal wharf. Fireman E. E. Harding was hurled from the cab, and received severe internal injuries. Engineer F. B. Sanborn was not in the cab at the time. The explosion consisted in the tearing away of the middle third of the barrel of the boiler.

(54.) — On March 1st a boiler exploded in Clark & Acker's shingle mill at Munising, Mich. Hugh Long and Peter Morris were killed, and Ellory Fisk, Peter Brix, Hiram Zanzt, and George Moore were more or less severely injured. It is thought that Zanzt will die, as he was injured internally.

(55.) — A boiler exploded, on March 2d, in S. D. Roberts' mill on South Mulberry street, Mt. Vernon, Ohio. William Mayberry was fatally injured, and Elmer Finerty, D. Medcalf, and J. C. Roberts were scalded and bruised. The boiler was thrown to a distance of about 200 feet, passing through several buildings in its course.

(56.) — On March 2d a boiler exploded at the No. 2 mine of the Cambria Coal Mining Company, at Cambria, Wyo. Engineer Kirkwood and machinists Bleschsmith and Robinson were standing on the boiler at the time, examining the safety-valve. Robinson was severely scalded, and was also bruised by flying debris. The other men were not seriously injured.

(57.) — A boiler exploded, on March 3d, in Andrew Bohn's sawmill, at New Vernon, Mercer county, Pa. Nicholas Trout and J. C. Bohn were badly hurt, and the mill was demolished.

(58.) — On March 3d the dome blew off of a heating boiler in the City and County Hospital, at San Francisco, Cal. The engineer and fireman were in the boiler-room at the time, but they escaped injury.

(59.) — A boiler explosion occurred, on March 4th, in T. M. Williams' tobacco prizing plant near Holmansville, Robertson county, Tenn. James Bethune was fatally injured, and W. H. Holt and Linus Gaines were badly scalded and burned.

(60.) — On March 7th a boiler exploded in a paper mill at Tippecanoe, near Troy, Ohio. The walls of the engine and boiler-room were blown down, but nobody was injured, as all of the workmen were out of the way of danger at the time.

(61.) — A boiler exploded, on March 8th, in Samuel Grill's sawmill at Spencerville, near Auburn, Ind. Fireman Lee Paterson was fatally injured, and the mill was totally wrecked.

(62.) — On March 10th a boiler exploded in Edward Brophey's sawmill on Cumberland mountain, at Whitwell, near South Pittsburg, Tenn. Engineer Joseph Griffith was killed, and Mr. Brophey, the proprietor, was seriously injured. The mill was totally destroyed.

(63.) — On March 11th a boiler exploded at Ira Cottle's orchard, at "The Willows," near San Jose, Cal. Engineer Elijah Ballard injured so seriously that he may die.

(64.) — Engineer Henry Porter was killed, on March 14th, by the explosion of a boiler in the Lehigh Milling Company's plant at Lehigh, I. T. The mill, which was owned by Messrs. Cooke & Notholf, was totally wrecked. Mr. Cooke was the only person in it at the time, besides the dead engineer, and it is considered marvelous that he escaped without injury.

(65.) — Mr. E. J. Baird, a fruit grower living three miles north of Woodland, Cal., was instantly killed, on March 16th, by a boiler explosion. John Martin was also badly injured.

(66.) — A boiler belonging to Mr. P. M. Boston, of Miami Station, near Carrollton, Mo., exploded on March 16th. Engineer William Ruckner was injured, and the building in which the boiler stood was demolished. It is said that "fragments from the explosion can be found in almost every street in town."

(67.) — On March 18th a boiler exploded at Goddard & Haskell's mine, at Spring City, near Joplin, Mo. Several men had narrow escapes from death, but none were seriously injured.

(68.) — A boiler exploded, on March 19th, in William M. McIntosh's mill, at West Cleburne, Tex. Mr. D. Fudge was thrown fifty feet, and his shoulder was badly crushed. The owner of the mill was seriously scalded and bruised, and his wife was also painfully hurt. Their dwelling, which adjoined the mill, was entirely destroyed, and pieces of the boiler and other wreckage were scattered over a large area.

(69.) — On March 20th a boiler exploded in a sawmill near Bryant, Saline county, Ark., John Hunter was instantly killed.

(70.) — On March 23d a boiler exploded in a furniture factory at Zeeland, near Holland, Mich. We have not learned further particulars.

(71.) — A boiler exploded, on March 23d, in the Babcock Grain Company's flouring mill at Reed City, Mich. Clark Grant and Peter Young, the engineer, were instantly killed. The entire plant was wrecked, and is a total loss. The residence of Augustus Rogo, which was near the mill, was also nearly demolished. The bodies of the victims were thrown more than 100 feet.

(72.) — The State Lumber Company's mills, at Manistee, Mich., were started up for the season on March 24th. Half an hour after shutting down at night, the main steam pipe burst, injuring Engineer William Beals seriously, and Night Watchman Frank Sheba painfully, but not so badly as Beals.

(73.) — On March 25th a boiler exploded in Sisney Connor's sawmill at Charlestown, in Clarke county, near Jeffersonville, Ind. Engineer John Cox, who was near the boiler at the time, was terribly burned and scalded, so that he died on March 28th. We do not know the amount of the property loss, but it is said to be heavy.

(74.) — On March 26th a boiler exploded in the electric light and power station at Houston, Texas, wrecking the power house, instantly killing Andrew M'White and Carl Hoffman, and seriously injuring Sidney Freeman, Thomas Tobin, and John L. Brown. Brown and Tobin will probably die. The power plant was wrecked, and the property loss will amount to $20,000 or more.

(75.) — A small boiler exploded, on March 26th, at Fernwood, near Steubenville, Ohio. David Gott and his son, William Gott, were seriously injured, and the younger man will probably die.

(76.) — William Murray was seriously injured, on March 29th, by the explosion of a small boiler at Stony Point, near Washington, D. C.

(77.) — On March 30th a boiler exploded in William Sisloff's mill, at Bradford, Harrison county, Ky. David Sisloff was fatally hurt, and William Sisloff and Charles Lagle, the engineer, received severe injuries. The mill was badly wrecked.

The Philippine Islands.

The Philippine Islands are an archipelago southeast of Asia. They extend almost due north and south from Formosa to Borneo, and they separate the South China Sea from the Pacific Ocean. The number of islands in the Philippines is variously estimated from 1,200 to 1,400, and it was not until the last few years that some of the larger islands were explored sufficiently to enable their area to be accurately computed. According to Domann's map (1882) the area of the islands is 114,356 square miles. The two largest islands are Luzon (area, 40,024) and Mindanao. Their aggregate area is 52,650 square miles. The islands were discovered by Magellan in 1521, and Manila, the capital, was founded by Legaspi in 1571, and since that time they have been under the dominion of Spain. Their conquest and retention was in marked contrast to the usual Spanish methods of dealing with conquered people, methods of which Cortez and Pizarro are the chief exponents. Legaspi with six Augustinians and a handful of soldiers accomplished the wonderful work of conquest. Without greed for gold and without any exhibition of cruelty or persecution, these devoted men labored among the docile people until they won their confidence, so that the islands were seized with little bloodshed and no massacre or depopulation. The name "Islas Filipas" was given by Legaspi in 1567. Contests with frontier rebellious tribes, attacks by pirates, and earthquakes and typhoons, serve to break up the monotony of an otherwise uneventful history.

Manila was captured by the English under Draper and Cornish in 1762, and ransomed for $5,000,000, but was restored in 1764. The present insurrections in the islands were put down with an iron hand and many atrocities were committed, so that it is little wonder that many of the inhabitants look upon the arrival of the Americans as a deliverance.

While none of the islands have very high mountains (the highest, Apo, in Mindanao, being over 9,000 feet), still all the islands may be described in general as mountainous and hilly. Volcanic forces have had a large share in shaping the archipelago, but few of the peaks are now volcanic. In 1814 a terrible eruption destroyed 12,000 people at Camalig, Budiao, Albay, Guinobatan, and Daraga. In 1867 the same district was visited with another eruption. The Philippines are also notorious for terrible typhoons. In 1876 one of the storms burst over Luzon, pouring down the sides of the mountain Mayon, bringing destruction to a number of cities and completely ruining 6,000 houses. Typhoons on the coast are also common. The third great evil to which the islands are treated are the earthquakes, which visit them so frequently that they affect the style adopted in the erection of buildings. The most violent earthquake occurred in 1880, destroying an immense amount of property, including the cathedral.

The Philippine Islands are peculiar in having three seasons — a cold, a hot, and a wet. The first extends from November to February or March. The winds are northerly, and woolen clothing and a fire are desirable; the sky is clear and the air bracing, and Europeans in this strange clime consider it the pleasantest time of the year. The hot season lasts from March to June, and the heat becomes oppressive and thunderstorms of terrific violence are frequent. During July, August, September, and October, the rain comes down in torrents, and large tracts of the lower country are flooded. The population of the Philippines is 7,670,000, the capital, Manila, having 154,062 inhabitants. There is a small Spanish resident population and about 100,000 Chinese, in whose hands are the principal industries. The native inhabitants are mostly of the Malayan race. The government is administered by a governor-general and a captain-general, and the forty three provinces are ruled by governors, alcaldes or commandants, according to their importance or position. The estimated revenue of the islands in 1894-95 was $13,500,000 and the expenditure $13,200,000. There is an export duty on tobacco, and nearly every article imported is taxed. The chief products are sugar, hemp, coffee, and indigo, and there are large coal fields which are now being opened, so it is expected that 5,000 tons of coal per month may be mined. The imports in 1896 were about $12,000,000 and the exports $20,500,000. There are 70 miles of railway on the islands and 720 miles of telegraph.

Manila lies on the western side of the island of Luzon, and is about 600 miles from Hong-Kong. It has one of the most spacious and beautiful harbors in the world. The shores are low and inland can be seen the outline of mountains. The city of Manila resembles a dilapidated fortress surrounded by stone walls 300 years old. There is also a wide, shallow moat. The gates are never closed, and it is doubtful if the city could make any defense. There is also an old fort. Several creeks branch off from the landlocked bay and afford a means of communication with the suburbs. These creeks are crossed by innumerable bridges, and canoes thread their way through these narrow water-ways, which somewhat resemble a tropical Venice. Around the walls and the edge of the bay is a fashionable drive lined with almond trees. It is here that the well-to-do inhabitants walk, drive, and meet their friends. Of nearly 300,000 people in the province there are not more than 5,000 who are Spaniards. One of the most curious sights to the traveler who comes from China are the large two-wheel drays drawn by so-called water buffaloes. They are guided by a ring through their nose to which is attached a cord leading back to the driver, who either mounts on the animal's back, or rides on the shafts. The weight of the load is borne on the neck by means of a yoke. The beasts are docile and their chief delight seems to be to wallow in the mud and to submerge themselves so that only the nose is out of the water. The water buffalo is particularly valuable to the inhabitants as a beast of burden, as it can drag a plow and can walk while knee deep in mud. The milk of the female is very generally used instead of cow's milk, but its meat is unfit for food.

In the two best streets of Manila there are excellent stores in which goods of all kinds can be purchased at moderate prices, many of the merchants being Chinese. The churches must have been imposing buildings years ago before they were shaken and in some cases wrecked by earthquakes. They contain no works of art of any value. The inhabitants are very faithful to their church, and the archbishop possesses almost unlimited influence with the inhabitants. It has often been said that if the priests were taken away, the natives would be ungovernable. The dwelling houses in Manila are constructed with a view of shutting out the intense heat of the summer. The houses are rarely more than two stories in height, owing to the ravages of earthquakes. Glass is of course unknown, as the earthquakes would shiver every pane. There is coal in abundance in the Philippine Islands, as already stated, and the streets of Manila would undoubtedly be lighted with coal gas if it were not for the fact that gas pipes would be destroyed in the unstable soil. Of course, accidents are of frequent occurrence with kerosene, but as the natives' houses are very inexpensive, their loss by fire is easily made good.

Strange to say, life in the old city does not present many points of interest to the traveler, for the streets are narrow and the houses solid and gloomy. It is in marked contrast with the businesslike cities of South America. The Spaniards born in the Iberian Peninsula look down upon those born in the islands, so that class distinctions are very closely drawn. This has resulted in the failure to make political combinations. Hatred and jealousy of the foreigner are carried to extreme limits, the Chinese coming in for a large share of disfavor. The theaters are poor, concerts are rare, and there is no library. The amusements of the Philippine Spaniards are mostly limited to hearing the band play, attending balls on Sundays, and cock fights. The cockpits are licensed by the government, and, though the betting is limited by law, the citizens will not hold to it. The revenues of the islands are furnished by direct taxes on every Indian, half-breed, and Chinese, and the export and import duties which have already been referred to.

The dress of the natives is exceedingly picturesque and is never adopted by the Spanish. Cigarmakers in and around the city of Manila number 22,000, and are all girls and women with the exception of 1,500 men. They present a picturesque appearance with their native costume and huge hats intended to protect them from the rays of the sun. They make their cigars squatting on their heels or sitting on bamboo stools two inches high. They frequently come from considerable distances, going back and forth in boats. Tobacco has always been and probably will continue to be the most important product of the Philippines; and, according to the old laws, the Indians were compelled to raise tobacco in certain regions which were not adapted to growing it, even to the exclusion of other crops, but in 1883 the laws were repealed and the result was the securing of finer tobacco and better cigars, for they are now made at a higher rate. The wants of the natives are few and are easily supplied. They live along the banks of the rivers in huts made of bamboo and cane thatched with palm leaves. Some of the views in the suburbs of Manila are enchanting. — *Scientific American.*

On December 10th, Michael Pursell, a boiler maker, was making some repairs inside the smokestack of the steamer *Wellington* at the Folsom street wharf, San Francisco, when six fires were started below him. He was strapped on a chair suspended from the top of the stack, about 40 feet from the dampers below. It was impossible to go up, and to go down without assistance meant being roasted alive. Dense volumes of hot smoke began rolling up the stack, and Pursell loudly shouted for help. The heat increased every moment, until the boiler maker's clothing caught fire. He beat on the iron with all his power, and shouted for fully ten minutes before his helper realized his plight, and rescued him.

The Locomotive.

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Boiler Explosion in an Oil Mill.

The statistics of boiler explosions, which we publish annually, show that there is a continual increase in the number of such explosions, from year to year, — probably on account of the increased number of boilers in use. It has been our custom, in the past, to illustrate certain of these explosions from time to time, when they appear to have instructive features, or to be of special interest for some other reason.

Fig. 1. — General View of the Ruins.

The explosion here described was selected for illustration because it carries a lesson which is well worth attention. It occurred in an oil manufacturing mill, and caused a serious destruction of property.

The steam plant included two boilers, known respectively as "No. 1" and "No. 2." No. 2 boiler was of steel, built in three courses, did not explode, but was thrown some distance from its setting by the explosion of its companion, No. 1. No. 1 boiler was 56 inches in diameter and 16 feet long. It was of iron, and was originally built with five courses or rings of plates. The sheets were about .295″ thick, and the heads were .54″ thick, with 50 tubes, 3½″ in diameter.

No. 1 boiler had given considerable trouble for some time previous to the explosion. The fire sheets had bagged considerably on several occasions, and during the year preceding the explosion, something like $350 had been expended upon repairs, and steel patches had been put on where the bulges had occurred. There were numerous incipient cracks in the sheets, running from the edges of the plates in to the rivet holes. About two weeks before the explosion a new fire sheet had been put in No. 1 boiler, as indicated in Fig. 2. This sheet was .385″ thick, and probably of steel. It was made wide enough to include two courses of the boiler as originally built. The upper sheets, to which this new sheet was attached, were .295″ and .300″ thick, respectively. The old sheet, that was taken out when these repairs were made, showed a crack about two feet long, along the girth seam at the bottom of the boiler.

On one side of the boiler the horizontal joint between the new sheet and the old ones above it came directly in line with the corresponding joint in the third course of plates, as shown in Fig. 2, so that the boiler had a continuous, unbroken longitudinal joint, at this place, for a length of over nine feet. When the new steel fire sheet had been put in, and the boiler was put in service once more, it was found that this longitudinal joint leaked, so that water sprayed out against the walls of the setting. Business being pressing, the boiler was run in this condition for a week, and at the end of that time it was put out of service long enough to have the joint thoroughly calked. Apparently, no further leakage was observed.

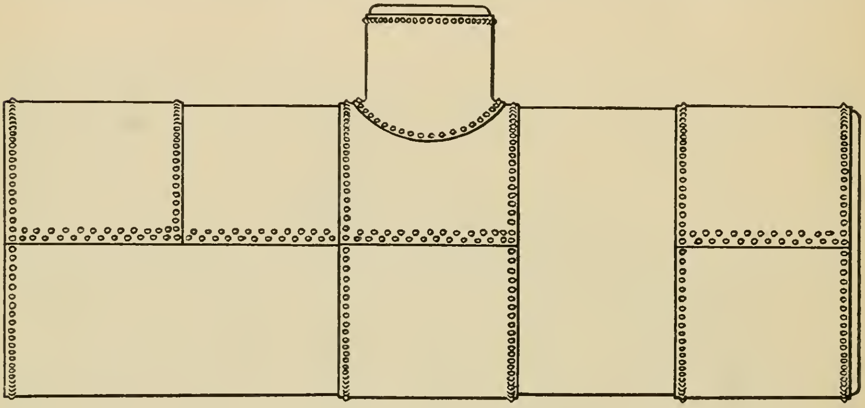

FIG. 2.—SHOWING THE LARGE NEW FIRE SHEET.

The day of the explosion being Sunday, the boilers had been lying idle, though probably filled with hot water, since the exploded boiler, at any rate, had been in service up to 3 o'clock A.M. of the same day. On Sunday evening the night fireman started fires under No. 2 at 7 P. M., and under No. 1 at 8 or 8.30 P.M. At 9 o'clock there were two inches of water in each gauge, and more feed was introduced into both boilers between 9 and 10. At 10 o'clock No. 1 boiler had 30 pounds of steam, and at 10.30 P. M. it had 60 pounds. The engine was then started, and ten minutes later the explosion occurred.

Some idea of the wreckage that resulted may be had from Fig. 1. The entire east wing of the substantial four-story brick building was destroyed, and most of the machinery in the mill was ruined. Two railroad bridges on the south side of the plant were destroyed, and a portion of a neighboring grain elevator was carried away. A freight car was blown into a canal, and the part of the building that was left standing was so badly damaged that considerable portions of it had to be torn down and rebuilt. It was at first thought that the property loss was from $50,000 to $70,000, but subsequent investigation showed that $30,000 was probably nearer to the true loss. It is hard to understand how anyone in the building could have escaped death; but Samuel Jones, John Whitby, and George Fine, who were about the place at the time, did escape with slight injuries. If the explosion had occurred on the following day, the loss of life would doubtless have been serious.

From all appearances the initial rupture in No. 1 boiler took place at the long, horizontal joint where the new sheet was secured to the old ones, as indicated in Fig. 3. Both heads of No. 1 were blown out, in opposite directions, and were found some distance away. Boiler No. 2 was blown out of its setting, and the sheets of boiler No. 1 were blown side-wise into the main mill.

Being abundantly satisfied as to the location of the initial fracture, we have no hesitation in saying that we believe the present explosion to be an excellent exemplification of the folly of putting new wine into old skins. As we have already said, the repairs on this boiler, during the preceding year, had amounted to $350; and the repair bill for the last job, we understand, was about $120, making total expenditures for repairs of about $470, within a period of about one year. A new boiler might have been had for that sum, and it would have been much wiser for the owners of the mill to throw away the old one, when it gave so much trouble, rather than to patch it continually. Doubtless this would be admitted, *after the explosion*, by the owners themselves. Wisdom comes to us all, with years and experience. But even admitting that there was some question about the proper course *before* the explosion, the fact remains that the repairs were carried out on a wrong principle, anyhow. An old boiler, made of iron plates .295″ thick, was repaired by the addition of a steel sheet, .385″ thick. The new material, being presumably sounder and stiffer, and certainly much thicker, doubtless threw an undue amount of strain upon the older and thinner sheets to which it was attached. Changes of form, slight, perhaps, but nevertheless exceedingly important in determining the distribution of the stresses, are occurring all the time in boilers that are under steam, from the variations in pressure and temperature to which they are subjected. Such changes would be resisted by the thick new sheet, and thrown upon the

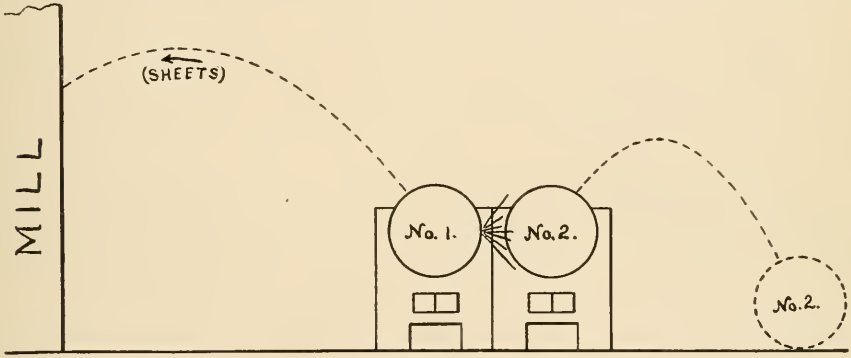

FIG. 3.—INDICATING THE GENERAL NATURE OF THE EXPLOSION.

older and less durable ones. The result might easily be, to strain these old sheets beyond the point of safety, and so bring about their destruction.

The two lessons that this explosion carries, therefore, are, first, that it is often better and cheaper to buy a new boiler, than it is to spend a lot of money in repairing an old one; and, second, that when an old boiler is to be repaired by the addition of a big patch or a new sheet, it is better to make the new material a trifle *thinner* than the old, so that it may yield with equal readiness to the irregular temperature and pressure stresses that normally occur in a boiler, and not throw all the strains upon the older (and presumably weaker) sheets.

Inspectors' Report.

APRIL, 1898.

During this month our inspectors made 8,619 inspection trips, visited 17,223 boilers, inspected 6,581 both internally and externally, and subjected 653 to hydrostatic pressure. The whole number of defects reported reached 10,605, of which 1,072 were considered dangerous; 82 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	975	43
Cases of incrustation and scale,	2,273	63
Cases of internal grooving,	113	11
Cases of internal corrosion,	604	19
Cases of external corrosion,	613	48
Broken and loose braces and stays,	161	34
Settings defective,	319	25
Furnaces out of shape,	354	19
Fractured plates,	275	36
Burned plates,	294	30
Blistered plates,	145	7
Cases of defective riveting,	922	133
Defective heads,	89	29
Serious leakage around tube ends,	1,844	307
Serious leakage at seams,	405	51
Defective water-gauges,	201	38
Defective blow-offs,	153	51
Cases of deficiency of water,	6	3
Safety-valves overloaded,	48	15
Safety-valves defective in coustruction,	73	22
Pressure-gauges defective,	499	50
Boilers without pressure-gauges,	29	29
Unclassified defects,	210	9
Total,	10,605	1,072

AN air tank exploded, recently, in the switching yards at the Union Station, St. Louis, Mo. The damage amounted to several thousand dollars. The air tanks are used to furnish pressure for throwing the switches from the switch tower.

Boiler Explosions.

April, 1898.

(78.) — A boiler exploded, on March 31st, in the electric light plant at Decorah, near New Hampton, Iowa. The engineer was in another part of the building at the time, and escaped without injury. [Received too late for insertion in the March list. — Ed.]

(79.) — On April 1st a boiler exploded in a shingle-mill some four miles north of Campbellsville, Ky., instantly killing Thomas Ratcliffe, Clarence Ratcliffe, Thomas Newcomb, and a man named Wright. Alma Ratcliffe was also scalded so severely that he cannot live. The mill was demolished, and fragments of it were thrown in every direction.

(80.) — A small saw-mill boiler exploded, on April 1st, just over the Virginia line from Whitesburg, Tenn. Thomas and Edward Edgecraft were fatally injured.

(81.) — On April 4th a boiler exploded at Rainbow, near Marietta, Ohio. Nobody was injured. The boiler belonged to Mr. John Huck.

(82.) — A boiler exploded, on April 4th, in the Wheeling Iron and Steel Works, at Benwood, W. Va. David Geary, a fireman, was instantly killed, and Owen Taffe, Louis Walkenfeldt, Frederick Landrey, Stephen Matish, Vincent Gentle, John Gosney, Joseph Angelo, George Rousser, Frank Berry, and one other man whose name is not known, were injured. Taffe died, later in the day. The property loss was probably about $3,000.

(83.) — The towboat *Stella* was destroyed, on April 7th, by the explosion of her boiler, near Gallipolis, Ohio, while she was on the way to Point Pleasant from Charleston, with a raft of ties. Pilot Joseph Wells, Engineer Hopkins Eastwood, and one other man, were injured. The *Stella* sank, after the explosion.

(84.) — A boiler exploded, on April 8th, in C. J. Miller's tannery, at Orillia, Ont. Nobody was injured, but the explosion destroyed a good deal of property. The boiler-house was a stone and brick building on the west side of the tannery, and was utterly demolished. A portion of the stone wall next to the tannery was blown entirely through the main building. About fifty feet of the tannery building, containing the greater part of the machinery, was blown outwards, and lay in the street, a total wreck. The chimney did not fall, but it was struck near the top by flying debris, and badly broken. The tubes of the boiler were scattered around for hundreds of feet, and shafting and big fragments of machinery were carried to incredible distances.

(85.) — A boiler owned by Granville Ball, of Holden, Mass., exploded on April 8th. Fortunately nobody was hurt.

(86.) — One of the boilers on the starboard side of the Iron Mountain transfer steamer *Missouri* exploded, on April 9th, while the *Missouri* was moored near the Illinois Central incline at Cairo, Ill. The explosion was due to the failure of the front head of the boiler. The fore end of the starboard side of the boat was completely wrecked, and the boilers were thrown thirty feet or more towards the stern, demolishing the engine-room, and badly damaging the engine and some other machinery.

(87.) — David Bates's mill, at Careyville, near Luther, Mich., was totally destroyed, on April 11th, by the explosion of a boiler. Engineer Eugene Wesner was buried in the ruins, and when taken out he was found to be fatally injured. James Bates was also injured, but will recover. These two were the only men in the mill at the time, the other hands arriving to go to work just after the accident.

(88.) — On April 12th, a small boiler exploded in Messrs. Adler & Zambelli's moss factory, on Moss street, New Orleans, La. Nobody was injured, and the loss will probably not exceed $1,000.

(89.) — The New Era Creamery, owned by G. W. Karrenbrock, and located at New Melle, St. Charles county, Mo., was badly wrecked, on April 13th, by the explosion of a boiler. Nobody was in the building at the time.

(90.) — William Brenner, engineer for the five-story building at 148 Halsted street, Chicago, was severely scalded, on April 13th, by a boiler explosion in the basement. The building is occupied as a hotel by Isaac Meyer. The shock of the explosion alarmed several men and women in the hotel, and a hasty exit was made. Brenner was taken to the county hospital, where his injuries were pronounced very serious.

(91.) — On April 14th, Edmund Holsopple's mill, in the town of Paint, Somerset county, Pa., was almost demolished by the explosion of a boiler. Sidney Holsopple was instantly killed, and Charles Holsopple was fatally injured. Clyde Holsopple, Bruce Holsopple, and Joseph Johns were also severely scalded and bruised.

(92.) — On April 14th, a traction engine boiler exploded on the farm of Mrs. Sarah Harnshorn, at Jerusalem, Yates county, Pa. One account that we have received says that the boiler "was tested by an expert on the day of the explosion, and it was listed at 100, cold water pressure, and 200 pounds hot water pressure." We don't vouch for this, however, because we don't know what it means.

(93.) — William Lacey was instantly killed, and Henry Firth was fatally injured, on April 15th, by the explosion of a boiler at the Enterprise mine, at El Dora, near Leadville, Colo.

(94.) — A boiler exploded, on April 19th, at the Pinkney mine, some twenty-two miles from Florence, Ala. A man named Brown was so badly scalded and bruised, that he can hardly recover, and two others, whose names we have not learned, also received serious injuries. The mine is owned by the Lawrence Ore Banks company.

(95.) — A big steam kier exploded, on April 19th, in the bleaching department of the Patchogue Lace Mills, at Patchogue, L. I. The top of the kier was blown through the roof of the building, taking about one thousand pairs of lace curtains with it, and the country round about was speedily decorated as it never had been before, in the memory of living man. The building in which the bleaching department was situated was completely wrecked, and the machinery destroyed. Nobody was injured, as the foreman and the night watchman were the only men on duty, and they had just left the building.

(96.) — Charles Webster was badly scalded, on April 21st, by the explosion of a boiler in the Rochester Car Wheel Works, at Rochester, N. Y. We have not received full particulars about this explosion. One account says that the head of the boiler blew out, while another states that several of the tubes failed simultaneously.

(97.) — On April 21st a boiler exploded in the hemp mill of O'Brien & Connor, at Ivesdale, near Urbana, Ill. Bernard Doyle, who was in charge at the time, received severe injuries, being almost completely buried beneath a pile of bricks and other debris. P. T. Gallivan had one of his arms broken. The boiler was thrown a distance of about 250 feet, cutting down several large willows in its flight, and finally landing in a ditch.

(98.) — A portable boiler, belonging to Mr. Richmond Tussie, exploded, on April 23d, about eight miles from Morehead, Ky. William Candill was killed, and Mr. Tussie was seriously injured.

(99.) — Roderick McNeill, a coal-passer on the Pacific Coast Steamship Company's steamer *Pomona*, died at San Diego, Cal., on April 24th, from the effects of injuries received the day before. As the *Pomona* was entering the harbor of San Diego, on the 23d, a flue in her boiler failed, and McNeill was fearfully scalded.

(100.) — A boiler exploded, on April 23d, in Samuel Jones' grist mill, at Pleasureville, Ky. Thomas and William Tingle, Sidney Carr, and James Jones were killed, and another man was badly hurt.

(101.) — "About 11 o'clock on April 25th," says a Western paper, "the boiler in J. Pratt's blacksmith shop, at Maxwell, Iowa, took a rise in the world, so to speak, and landed on top of the livery barn. Mr. Pratt says he was working at the boiler about two minutes before the explosion, and that the gauge only showed 40 pounds of steam. The back end of the building and the boiler and foundation were badly demoralized, but there was no other damage.

(102.) — On April 28th a boiler exploded in Bailey Bros.'s saw-mill, at Orange, Burnett county, Wis., killing Elias Bailey instantly.

(103.) — On April 29th a portable boiler belonging to C. B. Gladding, superintendent of the Geneva Wheel Company, exploded at Hart's Grove, Ashtabula county, Ohio. Several persons were about the boiler at the time, and all were more or less injured. Charles Gladding, father of the owner of the boiler, was most seriously hurt. One of his legs was broken near the hip, and he was also severely bruised about the head and body. It is thought, however, that he will recover.

(104.) — A boiler exploded in the California Theater, at San Francisco, on April 30th, but no great damage was done. The performance, an operatic production by Mme. Melba and her company, was interrupted for a short time. Later in the evening the theater took fire, and a panic resulted; but we do not know whether there was any connection between the fire and the explosion or not.

The *Montreal Pharmaceutical Journal* for May gives a description of the "laughing plant," and of its effects upon man. It grows in Arabia, and derives its name from the effects produced by eating its seeds. The plant is of a moderate size, with bright yellow flowers, and soft, velvety seed pods, each of which contains two or three seeds resembling small black beans. The natives of the district where the plant grows dry these seeds, and reduce them to powder. A small dose of this powder has effects similar to those arising from the inhaling of laughing gas. It causes the soberest person to dance, shout, and laugh, with the boisterous excitement of a madman, and to rush about, cutting the most ridiculous capers, for about an hour. At the expiration of this time exhaustion sets in, and the excited person falls asleep, to wake after several hours with no recollection whatever of his antics.

The *New York Medical Journal* adds: "This description reminds us of a plant known in the Lower Californian desert as the loco weed, which has a similar effect upon horses, driving them into a state of boisterous craziness." — *Scientific American Supplement.*

The Locomotive.

HARTFORD, JUNE 15, 1898.

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 Keystone local association of the National Association of Stationary Engineers, of Buffalo, N. Y., two very beautiful photographs of their rooms on Washington street. This branch of the National Association was organized in November, 1896, and it already has 122 members, with a reading-room containing a goodly supply of mechanical literature, and every facility for study and instruction among its members. It gives us much pleasure to note the educational spirit that is so strongly manifested among engineers. There are few professions or trades whose members band together in this way for systematic mutual improvement, and the engineers' societies are doing a great work, not only for themselves, but for others engaged in different vocations; for they are showing what a deal of good may be accomplished in this way by the exercise of a reasonable amount of perseverence and "push." They have our heartiest sympathies.

FOR many years past, the Hartford Steam Boiler Inspection and Insurance Company has maintained a department devoted to the preparation of designs and specifications for boilers. This department has grown steadily with increase of the Company's business, and its present importance may be estimated from the following data concerning the work it sent out during the first quarter of the present year:

January, 1898.—	41 specifications. covering	75 boilers, and requiring	225 drawings.
February, 1898.—	41 " "	66 " "	252 "
March, 1898.—	59 " "	106 " "	365 "
Totals, 3 mos.,	141 " "	247 " "	842 "

The drafting department was originated, and is conducted, for the benefit of patrons of this Company, to whom drawings and specifications for boilers are usually furnished free of charge. In occasional cases, where an unusual amount of time must be devoted to their preparation, a small charge may be made for such specifications and drawings; but even in these instances, the charge is intended merely to defray the actual expense to which we are put, and the benefit of our wide and varied experience of over thirty years is tendered to our patrons, free.

OUR esteemed Boston insurance contemporary, the *Standard*, published by Mr. C. M. Ransom, prints, in its issue for May 21st, an excellent descriptive article concerning the Hartford Steam Boiler Inspection and Insurance Company. One paragraph of this article in particular is so well written that we reproduce it below, although it is not our custom to discuss the business details of the Company's work in the pages of THE LOCOMOTIVE.

"The great care exercised by the Hartford company in the acceptance of new business," says Mr. Ransom, "is in a large measure responsible for the company's unparalleled results. Upon receipt of the application for insurance, an inspector of the company arranges for a thorough examination of the boilers, tanks, or whatever the risk may include, and if this inspection proves satisfactory, the policy is issued for the amount and rate agreed upon, and, with the inspector's report, is sent the assured. This report also recommends any changes in care and management that it is believed would add to the economy or safety of the risk. If any weakness or defect is discovered affecting the safety of the boilers or their attachments, the report also describes the best way of remedying the defect, whatever it may be, and no policy is issued until the danger is removed. The Hartford is the only company that from the commencement of its business has insisted upon making inspections of steam boilers and appliances before issuing a policy of insurance, thus affording steam-users the fullest protection possible, not only in a policy of unquestioned value, but a complete and comprehensive knowledge of their risk, guaranteed by their insurance policy to be without material defect. The boilers are thereafter visited at stated periods, gauges tested, safety-valves examined and properly weighted at the pressure insured, and all other appliances carefully examined. If necessary, other examinations will be made without additional expense to the assured. A written report of the condition of the boilers is furnished the assured after each inspection, with suggestions, compliance with which will secure increased safety, efficiency, and economy. The premium paid for insurance covers all expenses of this kind."

This, we are pleased to say, is a very good statement of the way we do business. And when it comes to the *payment of losses*, we are proud to say that our best argument in this regard consists in the letters that we receive from those who have had claims against us. This is not the place to reproduce matter of that kind. We publish such letters from time to time in our advertising circulars; and they make mighty interesting reading to owners of boilers.

Notes on Refrigerating Machines.

By an Idle Correspondent.

Oh, yes ! When I was interrupted, about a year and a half ago,* I was going to tell you how they store meats and make ice, out here in Pennsylvania. I suppose they do it much the same way up in Connecticut; but *I* never saw the thing done till I had circulated around out here for a spell. I spent two hours in a plant the other day, and learned the whole business, from top to bottom. If you hear of anybody wanting a general superintendent to run such a place, send me a postal; because, as I said, I am thoroughly posted. Well, I was going to tell you all about it. So here goes :

The production of artificial cold by means of a steam engine is one of the most striking achievements, I think, of modern times. I believe that this art is still in its infancy, too, and I venture to prophecy that some day or other we shall have "cold radiators" in our houses and offices, to temper the hot weather of summer, just as we now have furnaces and steam-heaters to keep us warm in winter. And more than that, I believe that the time is coming when the cook will make her ice cream without pounding up ice and mixing it with salt, but by merely putting some new-fangled kind of a freezer right on top of the kitchen stove, obtaining the necessary cold by means of some kind of internal machinery that will draw its power from the fire in the stove. Of

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* See The Locomotive for October, 1896.

course I can't tell you just how this thing is going to be done, because if I knew as much as that, it stands to reason that I shouldn't be writing articles like this for a penny a line. Not much. I should get to work right away and patent the machine, and build it and sell it, and make my everlasting fortune out of it. One of these days some other fellow will come along this road, who is brighter than I am, and he will see the whole thing in a minute, and know just how to do it.

But all that is away off in the future, and what I want to write about, in this article, is not so much what we are going to do when the millennium comes, as what we *are* doing now, in the year of grace 1898. In the first place, we are making ice by thousands of tons, every day. I have read, somewhere or other, that the untutored Esquimau's idea of sheol is a place where the weather is mighty cold all the year around, with plenty of icebergs and glaciers; but I am sure that if we should take that same heathen Esquimau and civilize him a little, and lead him around through some of our modern ice-making plants, he would go back to the inside of his Arctic circle with an idea that his brethren in the land of the midnight sun are weak in their theology, and that the very worst possible kind of a sheol would be one that is all stocked up with Yankee refrigerating machinery.

There are millions of men in hotter climates, however, to whom the ice machine must seem almost like a gift from heaven. Think of the little child burning with fever under a fierce, tropical sun, and then conceive, if you can, the infinite comfort and relief that comes to that child from the lump of ice that he holds to his lips. Does not the image touch your heart? And yet it shows but one of the untold multitudes of uses to which ice can now be put, in regions of the earth where it was formerly too dear to be afforded by any but the rich.

It is not in hot countries alone that artificial ice is precious, for we have improved upon nature to that degree that in many a colder region ice can be made by machine more cheaply than it can be cut from ponds and ditches. And how much better the home-made product is! Frozen from pure, distilled water, it contains none of the decayed organic matter, and few or none of the vast multitudes of disease-producing bacteria that swarm in the muddy holes and sewage-contaminated streams from which we take it in nature. Most people have an idea that microbes are killed by freezing, so that ice is bound to be healthy, no matter how populous and lively it may have been before the frost came; but this is a serious mistake. The "spores" from which such microbes grow are not killed by freezing, any more than a pine tree is. They are not like hot-house plants in this respect. Their activity is suspended for a time by cold, but they are ready to begin business in the same old way again, just as soon as they feel the thrill of a renewed warmth; and this is why artificial ice is so immeasurably healthier than the natural kinds.

Another application of cold-producing machinery, which is even more important from a commercial point of view than the mere production of ice, is the preservation of meats and fish and other perishable articles of food for long periods in the cold storage warehouses that ought to be found in every progressive city in the United States. Every housekeeper knows the advantages of an ice chest, and the modern cold storage plant is merely an ice chest on a grand scale, in which the temperatures of the different rooms are regulated with scientific precision, to suit the needs of the divers kinds of food materials that are kept there. Every article of food has its own peculiar temperature at which it will keep best, and these various temperatures have been investigated and studied with great care, until now we have a complete scheme of temperature, available for all purposes. Butter, for example, keeps best at about 18° Fahr. Watermelons should not be allowed to go above 38°, nor below 36°. Fish may be kept at any temperature below 32°, and will remain in good condition almost indefinitely, provided it is never allowed to thaw. Eggs may be kept "fresh" for a year at a temperature of 36°; but a careless attendant who should allow his egg room to vary more than one degree from this point, for any considerable time, would be likely to hear complaints from his employer's customers. And so we might go on with a long list of other temperatures, each adapted to the needs of a particular kind of food; but having said enough to show how carefully the thing is done, I must pass on to an explanation of the principle on which the freezing machine works.

You have seen men blow on a dishful of hot tea or soup to cool it, and probably some of you have done it yourselves, in the privacy of your own homes; though my book on etiquette says that it isn't a proper thing to do in polite society, but that it is much better form to scald the throat off of yourself, and say nothing. Now, why is it that blowing on a hot liquid cools it so quickly? The chief reason is, that the vapor that hangs over the liquid is removed by the breath, so that more vapor can be formed and be blown away in like manner. All of us who have shoveled coal under a steam boiler know that it takes a lot of heat to evaporate a liquid; and this is the secret of the rapid cooling of the tea. Each drop of tea, in order to evaporate, must absorb a considerable amount of heat, and the only way in which it can get that heat, is by taking it away from the tea which is left behind in the dish; so that it comes to pass very shortly, that the contents of the cup (or saucer) is cool enough to drink. The cooling effect of evaporation has been utilized in tropical countries for many centuries, to make water more palatable for drinking. The water to be cooled is poured into a porous earthenware vessel, which is hung up in the breeze in a shady place. Moisture oozes out through the pores of the vessel and evaporates on the outside, taking up enough heat, in doing so, to chill the water within to a point at which it is refreshing and invigorating. The same general principle underlies the automatic process by which our bodies are kept cool on a hot day. The skin pours out a film of perspiration upon itself, and this absorbs enough heat, in evaporating, to prevent the body from being warmed to a point that would be dangerous to life.

The refrigerating machine is nothing but a device to put this evaporative principle into practice on a large scale. For this purpose we choose a liquid such as ether, or carbon disulphide, or sulphur dioxide, or anhydrous ammonia, which will evaporate very rapidly, and we confine it in a closed vessel. Then by means of a pump we remove the vapor of the liquid as fast as it is formed, and the new vapor which keeps rising from the liquid takes with it so much heat that the vessel is soon cooled below the freezing point of water. When once the necessary degree of cold has been obtained, ice is readily produced by causing the cooled liquid to flow around metallic vessels filled with water.

In large machines it is not good practice to cause the ammonia itself to flow around the freezing vessels. The ammonia is used, instead, to cool a coil of pipes filled with a strong brine solution; and the cold brine, which does not freeze on account of the salt that it contains, is pumped through the freezing coils in the ice-making department, and also to the cold-storage rooms, where it circulates through other coils that run around the walls. The temperature of each room in the storage department is regulated by means of a valve which controls the flow of the cold brine, and it is one of the duties of the engineer to visit the rooms every hour or so, to make sure that he is keeping them all at the proper temperature.

Of course the ice manufacturer could not afford to throw away the ammonia vapor that he has pumped out of the cooling tank. He must save it and use it over again; and in order to do so, he passes it through a powerful compressing machine until it is condensed, once more, into the liquid condition. When a liquid evaporates it takes up a large amount of heat, and when it condenses it must give that heat all back again. The ammonia vapor, on being compressed into the liquid condition, therefore becomes very hot, and must be passed through coils of pipe surrounded by running water, until the greater part of its heat of condensation has been taken away. It is then in condition to be returned to the cooling tank, where it is again evaporated; and so it goes the rounds, being first evaporated to secure the necessary cooling effect, and then compressed and cooled to the ordinary temperature of the room, and pumped back into the evaporating tank, over and over.

If any serious accident should happen to the refrigerating machinery of a cold storage plant, which would necessitate the stoppage of the engines for a couple of days or more, the cold rooms would inevitably grow warm, and this might mean a heavy loss to the customers who had stored perishable articles there, especially in hot weather. To guard against such a result as this, it is common to have two independent sets of engines, either of which is capable of maintaining the desired temperatures without any help from the other one. It would be a poor business policy to put in duplicate machinery in this way and let half of it lie idle, merely awaiting an emergency that may not come, and so both engines are run all the time, one of them keeping the building cold, while the other is used for making ice for outside customers. In case of a serious breakdown, the plant is then quite capable of taking care of itself, and the only harm done is that which befalls the unfortunate outside customers, who have to get their ice somewhere else for a couple of days, until the damage to the spare engine can be repaired.

An engineer in charge of a big storage house that I visited in Pittsburgh told me a pitiful story of the loss of appetite that he experienced after working for a time in his present place. "The job is a good one," he said, "and I shouldn't want to throw it up; but, do you know, I can't eat a thing but bread and potato and veal. My wife 'll cook me a nice piece of steak, but I can't eat it. I sit and poke it around in my plate, and think of that side of beef, over in the corner of room No. 8, that I have looked at every hour for the last eight months till Jones took it away yesterday. I know it's all right, but somehow that steak seems like an old friend, and I can't eat it. I just mumble over it a little, and eat a bit of bread and butter, and then go back to work. It's just the same way with lamb and everything else but veal. They don't try to keep veal over — leastways, not in my plant. So I can eat that, and relish it, and I have it four times a week, till now my wife has got so sick of it, she can't hardly look at a piece."

The Ground Current of Electric Railways.

A Discussion of the Causes and Effects of Electrolysis.

In discussing the action and influence of ground currents in an electric railway, the usual methods of conveying currents should be fully understood.

Following the usual custom of supplying trolley cars with a current of electricity required for their operation, the trolley wire is fed from the positive pole of the generator; the current passes through the motors, performing its work of propelling the car, and then is delivered to the rails. So far in the circuit the current is confined to a definite path. On reaching the rail it may either follow the rail back to the power station, or ramify through the earth; it always follows the path of least resistance. Sometimes it travels by sub surface conductors belonging to the gas and water companies, but, in passing from one metallic body to another when imbedded in earth, especially that found under city pavements, which is charged with nitrates and ammonia, the current carries with it a certain portion of the conductor on leaving it to enter the earth. It is this action which causes electrolysis of the rails when the current leaves the railroad, and of the water pipes or other conductors when it leaves these to return to the power station. It is evident that, if the current, in passing along the rail, reaches an open joint, it will pass into the earth and back into the rail, bridging this joint. The same action will occur if a joint in an iron water pipe or a gas main offers resistance to the current. The effect of electrolysis can be reduced to a minimum, or to a negligible amount, by taking certain precautions and maintaining a periodical inspection and tests of the return flow.

The rail itself generally offers abundant conductivity, except on very large roads. But, as the rail is not continuous, the conductor is broken up into lengths, which are connected by splice bars. Oxide of iron being a partial insulator, these splice plates do not make a good electrical connection between adjacent rail ends. In order to make the rail a continuous conductor, some way must be found to bridge around and connect the rail ends electrically. The bonding of these rails has been a matter of considerable study. [Mr. Herrick here gives a number of engravings illustrating the evolution of the rail bond.]

There is no panacea for the evils arising from electrolysis, but there are general treatments which greatly relieve the condition. The damage is done when the current leaves the water pipe. If these points of departure are determined, by measuring the difference of potential between the rails and the affected system of underground conductors, and if the volume of current flowing through the parallel conductors adjacent to the railway system is known, certain areas where the current leaves the water or gas pipe and returns to the rail or to the ground will be indicated. It is generally assumed, but not correctly, that the difference of potential between the water-pipe system and the railroad indicates the true extent of electrolysis. It does indicate a tendency to divert the current, if the rail is negative to the pipe, but the amount of current diverted can be determined only by electrical measurements on the water pipe itself. The distribution of negative and positive areas must also be considered. The negative areas are adjacent to the power station, whereas the positive areas are the outlying districts. This is the case where the trolley is positive, which is the usual practice. It is evident that, if conductors were attached to the water pipes at the points where they are positive to the rail and carried back to the negative poles of the generators, the current would follow this path in preference to returning through the earth to the rail. This will reduce local electrolysis, but will tend to increase the flow of current through the water pipe, and, if there are any bad joints in the water pipe, the pipe will be badly eaten at these points. Cast-iron fittings and cast-iron pipe are not attacked or destroyed nearly so rapidly as wrought-iron pipe. Lead surfaces and brass nipples connecting lead surfaces with wrought-iron pipe suffer quickly from electrolysis. Gas pipes carrying an insulating medium are not so subject to marked depreciation from electrolysis, unless the ground return of the railway is in very bad shape. There is a condition of water distribution which has to be carefully guarded against. In the old systems of water piping cement-lined sheet-iron pipe was used. Now wrought-iron pipe has been so cheapened that these systems have of late been extended with wrought-iron pipe. With this mixed system of piping the matter of electrolysis may become very serious, as the current enters the wrought-iron pipe on its way to the station, only to be diverted as soon as it meets the high resistance offered by the cement-lined pipe, whereupon it disseminates through all metallic surfaces, such as gates and surface pipes.

It often becomes necessary to determine what should be done by the railway company to protect the property of the gas and water companies from the deterioration due to electrolysis. It is not necessary, as a rule, to impose any great burden on the railway company in order to accomplish this, if the system is gone over carefully and an examination made to determine the causes and localize those points where the action is dangerous.

The remedies applied are: first, to connect the rail to the water pipe at points where the pipe is positive to the rail; second, to use feeders, preferably by connecting the pipe at this point directly back to the station. Another method is to take the current from the water mains through a dynamo whose potential is negatively lower than the rail-return dynamos. Or the return through the ground and water pipes may be fed through the armature of a low potential machine, keeping this system electrically negative to the rail, so that the current does not leave the water-pipe system, but naturally returns through this generator as the lowest potential point in the system. The excellency of the bonding of the track and the proper placing of ground-return feeders is the most practicable and direct method of reducing electrolysis. If care and attention are given to these details, electrolysis can be reduced in most instances to a negligible quantity; this can be assured also by a few subsidiary feeders connected to the water-pipe system.

Another interesting point is the question of the responsibility of railroad companies for depreciation of the water-pipe plant. As no one has a right to the earth or to earth return, the responsibility of the railroad company has yet to be defined. Electrolysis is characteristic in its action. It will pit and seam piping in a way that rust does not, and in lead pipe solvents are always present in large quantities around or adhering to the pipe. Electrolysis in brass always eats it to needle points or knife edges. The soil through which the railroad and the pipes run has a great deal to do with the division of current between the two parallel circuits of water pipe and rails. Clay, as a rule, is the best insulator. Loam charged with salt water offers the lowest resistance. If loam or clay be charged with coal gas or sewer gas, the resistance is greatly reduced. Dry sand ranks next to clay as an insulator, and wet sand next to loam. Soil having water underlying it is always a low conductor; the current leaving the rail increases the capillary activity of the soil and draws water towards the rail. The rail positive to the soil is always moist. — Extract from an article by ALBERT B. HERRICK, in *The Engineering Magazine.*

The Liquefaction of Hydrogen Gas.

Some few particulars are given in a recent issue of the New York *Sun*, concerning the liquefaction of hydrogen by Professor Dewar. All of the other familiar gases had been liquefied previously, so that the final reduction of hydrogen to the liquid condition has a special interest for the physicist. "The Polish scientist Olszewski," says the *Sun*, "forestalled the present discovery a year or two ago by determining accurately the critical temperature and boiling-point of hydrogen, but he did not succeed in reducing the gas to the liquid form in a really practical way, so that it could be examined and its properties tested. This has now been done for the first time by Professor Dewar (in England), and most interesting are the discoveries which are certain to develop from experiments made at the inconceivably low temperature of 327° Fahrenheit below zero. This is within 124° of the absolute zero of cold, and in this neighborhood matter undergoes astonishing changes in all its characteristics. [The meaning of the phrase "critical temperature of a gas" is explained in The Locomotive for November, 1891, and an article on "Absolute Zero" was printed in our issue for August, 1892.]

"Professor Dewar explained his latest researches at a meeting of the Royal Society this week, and his disclosures were received with extraordinary interest. Two or three years ago Professor Dewar showed that a jet of hydrogen could be used to cool bodies below any temperature that could be reached by the use of liquid air; but all attempts to collect the liquid hydrogen in vacuum-jacketed vessels failed. The type of apparatus used in these experiments worked well, and it was therefore resolved to construct a much larger liquid-air plant, and to combine with it arrangements for the liquefaction of hydrogen. On Tuesday, May 10th, a start was made with hydrogen cooled to —337° Fahr., and under a pressure of 180 atmospheres, escaping continuously from the nozzle of a coil of pipe at the rate of about ten or fifteen cubic feet per minute, in a vacuum-jacketed vessel with double-silvered walls, and of special construction, all surrounded with a space kept below —328° Fahr. Liquid hydrogen began to drop from this vacuum-jacketed vessel into another, doubly isolated by being surrounded with a third vacuum-jacketed vessel. In about five minutes twenty cubic centimetres of liquid hydrogen were collected, and then the hydrogen jet froze up from the solidification of air in the pipes. The yield of liquid was about 1 per cent. of the gas. Five gallons were produced in an hour. Hydrogen in the liquid condition is clear and colorless, showing no absorption spectrum, and with a meniscus as well defined as in the case of liquid air.

"The liquid hydrogen, in Professor Dewar's opinion, must have a high refractive index and dispersion, and its density must be in excess of the theoretical density — 0.18 to 0.12 — which we deduce respectively from the atomic volume of organic compounds and the limiting density found by Amagat for hydrogen gas under infinite compression. Professor Dewar's old experiments on the density of hydrogen occluded by palladium gave a value of 0.62 for the density of the gas when combined in this way. Not having arrangements at hand to determine the boiling point, he made two experiments to prove the excessively low temperature of the boiling fluid. In the first place, if a long piece of glass tubing, sealed at one end and open to the air at the other, is cooled by immersing the closed end in liquid hydrogen, the tube immediately fills with solid air where it is cooled. The second experiment was made with a tube containing helium — a rare gas which has hitherto resisted all attempts to effect its liquefaction. Two years ago, arguing by analogy of the molecular weights of fluorine and oxygen, Professor Dewar suggested that the volatility of hydrogen and helium would probably be found close together. A specimen of helium was sealed in a bulb with a narrow tube attached, and was placed in liquid hydrogen, when a distinct liquid was seen to condense. From this result it would appear that there cannot be any great differences in the boiling points of helium and hydrogen. All known gases have now been condensed into liquids which can be manipulated at their boiling points under atmospheric pressure in suitably arranged vacuum vessels. With hydrogen as a cooling agent we shall get within a few degrees of the absolute zero of temperature. No one can predict the properties of matter when totally deprived of heat. Faraday liquefied chlorine in the year 1823. Sixty years later Wroblewski and Olszewski produced liquid air, and now, after fifteen years' interval, the remaining gases, hydrogen and helium, appear as static liquids."

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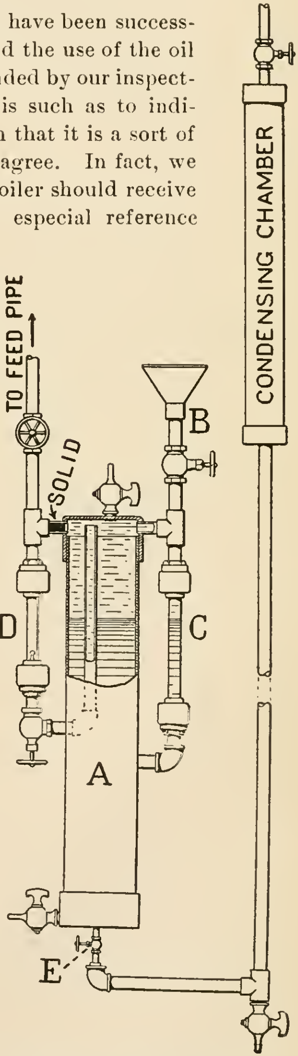
Mineral Oils as Scale Preventives.

Crude petroleum, and the products obtained from it, have been successfully employed for removing scale from steam boilers, and the use of the oil itself, or of some of its derivatives, is frequently recommended by our inspectors in certain localities where the quality of the water is such as to indicate that good results would follow. Its advocates claim that it is a sort of universal panacea for boiler ills, but with this we cannot agree. In fact, we believe that the scale preventive that is to be used in a boiler should receive the most careful attention, and should be selected with especial reference to the conditions under which the boiler is run. Petroleum derivatives, however, are certainly valuable in many places, and it is our purpose, in the present article, to give some information concerning their nature and action, and the best way of using them.



Apparatus for Introducing Kerosene into Boilers.

Oil, unlike most other substances used for the prevention and removal of scale, does not act chemically. It does not dissolve nor destroy the scale. It modifies the form in which new scale matter is deposited, and causes old scale to flake off copiously, and fall to the bottom of the shell.

It is of the utmost importance, whenever scale preventives are used in a boiler that is already scaled to a considerable extent, that the boiler should be systematically opened and cleaned at frequent intervals. This is particularly true when oil is the medium used; and if this precaution is overlooked or neglected, the scale that flakes off will lodge on the tubes and shell so as to prevent the free access of water to the iron, and the result will almost certainly be, that the tubes will be burned and bent and the sheets overheated and bulged. This danger must be borne in mind constantly, whenever a heavily-scaled boiler is treated with a compound that acts quickly.

Crude petroleum is sometimes called "rock oil," and sometimes "well oil." It varies considerably in composition, and the lighter oils are best adapted for use in boilers, since the heavier kinds, when used in the crude state, contain asphalt and other objectionable substances in considerable amounts. When crude petroleum is used for the prevention or removal of scale, it is of the highest importance that it should be pure "well oil"; for the crude oil is often mixed with tallow or some other similar grease, to form a heavy-bodied oil for lubricating car journals and other bearings that are subjected to great pressure. Oil thus modified retains the peculiar color and pungent odor of crude petroleum, so that it is likely to be confounded with it. The introduction of tallow into the boiler in this way would cause great trouble, and would almost certainly ruin the boiler if the practice were continued for any length of time, owing to the tallow coating the plates and forming a sludge with fragments of loose scale, which would keep the plates out of contact with the water, and cause them to become burned or bulged. The lighter oils having a density of from 38° to 46° Baumé are the best adapted, of the crude oils, for use as scale preventives. Owing to the differences in crude oils, and the danger of getting a mixed or "sophisticated" oil when buying unrefined petroleum in small quantities, engineers and manufacturers find kerosene to be quite satisfactory as a substitute. Kerosene is nearly or quite as effective, and as it is almost entirely free from asphalt and the heavier paraffins, it cannot combine with the sediment, nor form oily deposits on the heating surfaces.

In using crude petroleum or kerosene as a scale preventive, it is usual to introduce the oil into the boiler by means of an automatic sight-feed device, similar to those that are used for lubricating engine cylinders, since this method of introduction enables the engineer to gauge the amount supplied, very nicely. Numerous devices for this purpose are advertised in the trade papers. A good form of feeder is also shown in the *American Machinist* for June 16, 1898. A modified form of this apparatus is shown in the engraving. *A* is a piece of 4-inch pipe, which is capped at the top and bottom. C is a gauge glass, which shows the quantity of kerosene in the reservoir. *B* is a funnel by means of which the reservoir, *A*, is filled. *D* is a sight-feed for regulating the flow of oil, which rises, drop by drop, into the feed pipe, which passes along just above. The "condensing chamber" consists of a length of (say) 2-inch pipe, which is connected with the steam space of the boiler. Steam condenses in the "condensing chamber," and the water of condensation gives a static head, by means of which the oil in *A* is caused to pass out through the sight-feed, *D*, the flow of the condensed water into *A* being regulated by means of the small valve *E*. As the apparatus is practically balanced, so far as the direct boiler pressure is concerned, it is necessary for the "condensing chamber" to stand *above* the water level in the boiler, in order to get the static head required for the delivery of the oil. The upper nipple on the left, which is marked "solid," is filled with a lead plug, since its only purpose is to unite *D* rigidly to the reservoir *A*.

To fill the reservoir, *A*, with kerosene, we close the valve E, and also the one in the pipe leading to the feed pipe. Then we open the two pet cocks at the top and bottom of *A*. When the water in *A* has run off, we close the lower pet cock, and then fill the reservoir by means of the funnel *B*. When it is full, and all the air has been expelled from *A*, we close the upper pet cock and also the valve just below *B*, and the apparatus is ready for work again.

Some difficulty will be found in packing the glass gauges tightly enough to prevent the escape of oil. The plan recommended by Mr. Dutcher in the *American Machinist* is a very good one. He proposes a solid rubber washer, about an inch long, and made to fit the glass on the inside, and the reducer on the outside.

Although we have illustrated this device for the benefit of those who desire to use kerosene in this way, we are of the opinion that the introduction of the oil daily, mixed with the feed water, is not the most effective method of using oil for the removal of scale that has already formed on the plates. We believe that very much better results would be obtained as follows: The boiler is thoroughly dried out so as to remove all moisture from the scale. This is accomplished by opening the manhole and handholes, as soon as the boiler is blown down. When the boiler is cooled down sufficiently to be entered for examination and cleaning, the scale will have become dry. All sediment and loose fragments should then be brushed out, and kerosene oil sprayed over the plates and tubes, so as to saturate the scale thoroughly. The oil which accumulates in the bottom of the boiler will rise on the surface of the water when the boiler is filled, and be brought in contact with such parts of the tubes as may not be reached by the direct spray. Oil so applied will penetrate the scale and loosen it from the iron. The boiler should then be opened in a week or two, and all loose scale be removed. It is important to attend to this part of the operation, as otherwise there is great danger of the loose scale collecting upon the fire sheets, and causing them to burn or bulge, as already pointed out in this article. In tubular boilers it is often necessary to break down the scale lodged between the tubes. In water-tube boilers it is necessary to dry out as above described, uncap the tubes, and then, with a mop saturated in kerosene, brush through the tubes until the scale is saturated. If the boiler is allowed to stand for 24 hours, a scraper will remove considerable scale on which it would have no effect previous to the saturation of the scale with kerosene. Opening and scraping the tubes after running the boiler for a week will remove much larger quantities. The thorough *drying* of the boilers is important, when this method is used, since oil will not penetrate wet scale. Open lights should not be used in or about the boiler when applying kerosene oil as above described.

Another valuable use of kerosene, which is not generally known, is in removing lubricating oils from boilers that have become fouled by the return of the oil used to lubricate engine or pump cylinders. Of course every effort should be made, and every precaution used, to *prevent* the boiler from becoming fouled or even slightly coated with lubricating oil, as otherwise the boiler is likely to be injured or ruined by overheating and distortion of the plates, or, in water tube boilers, by the rupture of the tubes. In our work of inspection, however, we often find boilers saturated with this oil, and many times more or less injured. The lubricating oil, when once introduced, cannot be removed by washing, and it will not saponify so as to leave the plates clean, even when the boiler is boiled out with soda ash or potash. A residue remains adhering to the plates. If the engineer, in such cases, will clean the fire sheets by wiping them with a mop dipped in kerosene, he will find that the lubricating oils will readily dissolve. Water-tube boilers should have their tubes mopped out in a similar manner. Saturating the parts inaccessible to the mop with kerosene will remove the oil, if the operation is repeated two or three times.

Our conclusions may be summed up as follows: Mineral oil is often useful for the prevention or removal of scale, when it is properly applied; in the prevailing method of introduction, it gives good results in many cases; but when it has not proved as effective as desired, we recommend that the boiler be dried out, and that the kerosene be sprayed upon the plates and tubes. It is important to avoid the use of open lights in or about a boiler that is being so treated; incandescent electric lights are the safest to use. Finally, kerosene is very serviceable for removing lubricating oils from plates and tubes.

Inspectors' Report.

MAY, 1898.

During this month our inspectors made 7,874 inspection trips, visited 15,635 boilers, inspected 6,789 both internally and externally, and subjected 568 to hydrostatic pressure. The whole number of defects reported reached 10,283, of which 1,197 were considered dangerous; 54 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,189	57
Cases of incrustation and scale,	2,347	95
Cases of internal grooving,	120	19
Cases of internal corrosion,	701	40
Cases of external corrosion,	560	26
Broken and loose braces and stays,	302	100
Settings defective,	367	43
Furnaces out of shape,	381	13
Fractured plates,	389	43
Burned plates,	304	23
Blistered plates,	165	37
Cases of defective riveting,	717	227
Defective heads,	90	20
Serious leakage around tube ends,	1,260	245
Serious leakage at seams,	331	29
Defective water-gauges,	238	54
Defective blow-offs,	136	41
Cases of deficiency of water,	15	8
Safety-valves overloaded,	43	16
Safety-valves defective in construction,	86	25
Pressure-gauges defective,	429	18
Boilers without pressure-gauges,	18	18
Unclassified defects,	95	0
Total,	10,283	1,197

Boiler Explosions.

MAY, 1898.

(105.) — On May 4th a boiler belonging to Samuel Otto exploded near Baltimore, Md. Nathan Patrick was injured.

(106.) — A portion of the plant of the Passaic Rolling-Mill company of Paterson, N. J., was wrecked by a boiler explosion on May 4th. Fireman Edward Canser was instantly killed, and William Sherlock, Emil Derries, and Pasquale Marco were struck by flying fragments of the boiler and fatally injured. Two other men were also injured in a lesser degree. Canser's body was thrown 100 feet, passing over a railroad trestle. The boiler and engine-house, which was of brick, were completely destroyed. One end of the adjoining girder-mill was also demolished. The property loss was about $75,000.

(107.) — On May 4th a boiler exploded in Elias Bailey's mill at Orange, near Grantsburg, Wis. Mr. Bailey was injured so badly that he died about three hours later. The mill hands had left the mill for the day, so that they escaped injury.

(108.) — A boiler exploded on May 5th in T. Kauffman's machine-shop at Osborn, near Xenia, Ohio. Both heads of the boiler were blown out. The steam pressure at the time was only from 30 to 40 pounds.

(109.) — Robert Hermann, owner of a grain elevator at Kaufman, Ill., was seriously and perhaps fatally injured, on May 5th, by a boiler explosion. The boiler had been recently repaired, and the engineer was raising steam upon it for the first time since the completion of the work, when it suddenly exploded. Mr. Hermann was scalded on the face, arms, legs, and back. The engineer, John Ohren, was also fearfully burned, and he inhaled some of the steam. At last accounts both men were living, but were in a very dangerous condition.

(110.)— The boiler of locomotive No. 1,262, attached to an extra east-bound freight train on the Baltimore & Ohio railroad, exploded on May 8th near Watersville, Carroll county, Md. Engineer Clinton Burns and Fireman James E. Schillinger were buried under a huge pile of debris, and were evidently killed almost instantly. The locomotive was blown into fragments, and three cars of the freight train were derailed. The explosion tore up the tracks for a considerable distance.

(111.) — A boiler exploded on May 8th in Gottlieb Eyermann's quarry, St. Louis, Mo., just as the men were quitting work. Nobody was hurt.

(112.) — A slight boiler explosion occurred on May 10th in the I. H. Dewey Furniture Company's factory at Rochester, N. Y. The fire was blown from the furnace out into the room, which was ablaze almost instantly. The flames were promptly controlled, however, by the prompt arrival of a fire company, whose house is close by. Engineer Thomas Reilly, of the Dewey company, was burned about the face and neck.

(113.) — On May 12th an upright boiler exploded in a quarry just east of the city of Raleigh, N. C. Superintendent Charles Wallen, Engineer John Wood, and Fireman Edward Tate were seriously scalded. Tate's injuries are most severe, as he was firing the boiler at the time of the explosion.

(114.) — One of the safety boilers in the Edison company's Market street power-house, in Chicago, exploded on May 14th. Fortunately nobody was injured.

(115.) — A boiler in McFarlin Brothers' mill at Conway, five miles east of Petoskey, Mich., exploded on May 14th. The mill was demolished. Engineer Louis Robinson and John Hetch, a workman, were instantly killed. George Ballou was struck by flying wreckage, and was injured so badly that he can live but a short time. Arthur McFarlin, one of the proprietors, was also injured to some extent, but will recover.

(116.) — Edward Taylor was injured, on May 15th, by a slight boiler explosion on the Lindsay lease, at Cripple Creek, Colo. He was taken to the Pike's Peak Hospital, where it was said that he will recover.

(117.) — A fatal wreck occurred on the Erie railroad, on May 15th, about one mile east of Greycourt, near Goshen, N. Y. The boiler of locomotive No. 865, which was drawing a west-bound freight train, exploded while coming down the Oxford grade at a high rate of speed. The locomotive and a number of the freight cars were badly wrecked, and both tracks were blocked for some hours. Engineer William Cronk and

Fireman Isidor Franklin were instantly killed. Cronk was buried under the debris of the wrecked engine, and Franklin was blown 200 feet into a field.

(118.) — Emanuel Helser's saw-mill at Sayre, near Lancaster, Ohio, was wrecked on May 18th by a boiler explosion. Two men were injured.

(119.) — A boiler exploded, on May 19th, in W. H. Ward's coffin factory at Hertford N. C. Nobody was injured.

(120.) — On May 19th a boiler exploded in Hamilton & Dailey's stone quarry at Sharon, Pa. Bernard Johnston was blown forty feet and fatally injured. Two other workmen were also seriously hurt.

(121.) — A boiler exploded, on May 21st, in Speer & Co.'s saw-mill, four miles south of Mena, Ark. Engineer John Carpenter received injuries which will probably prove fatal. The mill was badly wrecked.

(122.) — The boiler of the pumping engine of the San Antonio & Aransas Pass railway, at West Point, Texas, exploded on May 23d. The explosion completely demolished the pumping machinery, and badly-wrecked the building in which it stood. Thomas Lynch, Thomas Reynolds, and a man named Richards were badly scalded and otherwise injured.

(123.) — A boiler exploded, on May 23d, in Charles Delp's mills, near Fanshawe, I. T. James Wilkinson, James Campbell, and two other men named Owens and Davenport.

(124.) — The boiler in A. J. Cunningham's mattress factory, at Sterling, Ill., exploded on May 27th. Nobody was seriously injured.

(125.) — A boiler exploded, on May 27th, in a mill at Murray, Iowa. We have not learned particulars.

(126.) — The boiler of the locomotive of the mixed noon train on the Hoosac & Wilmington railroad exploded, on May 31st, near the station at Wilmington, Vt. Engineer Zephaniah H. Douglass and Fireman Ernest T. Faulkner were killed. The locomotive and its tender were blown to pieces.

The Temperature of Boiler Plates.

Mr. Halliday and Mr. Seabury have worked up a very lengthy paper for the Institute of Marine Engineers of England, on water-tube boilers, from which we quote a few experiments that they have referred to for the benefit of those who believe in running with clean boilers.

The behavior of the plate which transmits the heat from the flame to the water is now of great interest, and especially so where the transmission is forced. But little was known of the temperature of the sides of the plate, even, until A. C. Kirk and Sir John Durston made experiments to ascertain the facts. The method adopted by both to obtain temperatures was the same; namely, by means of fusible plugs inserted in the bottom of the vessels with which the experiments were made. It was assumed that the temperature of the metal on the water side was the same as the temperature of the water. Sir John made some of his experiments with an open dish 10 inches in diameter, 8 inches deep, and a quarter of an inch thick. He placed this dish, containing water, over a flame at a temperature of 1500° F. Fusible pieces of solder, ranging in melting point from 220° to 250° F., were fixed on the bottom. With these he ascertained the temperature to be 240° F. The water was open to the atmosphere, and was at a temperature of 212°. A layer of grease obtained from the interior of a ship's boiler was put on the inside bottom of the vessel, 1-32 of an inch thick, and this caused the temperature of the vessel's bottom next to the fire to rise to 330° F.

A flanged plate with a tube expanded into it showed a temperature at the middle of its thickness between 290° and 336° F., the temperature of the fire being about 2000° F. With a vessel having flat ends, and through tubes of steel, brass, and iron, placed vertically on a fire so that the tube-plate was subject to a heat of about 1400° F. and the pressure of steam inside the vessel 100 pounds, it was found, after being overheated and then allowed to cool, that the tubes leaked so badly that no pressure could be obtained; no difference was observed in the behavior of the tubes. The same experiment was made with lead plugs inserted in the plate, and as soon as the plugs — with a melting point of 617° F.— had melted, the vessel was taken from the fire and tested to 200 lbs. pressure, and found to be quite tight. A similar result was obtained after fusing some plugs of zinc with a melting point of 770° F. It was concluded that up to a temperature of 770° F. no damage was done to the boiler. It was further found by a series of experiments that the loss of transmitting efficiency in an iron tube due to a thin coating of grease was 11 per cent. With an open dish partly filled with fresh water and placed horizontally over a fire urged by a moderate blast, the temperature of the plate was 240° F.; with a higher blast the temperature rose to 280° F.

These experiments show very clearly the difference in "transmitting efficiency" between a vertical and a horizontal surface, and also the very bad effect of a thin coating of grease. When the surfaces of the plate were practically clean the difference in temperature between the water side and the fire side of the plate did not exceed 100° F. even with high steam pressures, while the addition of 5 per cent. of linseed oil raised the difference by about 30° F., and a greasy deposit of 1-16 inch thick made the temperature on the fire side of the plate rise to about 300° F. above the temperature of the water side, the temperature of the fire varying from about 2300° to 2500° F. Variations in the pressure did not alter the relative temperatures of the two sides of the plate.— *Manufacturers' Gazette.*

[These experiments are interesting, but we hardly think that the fundamental assumption that was made is justifiable;— that is, we think it is quite improbable that the temperature of the plate on the water side is always the same as the temperature of the water. This may be nearly the case when the plate is bright and clean, but we are inclined to believe that a slight coating of scale, or oxide, or grease, would cause the plate to have a temperature much higher than that of the water. For example, the temperature of the outer surface of the plate was found, at the outset of these experiments, to be 240° Fahr. A layer of grease 1-32 of an inch thick on the water side then caused the temperature of the fire side to rise to 330° Fahr., or 90° higher than before. If the temperature of the inside surface remained constant, this rise of 90° on the fire side would represent an *increased* transmission of heat, because there would be a steeper temperature-gradient in the plate. But it was found that the grease coating *lessened* the heat transmission by something like 11 per cent. We should say, from this, that it is legitimate to conclude that the coating of grease caused the temperature-gradient in the plate to become (roughly) 11 per cent. less steep than it was in the first place, so that the inner surface of the plate, when protected by the grease-layer, was at a temperature of something like 305° Fahr., while the water was at 212° and the fire surface of the plate was at 330°. We do not insist upon the strict *accuracy* of this estimate, as it is given merely for the sake of illustration. The point that we wish to make is, that it is not legitimate to make assumptions when we are trying to find out the difference in temperature of the two sides of a boiler-plate in service. The only right way to do is to actually *measure* the temperature of each surface. This, however, is a very difficult thing to do; for it is almost impossible to attach any temperature-measuring device to a boiler-plate in such a way that it shall give the actual temperature of the plate without modifying that temperature by its own presence.— EDITOR.]

Indian Kettles.

Summer visitors who have found health-giving recreation along the shores of America's fairest sheet of water, Lake George, cannot have failed to notice in different localities certain strange and wonderful holes in the rocks, having a diameter of a foot or more, and with a perfectly smooth interior, as carefully made as though a stone carver had worked them out of the solid bedrock. Seek information of a resident or a tourist wonted to the locality, who is familiar with the sight of them, and the reply will come, "Oh, those are simply Indian kettles." When pressed further for an explanation, the fanciful answer is made that Indians who hunted in the Adirondack region, then known as the Great Northern Wilderness, hollowed out these holes in the rocks along the shores wherever they pitched their camp, and therein cooked their liquid food. But how, one naturally asks, did they heat so peculiar an oven, without a bottom or sides? A seemingly good explanation is given, that the liquid was placed in the hole, and a large stone, or many of them, heated and dropped in, until the temperature was raised to the boiling point. In this way large quantities of soup, enough for all the camp followers, could be made. Such is the traditional, or rather the mythical, explanation of the "kettles" to be found in plenty along the shores of Lake George ; but such is far from the true way in which these peculiar holes were constructed.

The "kettles" are the handiwork of nature, and beautifully constructed they are. There is a more common name for them, generally bestowed in regions where Indians are forgotten, and it is that of "potholes." They were made by the action of water many years ago, but, to be more definite, the state geologist will tell you that they were made something over 30,000 years ago. As these holes are found far above water, it is of interest to explain how they were formed by the water. About 50,000 years ago, almost the entire state of New York was covered by ice. The Hudson River was a frozen mass, from the high ridge of hills on the one side to the other, as is shown to-day by corresponding erosions of the rocks caused by moving ice, on both sides. Lake George bore the same appearance. From hilltop to hilltop was a single mass. Every valley was filled. Then there came a change. There was a breaking up of this immense field, and glaciers were formed. Invariably, all the glaciers of North America passed southward, although the water of Lake George now flows northerly. There is a valley now from Baldwin, at the northern end of the lake, continuing southward, which is filled with water, forming the lake. Rogers Rock, an immense elevation rising abruptly with a precipitous face toward the water, is about five miles south of the town of Baldwin and on the west side of the lake. It is one of the features of this beautiful region. To the west of this elevation is another valley, now dry. When the ice broke up, one body moved southward by way of the valley, now filled by Lake George, and the other passed to the left of Rogers Rock. The two immense bodies met at the promontory just north of the hamlet of Hague, N. Y. Eddies were formed. The larger eddies were nearest the confluence of the two streams, and smaller eddies, diminishing in size, were strung along in the general course. Bowlders carried down by the fierce current were held in these eddies and passed around and around in one spot. Knocking against the bedrock, which at this locality is crystalline limestone, they wore a hole. Gradually it increased in depth and diameter, until after many years there was formed a hole of considerable size. Some of these potholes — and there are twenty-two of them on the one promontory of one-fourth of an acre in extent — measure 40 inches in diameter and range from 6 inches to 14 feet in depth. They occur as close together as 4 feet, and normally are filled with muck formed of dry leaves and the water which collects there after a rain, for none has any natural outlet. Frequently, one finds in the holes the stone or a number of small stones, which bored the hole. They are generally worn round, and seldom weigh more than a few pounds.

Although the Lake George kettles are, perhaps, the most interesting in the country and have been seen by the greatest number of persons, they are to be found in other parts of the state of New York. In 1866, when clearing a place to establish the Harmony Knitting Mills, at Cohoes, N. Y., a large pothole was found. It appeared as a bog, like many a mountain pond covered with floating moss and to which there is no outlet below the surface because it is a bowl in the rock. Excavating disclosed the remains of a mastodon fifty feet below the surface. Evidently, in prehistoric times, the huge beast had fallen into the hole in the ground (for this one is thirty feet in diameter), and could not extricate himself because of his unwieldy form, or else his remains had been washed down with the glacier and had lodged there. The bones of this big fellow are now on exhibition in the New York State Geological rooms. It is proposed to continue the work of cleaning out these potholes, in order to gain information of the animal kingdom of centuries ago. In Scandinavia the potholes are called "Thor's kettles," and a quantity of remains of extinct animals have been found in them.

In the Canajoharie limestone many "kettles" are to be found, — in fact, the name of that city is the Indian term for Hole-in-the-Rock. Near the town of Naples, Ontario County, N. Y., where there is a valley containing four lakes, the result of a glacial wash, and where the ice was stopped by the dirt washed down with the torrent, there are a number of them of great interest. Here the rock is sandstone. Near Lucerne, Switzerland, the glaciers have formed some beautiful eccentricities in the form of potholes of a variety of shapes and sizes. Visitors always spend some time at the spot, and the place is so beautiful that it is called the Glacial Garden. The Hon. Verplanck Colvin, head of the Adirondack Survey, states that he has recently discovered a pothole located 2,000 feet above sea-level, and several hundred feet deep, but he is not prepared to make his wonderful find public.

As they vary much in size, so do they also differ considerably in appearance. Some have a cone at the bottom, while some are flat ; the surface along the sides of some is smooth as though sandpapered, while others present spiral grooves. While some are double at the top and end in a single chamber, others run down to a fine point, as though prepared for a blast of powder. All point directly downward, and a majority are large enough to admit a person's body. Perhaps the Lake George villagers are not far from right when they style these potholes Indian kettles ; for though they were not made by Indians, still they may have been put to some practical use by them, and thus the name may not be a misnomer after all. — CUYLER REYNOLDS, in *Scientific American.*

The Locomotive.

HARTFORD, JULY 15, 1898.

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 a copy of the Protocol of the 26th meeting of the International Union of Boiler Inspection Associations, which was held at Dresden, Germany, in June, 1897. In it we find an extremely valuable paper by Professor Bach, on the strength of unstayed flat surfaces. This paper is of such importance that we propose to publish an extended review of it within a short time.

WE are indebted to Herr H. Minssen, chief engineer of the Schlesischer Verein zur Ueberwachung von Dampfkesseln, of Breslau, Germany, for a complete set of bound volumes of the technical periodical of which he is editor — the "Mittheilungen aus der Praxis des Dampfkessel- und Dampfmaschinen-Betriebes." The "Mittheilungen" is an excellent journal, and is the official organ of the general association of Prussian boiler inspection companies. We also desire to acknowledge the *Report* of the Schlesischer Verein for the year 1897–8.

Horse-Power Novelties.

In the above heading we do not refer to the mechanical horse-power represented by doing 33,000 foot-pounds of work in a minute, but rather to the original and true meaning of the term before James Watt borrowed it for steam-engineering purposes.

But we need not go back to the time of James Watt to find genuine examples of horse-power. It is still used for agricultural and other purposes where horse flesh is cheaper or more common than iron, steel, and coal, and sometimes the means adopted for converting horse-power from the "noble animal" himself into mechanical horse-power are decidedly novel. Such an instance is described in a recent issue of *The Railway and Engineering Review.* In North Chicago there was a drawbridge that was designed to be operated by hand, and that was tended by a man who didn't like to work any harder than most other people do; but, unlike many other people, he had brains enough to get out of the trouble and earn for himself a place of comparative ease and comfort. He connected a treadmill with the bridge gearing and enclosed it within a stable. The horse remained standing upon the treadmill during the day ready for instant service, but for his comfort the floor of the mill was inclined only about 1 inch in 2 feet. To overcome this disadvantage a harness was arranged for the horse to brace against when operating the mill. This seems like a sensible plan, as it enabled the horse to work under more natural conditions than in the ordinary mill, and he could also conveniently take a nap between the acts. To prevent accident to the horse by falling when the mill was in motion, a strong girth was used, attached to the sides of the stall.

Not the least novel part of the system was the provision for operating the bridge at night when the horse was not there, and the man was not over anxious to be. It was arranged so that a 3,000-pound weight could be raised 26 feet high through the efforts of the horse, and the potential energy thus stored was sufficient to open the draw three times while the weight was descending to the limit of its travel.

For downright ingenuity and all-round utility, however, a country editor up on the Canadian border had a horse-power appliance that easily bore off the honors. He evidently reasoned that a horse and carriage would be a luxury for his family and that when not thus employed the horse might as well be worked in at the office.

His printing press was on the third floor. In the basement he mounted a large circular platform on a central shaft that was inclined somewhat from the vertical. This shaft was geared with a horizontal pulley through a pair of old-fashioned, beveled cog-wheels, and a vertical belt ran from the pulley up to the press. On publication day the horse was led up on to the platform and hitched, a brake having previously been set up to hold the platform stationary. When the pressman was ready he released the brake. The horse felt himself going backwards, owing to the inclination of the platform, and was obliged to commence walking in order to keep his equilibrium. The press was stopped by applying the brake until the machine went so hard that the horse had to stop.

Like the first apparatus described, this one seemed well adapted to its purpose. One leap year the weeks spaced around so that there should have been fifty-three issues of this enterprising publication; but the editor announced that his subscribers were entitled to only fifty-two numbers, and went off on a vacation instead of getting out the fifty-third. It was a one-horse paper in a one-horse town, and nothing could be more fitting than that it should have a one-horse horse-power.— *Engineering.*

Areas and Circumferences of Circles.

Although a great many tables have been published, giving the areas and circumferences of circles for various diameters, it is not common to find one in which these are given for every sixty-fourth of an inch. In the belief that such a table would be a welcome addition to engineering literature, we have calculated the table which is given on the last four pages of this issue of The Locomotive.

The diameter of the circle is given in sixty-fourths of an inch in the fifth column, and in the fourth, third, second, and first columns we have given the corresponding values of the diameter in thirty-seconds, sixteenths, eighths, and quarters, respectively, wherever the fraction that expresses the diameter in sixty-fourths admits of such expression. In the sixth column the diameters are expressed decimally, to four places of decimals. The circumferences are everywhere given to four decimals, and the areas to five. It has not been thought necessary to extend the table beyond a diameter of two inches.

The decimal diameters and the circumferences and areas have been calculated in the usual way, the values of the circumferences and areas being computed to three places of decimals beyond the last one retained in the table. The extra decimals were then rejected, the last figure preserved being increased by one unit when the rejected part was greater than half a unit in the last place preserved. The entire table was then

Table of Areas and Circumferences of Circles.

DIAMETER						CIRCUMFERENCE.	AREA.
4ths.	8ths.	16ths.	32ds.	64ths.	Decimally.		
				$\frac{1}{64}$	0.0156	0.0491	0.00019
			$\frac{1}{32}$	$\frac{2}{64}$	.0312	.0982	.00077
				$\frac{3}{64}$	.0469	.1473	.00173
		$\frac{1}{16}$	$\frac{2}{32}$	$\frac{4}{64}$	.0625	.1964	.00307
				$\frac{5}{64}$	.0781	.2454	.00479
			$\frac{3}{32}$	$\frac{6}{64}$	.0938	.2945	.00690
				$\frac{7}{64}$	.1094	.3436	.00940
	$\frac{1}{8}$	$\frac{2}{16}$	$\frac{4}{32}$	$\frac{8}{64}$	.1250	.3927	.01227
				$\frac{9}{64}$	.1406	.4418	.01553
			$\frac{5}{32}$	$\frac{10}{64}$	.1562	.4909	.01918
				$\frac{11}{64}$	.1719	.5400	.02320
		$\frac{3}{16}$	$\frac{6}{32}$	$\frac{12}{64}$	.1875	.5890	.02761
				$\frac{13}{64}$	.2031	.6381	.03241
			$\frac{7}{32}$	$\frac{14}{64}$	.2188	.6872	.03758
				$\frac{15}{64}$	.2344	.7363	.04314
$\frac{1}{4}''$	$\frac{2}{8}$	$\frac{4}{16}$	$\frac{8}{32}$	$\frac{16}{64}$	.2500	.7854	.04909
				$\frac{17}{64}$	.2656	.8345	.05542
			$\frac{9}{32}$	$\frac{18}{64}$	.2812	.8836	.06213
				$\frac{19}{64}$	.2969	.9327	.06922
		$\frac{5}{16}$	$\frac{10}{32}$	$\frac{20}{64}$	.3125	.9818	.07670
				$\frac{21}{64}$	.3281	1.0308	.08456
			$\frac{11}{32}$	$\frac{22}{64}$	.3438	1.0799	.09281
				$\frac{23}{64}$	.3594	1.1290	.10144
	$\frac{3}{8}$	$\frac{6}{16}$	$\frac{12}{32}$	$\frac{24}{64}$	.3750	1.1781	.11045
				$\frac{25}{64}$	.3906	1.2272	.11984
			$\frac{13}{32}$	$\frac{26}{64}$	.4062	1.2763	.12962
				$\frac{27}{64}$	.4219	1.3254	.13979
		$\frac{7}{16}$	$\frac{14}{32}$	$\frac{28}{64}$	.4375	1.3744	.15033
				$\frac{29}{64}$	.4531	1.4235	.16126
			$\frac{15}{32}$	$\frac{30}{64}$	.4688	1.4726	.17258
				$\frac{31}{64}$	.4844	1.5217	.18427
$\frac{1}{2}''$	$\frac{4}{8}$	$\frac{8}{16}$	$\frac{16}{32}$	$\frac{32}{64}$	.5000	1.5708	.19635

verified by taking the differences between successive areas, circumferences, and decimalized diameters. Each decimalized diameter should be greater than the one immediately before it by .0156 or .0157, and each circumference should be greater than the one immediately before it by .0490 or .0491. With the areas the case is a little more complicated. Each area in the table was subtracted from the one next following it, and

Table of Areas and Circumferences of Circles.

Diameter.						Circumference.	Area.
4ths.	8ths.	16ths.	32ds.	64ths.	Decimally.		
				$\frac{33}{64}$	0.5156	1.6199	0.20881
			$\frac{17}{32}$	$\frac{34}{64}$	.5312	1.6690	.22166
				$\frac{35}{64}$	.5469	1.7181	.23489
		$\frac{9}{16}$	$\frac{18}{32}$	$\frac{36}{64}$	.5625	1.7671	.24850
				$\frac{37}{64}$	.5781	1.8162	.26250
			$\frac{19}{32}$	$\frac{38}{64}$	.5938	1.8653	.27688
				$\frac{39}{64}$	.6094	1.9144	.29165
	$\frac{5}{8}$	$\frac{10}{16}$	$\frac{20}{32}$	$\frac{40}{64}$	.6250	1.9635	.30680
				$\frac{41}{64}$	.6406	2.0126	.32233
			$\frac{21}{32}$	$\frac{42}{64}$	.6562	2.0617	.33824
				$\frac{43}{64}$	.6719	2.1108	.35454
		$\frac{11}{16}$	$\frac{22}{32}$	$\frac{44}{64}$	.6875	2.1598	.37122
				$\frac{45}{64}$	.7031	2.2089	.38829
			$\frac{23}{32}$	$\frac{46}{64}$	.7188	2.2580	.40574
				$\frac{47}{64}$	.7344	2.3071	.42357
$\frac{3}{4}''$	$\frac{6}{8}$	$\frac{12}{16}$	$\frac{24}{32}$	$\frac{48}{64}$	.7500	2.3562	.44179
				$\frac{49}{64}$	.7656	2.4053	.46039
			$\frac{25}{32}$	$\frac{50}{64}$	.7812	2.4544	.47937
				$\frac{51}{64}$	.7969	2.5035	.49874
		$\frac{13}{16}$	$\frac{26}{32}$	$\frac{52}{64}$	.8125	2.5525	.51849
				$\frac{53}{64}$	.8281	2.6016	.53862
			$\frac{27}{32}$	$\frac{54}{64}$	.8438	2.6507	.55914
				$\frac{55}{64}$	.8594	2.6998	.58004
	$\frac{7}{8}$	$\frac{14}{16}$	$\frac{28}{32}$	$\frac{56}{64}$	.8750	2.7489	.60132
				$\frac{57}{64}$	.8906	2.7980	.62299
			$\frac{29}{32}$	$\frac{58}{64}$	.9062	2.8471	.64504
				$\frac{59}{64}$	.9219	2.8962	.66747
		$\frac{15}{16}$	$\frac{30}{32}$	$\frac{60}{64}$	.9375	2.9452	.69029
				$\frac{61}{64}$	.9531	2.9943	.71349
			$\frac{31}{32}$	$\frac{62}{64}$	.9688	3.0434	.73708
				$\frac{63}{64}$	.9844	3.0925	.76105
1'	$\frac{8}{8}$	$\frac{16}{16}$	$\frac{32}{32}$	$\frac{64}{64}$	1.0000	3.1416	.78540

the differences so obtained were set down in a column, in regular order. Each of the new numbers so obtained ought then to be greater than the one immediately before it by either .00037, .00038, or .00039. These tests were applied to the accompanying table throughout, after it was in type; so that there is hardly any chance of its containing any serious error.

Table of Areas and Circumferences of Circles.

DIAMETER.						CIRCUMFERENCE.	AREA.
4ths.	8ths.	16ths.	32ds.	64ths.	Decimally.		
				$1\frac{1}{64}$	1.0156	3.1907	0.81013
			$1\frac{1}{32}$	$1\frac{2}{64}$	1.0312	3.2398	.83525
				$1\frac{3}{64}$	1.0469	3.2889	.86075
		$1\frac{1}{16}$	$1\frac{2}{32}$	$1\frac{4}{64}$	1.0625	3.3379	.88664
				$1\frac{5}{64}$	1.0781	3.3870	.91291
			$1\frac{3}{32}$	$1\frac{6}{64}$	1.0938	3.4361	.93956
				$1\frac{7}{64}$	1.1094	3.4852	.96660
	$1\frac{1}{8}$	$1\frac{2}{16}$	$1\frac{4}{32}$	$1\frac{8}{64}$	1.1250	3.5343	.99402
				$1\frac{9}{64}$	1.1406	3.5834	1.02182
			$1\frac{5}{32}$	$1\frac{10}{64}$	1.1562	3.6325	1.05001
				$1\frac{11}{64}$	1.1719	3.6816	1.07858
		$1\frac{3}{16}$	$1\frac{6}{32}$	$1\frac{12}{64}$	1.1875	3.7306	1.10753
				$1\frac{13}{64}$	1.2031	3.7797	1.13687
			$1\frac{7}{32}$	$1\frac{14}{64}$	1.2188	3.8288	1 16659
				$1\frac{15}{64}$	1.2344	3.8779	1.19670
$1\frac{1}{4}''$	$1\frac{2}{8}$	$1\frac{4}{16}$	$1\frac{8}{32}$	$1\frac{16}{64}$	1.2500	3.9270	1.22718
				$1\frac{17}{64}$	1.2656	3.9761	1.25806
			$1\frac{9}{32}$	$1\frac{18}{64}$	1.2812	4.0252	1.28931
				$1\frac{19}{64}$	1.2969	4.0743	1.32095
		$1\frac{5}{16}$	$1\frac{10}{32}$	$1\frac{20}{64}$	1.3125	4.1233	1.35297
				$1\frac{21}{64}$	1.3281	4.1724	1.38538
			$1\frac{11}{32}$	$1\frac{22}{64}$	1.3438	4.2215	1.41817
				$1\frac{23}{64}$	1.3594	4.2706	1.45134
	$1\frac{3}{8}$	$1\frac{6}{16}$	$1\frac{12}{32}$	$1\frac{24}{64}$	1.3750	4.3197	1.48489
				$1\frac{25}{64}$	1.3906	4.3688	1.51883
			$1\frac{13}{32}$	$1\frac{26}{64}$	1.4062	4.4179	1.55316
				$1\frac{27}{64}$	1.4219	4.4670	1.58786
		$1\frac{7}{16}$	$1\frac{14}{32}$	$1\frac{28}{64}$	1.4375	4.5160	1.62295
				$1\frac{29}{64}$	1.4531	4.5651	1.65843
			$1\frac{15}{32}$	$1\frac{30}{64}$	1.4688	4.6142	1.69428
				$1\frac{31}{64}$	1.4844	4.6633	1.73052
$1\frac{1}{2}''$	$1\frac{4}{8}$	$1\frac{8}{16}$	$1\frac{16}{32}$	$1\frac{32}{64}$	1.5000	4.7124	1.76715

DESTRUCTION OF A SPANISH WAR VESSEL.— On May 10th a British steamer passed a Spanish torpedo boat destroyer which was guarding Algeciras bay and straits, near Gibraltar. Shortly after the steamer passed, all the lights of the destroyer were suddenly extinguished, a terrific explosion followed, and the destroyer disappeared. Her boilers probably exploded, and it is believed that all on board of her perished.

A BOILER EXPLODES AT HAVANA.—Word was received from Havana, Cuba, some

Table of Areas and Circumferences of Circles.

Diameter.						Circumference.	Area.
4ths.	8ths.	16ths.	32ds.	64ths.	Decimally.		
				$1\frac{33}{64}$	1.5156	4.7615	1.80415
			$1\frac{17}{32}$	$1\frac{34}{64}$	1.5312	4.8106	1.84154
				$1\frac{35}{64}$	1.5469	4.8597	1.87932
		$1\frac{9}{16}$	$1\frac{18}{32}$	$1\frac{36}{64}$	1.5625	4.9087	1.91748
				$1\frac{37}{64}$	1.5781	4.9578	1.95602
			$1\frac{19}{32}$	$1\frac{38}{64}$	1.5938	5.0069	1.99494
				$1\frac{39}{64}$	1.6094	5.0560	2.03425
	$1\frac{5}{8}$	$1\frac{10}{16}$	$1\frac{20}{32}$	$1\frac{40}{64}$	1.6250	5.1051	2.07394
				$1\frac{41}{64}$	1.6406	5.1542	2.11402
			$1\frac{21}{32}$	$1\frac{42}{64}$	1.6562	5.2033	2.15448
				$1\frac{43}{64}$	1.6719	5.2524	2.19532
		$1\frac{11}{16}$	$1\frac{22}{32}$	$1\frac{44}{64}$	1.6875	5.3014	2.23654
				$1\frac{45}{64}$	1.7031	5.3505	2.27815
			$1\frac{23}{32}$	$1\frac{46}{64}$	1.7188	5.3996	2.32015
				$1\frac{47}{64}$	1.7344	5.4487	2.36252
$1\frac{3}{4}''$	$1\frac{6}{8}$	$1\frac{12}{16}$	$1\frac{24}{32}$	$1\frac{48}{64}$	1.7500	5.4978	2.40528
				$1\frac{49}{64}$	1.7656	5.5469	2.44843
			$1\frac{25}{32}$	$1\frac{50}{64}$	1.7812	5.5960	2.49195
				$1\frac{51}{64}$	1.7969	5.6450	2.53586
		$1\frac{13}{16}$	$1\frac{26}{32}$	$1\frac{52}{64}$	1.8125	5.6941	2.58016
				$1\frac{53}{64}$	1.8281	5.7432	2.62483
			$1\frac{27}{32}$	$1\frac{54}{64}$	1.8438	5.7923	2.66989
				$1\frac{55}{64}$	1.8594	5.8414	2.71534
	$1\frac{7}{8}$	$1\frac{14}{16}$	$1\frac{28}{32}$	$1\frac{56}{64}$	1.8750	5.8905	2.76117
				$1\frac{57}{64}$	1.8906	5.9396	2.80738
			$1\frac{29}{32}$	$1\frac{58}{64}$	1.9062	5.9887	2.85397
				$1\frac{59}{64}$	1.9219	6.0377	2.90095
		$1\frac{15}{16}$	$1\frac{30}{32}$	$1\frac{60}{64}$	1.9375	6.0868	2.94831
				$1\frac{61}{64}$	1.9531	6.1359	2.99606
			$1\frac{31}{32}$	$1\frac{62}{64}$	1.9688	6.1850	3.04418
				$1\frac{63}{64}$	1.9844	6 2341	3.09270
$2''$	$1\frac{8}{8}$	$1\frac{16}{16}$	$1\frac{32}{32}$	$1\frac{64}{64}$	2.0000	6.2832	3.14159

little time ago, to the effect that a boiler had exploded at the arsenal of Marinelena, the Havana government dock, within a stone's throw of where the Maine lies. Seven workmen were reported killed, and fifteen were wounded. The explosion shook everything in the vicinity, and the excited crowd imagined that the American fleet was then off the harbor and had begun a bombardment. Men, women, and children immediately started inland, and the police and the volunteers had to use force to restore order and allay fear.

Incorporated
1866.

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Charter Perpetual.

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The Locomotive.

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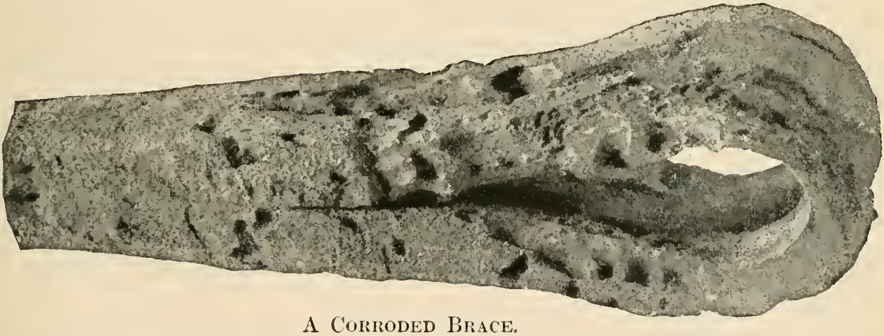
A Peculiar Case of Corrosion.

It is a matter of common observation that steam boilers are sometimes erratic in their behavior. They may run along all right for a considerable time, and then suddenly develop a defect that appears to be without adequate assignable cause. Usually a careful examination of the surroundings and conditions under which the boiler is run will show, beyond doubt, what the source of the trouble is; but it occasionally happens that the cause can only be conjectured with more or less probability, and is never established upon a satisfactory basis of certainty.

An interesting case of this latter kind came to our attention some few years ago, and as the trouble was only temporary, and has never since returned, we feel a sufficient degree of confidence in the explanation that we proposed at the time, to lay the case before our readers. The boiler in question had been inspected not long before, and had been found to be in good condition, with the shell, tubes, rivets, and braces quite sound, and reasonably clean. At one inspection, however, it was discovered that a violent corrosive action had set in since the previous visit. At the rear end of the boiler the plates and tubes had begun to pit badly, and the rivet heads and the submerged braces were wasting away with alarming rapidity. The engravings will give some idea of the condition in which these parts were found. It was obviously of great importance that the cause of the destructive action should be discovered and removed.



A Corroded Brace.

As the boiler had been running for a number of years under what appeared to be identically the same conditions, it was natural to look for the cause of the corrosive action outside of the boiler-room; and our attention was directed first of all to the feed water. The reservoir from which the supply was drawn was carefully examined, although it was not thought probable, even at the outset, that the root of the difficulty lay here. Nevertheless, the reservoir and its surroundings were investigated, in order that the search might be thorough. It consisted in a small pond, about a mile from the factory. There was no visible source of contamination which might account for the corrosion. There were two houses and a barn on the watershed and near the stream; but everything about both of these places appeared to be neat and clean, and as there had been no changes in the drainage for some years, it could not be supposed that the sudden corrosive action was due to organic acids derived from either of these houses or from the barn. A sample of water was taken from the reservoir, and subsequent analysis fully confirmed this conclusion, as the sample was found to be very pure and free from corrosive elements, and to consist chiefly of surface water from a practically uninhabited watershed.

A CORRODED RIVET.

The question of the drips from the various departments of the factory was then taken up. There were no signs of oil in the boiler, and no recent change had been made in the lubricants used about the engine. Attention was therefore directed toward the vulcanizing department, where large quantities of rubber were vulcanized by steam heat. Some of the vulcanizers were "closed," so that the steam never came into direct contact with the rubber; but in the majority of them the articles to be vulcanized were placed in vessels that were provided merely with loosely fitting lids. These vessels, filled with the rubber goods, were then immersed in steam of the requisite temperature, until the vulcanization was effected. It was thought possible that some organic product might be distilled off from the rubber and returned to the boiler by means of the drips; and some color of probability was given to this hypothesis by the fact that the engineer stated that at times an odor of rubber was plainly noticeable about the engine. However, it was found that no change in the process of vulcanizing had been made for a considerable time, and the vulcanizer hypothesis was therefore abandoned, since it failed to account for the sudden appearance of the corrosive action, after the vulcanizers had been run in precisely the same way for several years without giving the least trouble. Moreover, it did not seem probable that any distillate from the rubber would be likely to produce such rapid and severe destruction of the metal of the boiler.

The entire system of steam piping was then traced out, and it was found that the drips from the various parts of the works were all returned to an underground cistern, situated some three hundred feet from the boiler-house. This cistern, which was of brick, was only about twenty-five feet from the "pickling shop," where various small metal articles were cleaned by immersion in acid baths, preparatory to plating them with nickel. It was thought probable that a small underground passage had opened up between the pickling shop and the cistern, so that such portions of the acid baths as might be spilled upon the floor of the shop could find their way into the cistern. A sample of water taken from the cistern was then analyzed, and it was found to be quite free from acid of any kind, and to be, in fact, of practically the same composition as the sample that was taken from the main reservoir from which the feed water was originally taken. This appeared to dispose of the acid-leak hypothesis, and at the same time it completed the proof against the vulcanizer theory, by showing that the vulcanizer drips had not carried any sensible amount of organic matter into the cistern.

Only one credible explanation remained, and hence we concluded that it was to this that the corrosion was due. The cistern which collected the drips was, as we have said, below the surface of the ground. Wagons were driven in over it, to bring supplies to the pickling shop. These supplies consisted chiefly of carboys of sulphuric and muriatic acids, which were unloaded nearly over the cistern, and left outside on the ground until they were wanted, or until it became convenient to store them elsewhere. Now if one of these carboys should be broken, and the fragments of glass were cleared away, there would be no way for the office to know whether the acid so lost were used in the pickling shop, or wasted; and the one remaining plausible explanation to which we referred at the beginning of this paragraph is, that some workman, either unavoidably or through carelessness, did break one of the carboys, perhaps in unloading it from the wagon. Fearing that the value of the acid would be charged up against him and deducted from his wages if the true state of affairs were known, he probably reported the acid as used in the pickling baths, when it really was spilled on the ground, and part of it, after percolating into the cistern, was introduced into the boiler with the feed. This theory appears to fit all the requirements of the case. It explains the suddenness and intensity of the corrosive action. It is also consistent with the fact that no such action had been observed before, and that nothing of the kind has manifested itself in the three years or more that have elapsed since. We cannot, of course, be certain that we have found the real origin of the trouble, because the case is one of those referred to at the beginning of this article, where " the cause can only be conjectured with more or less probability." But we believe that we were right, and in any event the incident affords an excellent illustration of the necessity of keeping a watchful eye on the boiler and all its surroundings. We once heard a philosopher say that men are strange creatures, inasmuch as the best of them will go along all right for years, and become known for his integrity and general moral rectitude; and then suddenly, without the least warning, he will do some foolish or dishonest thing, which loses for him all the confidence and respect that years of good behavior have won. We shall not undertake to pronounce upon the accuracy of this observation, so far as it applies to *men;* but we can certify that it is strictly true of *boilers.* The only good Indian is said to be a dead Indian; and the only boiler that doesn't need watching, is the old, condemned one that lies in the yard on the scrap heap.

Boiler Explosions.

June, 1898.

(127.) — A boiler exploded, on June 1st, in Tobias New's tar-roof factory, in New York. Victor Brocht, Philip Greenfield, Joseph Lomatino, Tobias New, John O'Neil, and Victor Rush were severely burned and bruised, and were removed to the hospital. Five other persons received slight injuries. The entire plant was destroyed, and the damage is estimated at $75,000.

(128.) — On June 1st a boiler exploded in the 28-inch mill of the Homestead steel works, Pittsburgh, Pa. Joseph Ebanish, a coal passer, was burned over the head and body so badly that he will die. Henry Dodge, Michael Konviski, and John Mongel were also severely burned and scalded, but it is believed that they will recover. We have seen no estimate of the property loss.

(129.) — On June 1st a boiler exploded in Charles Phelps' mill, near Cameron, in the Choctaw nation. James Wilkinson, James Campbell, and two young men named Owens and Davenport were killed. The mill also sustained considerable damage.

(130.) — The Geneva Paint Factory, at Geneva, Ohio, was destroyed by a boiler explosion on June 2d. The only persons in the building at the time were Ely C. Bartholomew and Engineer George McGee. Mr. Bartholomew was injured so badly that he died later in the day. Mr. McGee was also severely burned about the neck, face, hands, and arms.

(131.) — A small boiler exploded, on June 4th, in P. F. Olds & Son's engine works, at Lansing, Mich. M. F. Bates and Edward Brown were severely injured, and the building in which the boiler stood was badly damaged.

(132.) — On June 5th a boiler exploded at the No. 22 Forest oil well, at McDonald, near Washington, Pa. Roy Goe was killed, and his father, Robert Goe, was badly injured.

(133.) — On June 7th a boiler exploded in G. H. Eckler's turning mill, at Flint, Mich. The mill took fire, and was totally destroyed. It does not appear that any one was injured.

(134.) — A boiler exploded, on June 7th, in the Arkansas Mining Company's plant at Hatfield, some 50 miles north of Texarkana, Ark. One man, named Faulkner, was killed, and twelve others were severely injured.

(135.) — The boiler of the locomotive *John Campbell* exploded, on June 14th, on the Ironton railway, just outside of Ironton, Ohio. Engineer Robert Royer was killed and his body was blown into the river, from which it has not been recovered. Fireman Andrew Foit and Brakeman Hobble were fatally injured, and Conductor Charles Meyers and Brakeman Charles Tulga were seriously injured. The front head of the boiler was blown over the river bank and through a barn, narrowly missing a dwelling-house. The locomotive was blown to atoms.

(136.) — A flue collapsed, on June 16th, in one of the boilers of the packet steamer *Dubuque*, of the Diamond Jo line, while she was in mid stream off St. Louis, Mo. The steamer was quickly headed for the west shore, and the panic-stricken passengers were landed at the Burlington yards. Fireman Charles Storrs was fearfully scalded, and was removed to the City Hospital in St. Louis, where he died later in the day.

(137.) — On June 18th a dry kiln boiler exploded in the James Lumber Company's plant at Adrian, Mich. The fireman and a watchman named Lewis were badly injured.

(138.) — A boiler exploded, on June 20th, in the Hilton & Dodge Lumber Company's lower bluff mill, on Union island, near Darien, Ga. Charles McClosker was killed, and Charles Desverges and Dean Willliams were fatally injured.

(139.) — A boiler exploded, on June 21st, in George W. Monroe's planing mill, at Sand Beach, Mich. Engineer D. S. Harriman was fatally injured, and the building in which the boiler stood was about half destroyed.

(140.) — On June 21st a boiler exploded in Lentz, Lilly & Co's Park No. 2 colliery, at Park Place, near Mahanoy City, Pa. John Arnotsky, John Morrell, Thomas Maher, John Tolan, Daniel Purcell, John Rowley, and Peter Logetis were seriously injured. Morrell and Maher afterwards died, and Tolan and one other man cannot recover. The boiler-house was destroyed.

(141.) — A boiler exploded, on June 22d in J. B. Ramsey's tobacco warehouse, at Sebree, Ky. The weather not being right, an attempt was made to cure the tobacco by steam, and the explosion was the result. Engineer Lee Reeder was killed, and his daughter, Gertrude, and a factory hand named Frederick Brown, were seriously injured.

(142.) — A slight explosion occurred, on June 22d, on a locomotive near Toledo, Iowa. A plug, used for closing a defective tube, blew out in the fire-box. Fireman C. H. Stillman, who was firing up at the time, was badly burned and scalded. The engineer was not injured.

(143.) — On June 22d a boiler exploded in the Kent Stone Company's quarry, on North Front Street, Grand Rapids, Mich. Chief Engineer John Connors was seriously injured, and the building in which the boiler stood was destroyed.

(144.) — The boiler that runs the presses of the Sigourney *Review*, at Sigourney, near Columbus, Iowa, exploded on June 22d, passing upward through two floors and the roof, and badly wrecking the building. The local editor, Mr. Guy Davis, was injured. Mr. George L. Bartow, the proprietor of the *Review*, carried no boiler insurance, and the public-spirited citizens of Sigourney raised a generous purse for him, to enable him to continue the paper. Within eleven months Mr. Bartow has been burned out, and had two boiler explosions. He has our sympathy. He ought also to have our policy.

(145.) — On June 23d two boilers exploded in Christopher Hinsman's stave mill, at Kansas, Ohio. The mill was blown to pieces and three men were injured.

(146.) — A boiler exploded, on June 24th, on the tug *Ridgewood*, near Norfolk, Va. Benjamin White was killed, and John Griffin was fatally injured. The explosion occurred while the tug was off Boush Bluff Lightship, with a three-masted schooner in tow. The property loss was about $3,000.

(147.) — One of the boilers in the waterworks at Manitowoc, Wis., failed on June 24th, cutting off the city from fire protection. We did not learn of any personal injuries.

(148.) — A boiler exploded, on June 28th, in Hendrick's saw-mill, near Des Arck, Tenn., on the Des Arck & Northern railroad. Engineer Henry Barnett was fatally scalded, and the mill was totally demolished.

(149.) — On June 29th a boiler exploded in F. L. Sawyer's mill at Greenville, Me. One side of the building was blown into the street, and the opposite side was blown into the lake. Carroll Watson was burned about the face. Mrs. Laura Hildreth, who was passing, was struck by the debris and badly injured. Another woman was also hurt.

(150.) — A boiler exploded, on June 30th, at the Dark Water colliery, near Hazleton, Pa., wrecking every house in the village. Patrick Joyce had his leg broken and was otherwise injured. He may die.

(151.) — On June 30th a boiler exploded at the South Penn Oil Company's well, near Waynesburgh, Pa., on the Enoch Brooks farm, in Morris Township. Hicey Brooks was blown 20 feet into the air, and was fatally scalded. Bruce Harris, an old driller, had his arm badly injured by a fragment of the boiler. The well had just struck pay sand, and was delivering nearly 50 barrels of oil per hour.

WHAT IS THE "BOILER EXPLOSION RACKET"? — Two young men have been working the boiler explosion racket in the neighborhood of Center Moscow, this week. People did not pay very liberally, as they were recognized as two Hillsdale bums who would rather blister their legs and arms than to work; such as they should be put where they could work in a chain gang. — *Hillsdale* (Mich.) *Standard.*

The Locomotive.

HARTFORD, AUGUST 15, 1898.

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

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The "International Date Line."

The war between the United States and Spain has stimulated the study of general geography to a wonderful degree, and persons to whom the Pacific Ocean was merely a broad, uninteresting waste of water, a few months ago, are now fairly familiar with the positions, resources, and strategic values of Hawaii, the Philippines, the Ladrones, the Carolines, and many other groups of islands, and tolerably conversant with cable routes, differences of longitude and time, ocean distances, and other matters that formerly attracted but slight attention except from mariners, large trading houses, and professed geographers. There is one point, however, upon which it appears that there is still something to be said for the public enlightenment, and it is the purpose of this article to say it.

Dewey's great battle at Manila was begun at about five o'clock in the morning, on May 1st, by *Manila time* ; and the public press has frequently discussed the question of when the battle began, by *New York time.* We have not seen any conclusion in the press which is at all satisfactory. Some of the articles have favored Sunday afternoon, May 1st, and some Monday afternoon, May 2d, although the majority have decided upon Saturday afternoon, April 30th (which is correct), although apparently without giving the question the full examination that it calls for. We propose to establish the correctness of the Saturday date, and to give data which will enable the reader to compare any proposed New York date and hour with the corresponding date and hour upon most of the Pacific Islands that are of any considerable present importance.

First of all, it is necessary to understand clearly the fact that at any given instant the local time at any given place *west* of New York is *earlier* than New York time by one hour for every 15 degrees of longitude that lies between the two places. Thus when it is 4 o'clock p.m. by New York local time, it is 3 o'clock (local time) at a place 15 degrees west of New York, 2 o'clock at a place 30 degrees west, and so on. This is indicated by the figures at the bottom of the accompanying map of the world. (The longitude of New York is not precisely 75° west, but the map illustrates the point we are making well enough for present purposes.) The fact that local time is 1 hour earlier for every 15 degrees that we go to the westward is readily understood by the following reasoning : When the sun is just rising at New York, it will not have risen, yet, at any point due west of that place. That is, it will rise *later* at points that are to the westward. Suppose, now, that we wait precisely one hour. The sun will then be one hour high at New York, and there will be a place, somewhere to the west of New York, where it is *just rising.* Let us mark this new place, wherever it may be.

Then, whatever the hour may be at New York, the local time at the spot so marked is one hour earlier. In the same way, let us select another place, further yet to the westward, where the local time is one hour earlier still, and having marked this place, let us proceed in the same way until we have portioned out the entire 24 hours, and found 24 stations, such that between every two consecutive stations there is a difference in local time of one hour. The vertical lines on the map are spaced off in this way, as indicated by the figures at the bottom of each of them. Now there are 360 degrees in every circle; and therefore when we go entirely around the world along any one of the horizontal lines (which represent circles of latitude), we must pass through 360° of longitude. As there are 24 vertical lines, each one hour from it neighbors, we see that the difference in longitude between any two of the 24 successive hour lines is

$$360^\circ \div 24 = 15^\circ;$$

and that is how we know that the local time is 1 hour earlier for every *fifteen* degrees that we travel to the westward.

It is now easy to compare the *hours* at any two places on the earth, by allowing one hour for every 15° difference of longitude between the two places, and remembering that the time grows *earlier* towards the west, and *later* towards the east. Thus Manila is approximately on the 120th meridian of east longitude (reckoning always from Greenwich, England); and hence when it is 5 o'clock, A.M., at Manila, it is approximately 4 o'clock, P.M., in New York. The figures at the bottom of the map show the hour for every 15° of longitude, throughout the world, when it is 5 o'clock, A.M., at Manila. The relations of longitude and the local hour are so simple, that it may seem strange that any question should arise about the New York time of Dewey's fight; but it will be observed that thus far we have only discussed the *hour* on each meridian, and the fact is, that it is not the *hour* that gives rise to the numerous discussions that have been held, but the *day*. It is generally admitted that the fight began at four o'clock in the afternoon, by New York time, and the only question at issue is, whether Sunday at Manila corresponds to Saturday, Sunday, or Monday in New York.

To clear up this matter, let us imagine a traveler journeying to the westward. Let us suppose that he leaves New York at noon on *Sunday*, and let us suppose, further, that he travels just as fast as the earth turns on its axis, so that he follows the sun in its apparent westward progress with such precision that he always keeps it directly south of him. It will be noon, therefore, at every place he passes. Suppose, now, that he asks, at every point of his journey, what day of the week it is. Leaving New York on Sunday noon, he will be told, in Jersey City, that it is Sunday. At Pittsburgh he will also be told that it is Sunday. At Chicago they will answer "Sunday", and the reply will be the same at Omaha, Denver, and San Francisco. Even away out in the Pacific, at Hawaii, they will still tell him, as he passes through the islands, that it is Sunday noon. But this thing will not be kept up indefinitely, because when he has gone all the way around, and has returned to New York, he will have been gone 24 hours, and the New Yorkers will insist that it is *Monday* noon. Everywhere in Europe, too, he would have been told that it is Monday noon. Yet it has always been the same day to him. The sun will have been always due south, and everybody that he has met will have admitted that it is *noon*. There must be some place on the journey where he will be told, for the first time, that it is *Monday* noon, instead of Sunday noon. At this place, if he wishes to be in accord with the people that he meets, he must arbitrarily change the name of his day from Sunday to Monday. To a landsman this arbitrary change in the date is strange and confusing; but the mariner who sails the Pacific ocean quickly grows accustomed to it, so that for him it loses its strangeness.

Our imaginary traveler would find that the change in his day would come somewhere between North America and Asia; but when we come to ask more precisely where the change would take place, we find that there is some difficulty in deciding; and it is this difficulty, in all probability, which has led to most of the disputes about the New York date of Dewey's victory.

Mariners are in the habit of changing the date arbitrarily, upon crossing the 180th meridian from Greenwich, England; but this fact is of no service to us, if we wish to compare the date of one of the Pacific islands with the corresponding date at New York, since the mariners pay no attention to the local dates on the islands that they pass. The ideal way to find out where the date actually does change would be, to canvass the entire Pacific ocean, so as to find out what date is actually in use on every one of the islands, when it is (say) noon on the 180th meridian of a certain day at a particular place. A line drawn from pole to pole in such a manner as to keep all islands bearing one date on one side, and all islands bearing the other date on the other side, would afford us a perfectly definite basis for the comparison of dates. Such a line is called the "International Date Line." In a memorandum recently transmitted to The Locomotive from the Hydrographic Office of the U. S. Navy Department, we are assured, however, that "no information concerning the actual date in local use on each of the Pacific islands has as yet been collected and published, in such authoritative form as to be entitled to entire confidence. As a general rule, it may be said that the date will probably be found in use, at the different islands or groups, which results from the one carried there by the first European or American colonists, and which, therefore, must be a different one according as the colonists came from the east or west."

A line drawn, presumably, from data of this kind, is given on page 120 in the edition of Harper's School Geography for 1887. This line (which is reproduced in the map accompanying the present article), comes down through Bering's strait, sweeps away to the westward so as to just pass to the westward of the Philippines, and then returns, in a southeasterly curve, so as to pass south, just to the eastward of New Zealand. Exact information concerning the course of the International Date Line is surprisingly hard to find; and we desire, in passing, to commend the author and publishers of the geography in question, for the pains they have taken to include this line in a school text-book.

The line that we have just described was intended, as we have said, to separate the islands that were colonized from the east from those that were colonized from the west. Since this line was published, however, new information concerning the early history of the Pacific islands has become accessible, owing to the labors of a German geographer; and we are now able to draw a line which effects the separation a little more accurately. If drawn strictly according to historical principles, the date-line should cut across North America, following the line that now separates Alaska from Canada; for Alaska was first colonized by the Russians, who brought with them the Russian date. When American settlers moved there, they carried with them the date of the United States, and this led to some considerable confusion. The difference in the dates was rendered of less importance, however, by the fact that Russians still use the Julian calendar, and hence their dates do not agree with those of other countries, under any circumstances. The only practical difficulty that the double origin of the settlers introduced, was that the Sunday of the Americans was the Monday of the Russians. When Alaska was purchased from Russia, in 1867, the date in use there was made to conform to that used in the United States; so that at present, there is a uniform practice regarding dates, throughout the continent of North America.

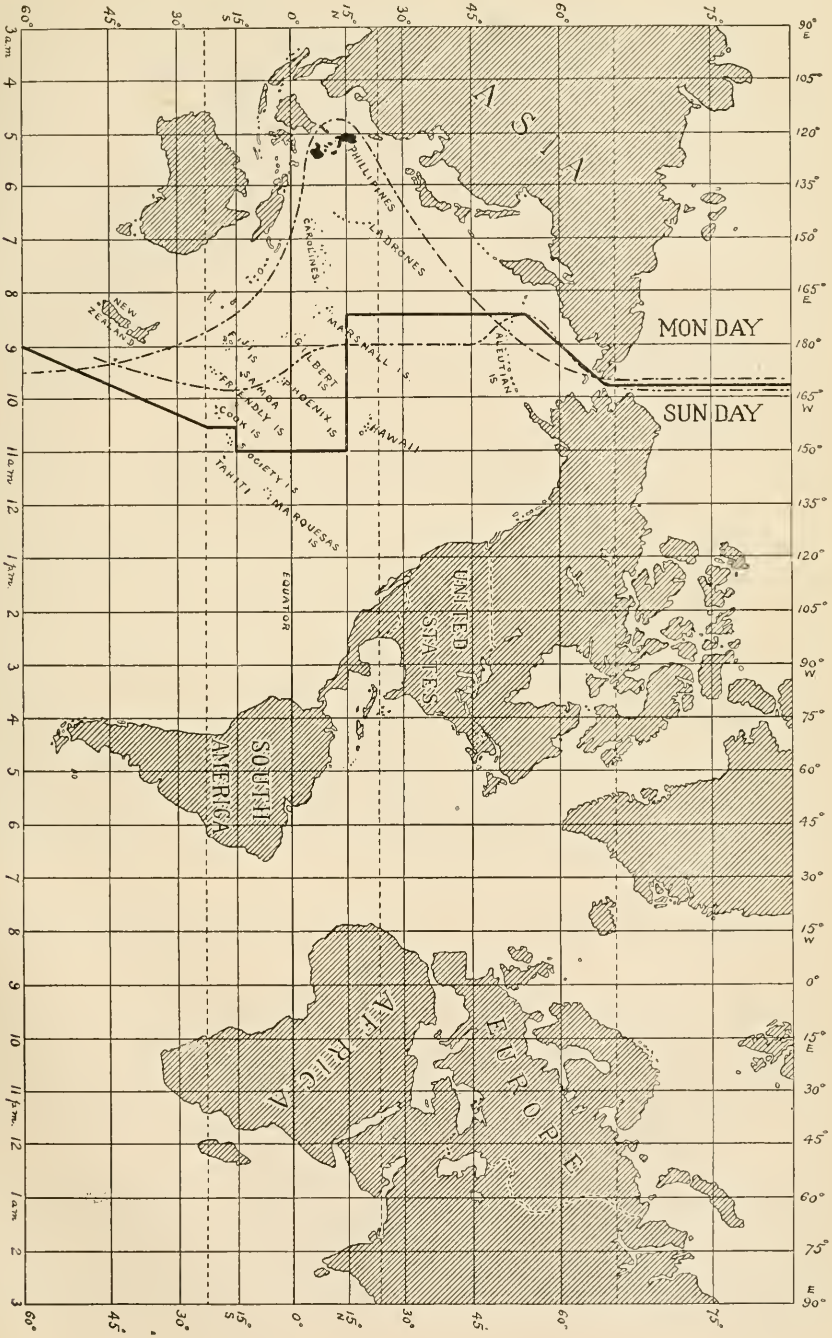
Ignoring the history of Alaska for this reason, the International Cyclopaedia gives the course of the line that divides the islands that were settled from the west from those that were settled from the east, as follows: "It passes through Bering's Strait, or, according to some authorities, just west of that strait. North of the strait, some authorities claim that it passes between Plover and Herald Islands, and this is true, because the former was discovered from the eastern continent, and the latter from the western. South of the strait the line passes west of Clarke's or St. Lawrence Island. Thence it passes west of Gore's island; thence southwesterly between the Aleutian islands and Asia. It then passes southwesterly some degrees east of Cape Lopatka and the group of Kurile islands, thence just east of the Japanese islands, Jesso and Niphon, keeping west of Guadalupa and Margaret's islands, but east of Bonin, Loo Choo, and Patchoo islands, and southeast of Formosa. The line then passes through Bashee channel, just north of the Bashee islands. It enters the China sea east of Hong Kong. It then passes south, just west of the Philippine islands, but keeps east of Palawan island. It is here that it reaches its most western point, at about 116° east longitude. It then takes a southeasterly course, passing through the Sulu islands, south of Mindanao and north of Gilolo. Thence it passes east, nearly parallel with the equator but just north of it, to a point about 165° east, just north of Shank island; thence southeasterly, leaving High island, Gilbert archipelago, Taswell islands, and the De Peyster group on the northeast; thence to a point northeast of the Navigator or Samoan islands in longitude about 168° west; thence it turns south, keeping east of the Navigator, Friendly, Tonga, Vasquez, Kermadec, and Curtis islands, and west of the Society islands and Cook's or Harvey islands; thence it continues south, bearing a little to the west so as to cross, according to some authorities, Chatham island; thence to the south pole."

Even this line, however, though it probably separates with some degree of accuracy the islands that were colonized or discovered from the east and west respectively, does not represent the present course of the true "international date-line," where the day changes as we pass from island to island. The actual present date-line passes to the *eastward* of the Philippine islands, for example, as will be seen by the following bit of history. The Philippines were discovered by Magellan, in 1521, and Manila, the chief city, was found by Legaspi just fifty years later, in 1571. Magellan sailed around Cape Horn, bringing his date from the east. After the islands were colonized, too, they kept the same date as the Spanish possessions on the opposite side of the Pacific; and this condition of matters prevailed until nearly the middle of the present century. The Philippines having then come into commercial relations with neighboring countries and islands to which the date had been brought by way of Cape of Good Hope, it was found to be inconvenient to retain the date that had been brought from South America. Accordingly, under date of August 16, 1844, Narciso Claveria, who was then Governor-General of the Philippine Islands, issued a proclamation in which he decreed that, "considering it convenient that the mode of reckoning days in these islands shall be uniform with that prevailing in Europe, China, and other countries situated to the east of the Cape of Good Hope, I ordain, with the consent of his Excellency the Archbishop, that, for this year only, Tuesday, December 31st, be suppressed, and that the day following Monday, the 30th of the same month, be styled Wednesday, January 1, 1845." This proclamation, having the sanction of both the civil and ecclesiastical authorities of the islands, was effective; and the date now used on the Philippine islands agrees with that prevailing at Hong Kong and other Asiatic ports to which the date was carried by way of Cape of Good Hope. This places the Philippines to the *west* of the present date line. The Hydrographic Office states that "the Mariana or Ladrone islands, which are under the political government of the Philippines, may also be safely placed as west of the date line, but some doubt is felt as to the date in the Caroline islands, although this group, being mainly under Spanish rule, probably carries the same date as the Philippines. The Fiji islands are reported to carry the same date as Australia."

The recent editions of Harper's School Geography, and the Natural Advanced Geography, both of which are now published by the American Book Company, take account of these facts. In the Natural Advanced Geography the date-line is shown as following the 180th meridian much more closely. It is shown as passing through Bering strait and sea, leaving all the Aleutian islands to the east, and joining the 180th meridian just south of that chain. It leaves the meridian of 180° again just north of the equator, and after passing to the east of Samoa, Tonga, and Chatham islands, which use the same date as Australia, it joins the meridian of 180° again in about 45° south latitude. This line is shown on the accompanying map, and is doubtless very nearly correct.

Finally, Professor William Harkness, Director of the United States Naval Observatory, gives the course of the date-line as follows: "Starting in the Arctic ocean, along the 169th degree of west longitude from Greenwich, to latitude 65° north; thence to a point in latitude 55° north, longitude 172° east; thence along longitude 172° east to latitude 15° north; thence along latitude 15° north to longitude 150° west; thence along longitude 150° west to latitude 15° south; thence along latitude 15° south to longitude 156° west; thence along longitude 156° west to latitude 23° south; thence to a point in latitude 60° south, longitude 180°; and thence along longitude 180° to the south pole." The line so defined is shown full and black in the accompanying map. It agrees in the main with the line given in the Natural Advanced Geography, the only important difference being, that the two lines run on opposite sides of the Cook islands. As these islands belong to England, it seems likely that they carry the same date as Australia, as indicated by the Naval Observatory line. The Naval Observatory line has the further advantage, too, of being perfectly definite, so that there can be no question whether a given island is to the east of it, or to the west. As intimated by the Hydrographic Office, it is probably impossible, at the present time, to draw a date-line that is absolutely correct, since authoritative data concerning some of the islands are not accessible. There are probably Portuguese possessions, even west of the Philippines, which use the same date as Hawaii and the American continent; but we are not absolutely sure that this is so. At all events, there are very likely anomalies of this sort, here and there, since the date-line has never been made a subject of international agreement, as its name might lead one to suppose. We believe, however, that the Naval Observatory line, as indicated by the heavy, full line on the map, is as definite and as correct as any such line can be, until further information is available.

A few words more will make the use of the date-line clear. Manila, as we have said, is in longitude 120° east (its exact position is latitude 14° 36′ north, longitude 120° 52′ east). When it is 5 o'clock, Sunday morning, at Manila, it is 8 o'clock, Sunday morning, in longitude 165° east, as will be seen by the map. If we continue to go east, we shall find that when we reach longitude 135° west, that the hour will be 12 o'clock, noon; but the name of the *day* must be changed from Sunday to *Saturday*, since we have crossed the black date-line; and in crossing the date-line going *east*, we must go *back* one day in our date. Therefore, although our journey from Manila has been instantaneous, and we have not seen the sun either rise or set, we must call the time



Map of the World, Showing the International Date Line, According to Various Authorities.

Saturday noon when we reach longitude 135° west. From this longitude eastward to New York we do not cross the date-line again, so we merely add one hour to the time of day, for every 15 degrees of longitude that we cover. New York does not use her own local time, having substituted for it, "standard time," which in her case is the local time of the 75th meridian. Following eastward to longitude 75° west, and adding one hour to the time for every 15 degrees of longitude traversed, we find that it is 4 o'clock Saturday afternoon, by New York time, when it is 5 o'clock Sunday morning, by Manila time. Hence Dewey's battle began at 4 P.M., on Saturday, April 30th, by New York time. In order to verify this result, let us continue eastward from New York until we reach Manila again. Adding one hour to the time for every 15 degrees of longitude, we find that it is 11 o'clock, Saturday night, when we reach longitude 30° east ; midnight, Saturday night, at longitude 45° east ; 1 o'clock Sunday morning at longitude 60° east ; and so on, until we reach Manila, in longitude 120° east, where we find that it is 5 o'clock Sunday morning, which verifies our work. In going from New York eastward to Manila we do not make any sudden change in the date, because we do not cross the date-line.

A few examples may make the use of the date-line clearer. (The full, black line of the Naval Observatory is to be taken as the true date-line in these examples.) (1) When it is 4 o'clock Wednesday morning at a place on the equator in longitude 135° west, it is 1 o'clock Thursday morning at the point whose latitude is 30° south, and whose longitude is 180°. (2) When it is Friday at 4.30 P.M. in latitude 45° south and longitude 165° west, it is also Friday at 4.30 P.M. in latitude 30° north and longitude 165° west. (3) When it is Tuesday at 11 o'clock P.M. in latitude 14° north and longitude 179° east, it is Tuesday at 1 o'clock A.M. in latitude 16° north and longitude 151° west.

This article is already so long that we cannot enter into the discussion of a very curious fact that the date-line suggests. The fact is this : If the heavy black date-line is correct, then from 5 o'clock A.M. to 7.32 A.M., *New York time*, there are three different days in use in the world. For example, from 5 A.M. to 7.32 A.M., New York time (*i. e.* 75th meridian time), on Thursday morning, it is Thursday throughout most of the world ; but there is one region where it is Wednesday, and another region where it is Friday. If the reader can prove this fact, and locate the regions, he will have a pretty clear understanding of what the date-line is.

The First and Last Voyage of the United States Cruiser "Amazonas."*

A short time previous to the outbreak of the present war with Spain, the U. S. S. *San Francisco* was ordered to proceed with the utmost despatch from Lisbon, Portugal, to Gravesend, England, to place a crew on the cruiser *Amazonas* recently purchased by the United States from the Brazilian Government. On arrival we found the Stars and Stripes already floating over the cruiser, she having been placed in commission by Lieutenant J. C. Colwell, Naval Attaché at London that same forenoon.

The transfer of a man-of-war from the flag of one nation to that of another in the port of a third power is a very unusual proceeding, though here it was marked with but little ceremony. The Brazilian crew was mustered aft on the quarter deck. Briefly the commanding officer expressed his regret at losing his ship for which he had waited *so many years*. This sad duty, he said, became a pleasure, for by this act his government

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* The *Amazonas* made only one trip under that name, being immediately afterwards re-named the *New Orleans*.— ED.

was able to show its friendship to a power which recently had so signally shown its friendship to his country. The Green and Yellow ensign was then hauled down, and in its place was hoisted the Red, White, and Blue, and eight officers and ninety-five enlisted men were transfered from the *San Francisco* to the new ship. Placing a ship in commission under the best of circumstances is no sinecure, and in the present case one felt like a cat in a strange garret. A hasty tour around the ship showed that the names of the various compartments, and all instructions on signal gear, were in Portuguese, and everything was locked and the keys bunched promiscuously on the cabin table. There was an immediate council of war at which the executive officer presided, and with the aid of certain plans, and the Portuguese dictionary of the chief engineer, a successful attack was made upon the ship's compartments. This was none too soon; for already Jack, forward, had formed a boarding party and knocked in the head of a stout puncheon of liquor left behind by the Brazilian sailors in their retreat. This was speedily carried aft and subsequently it proved to have wonderful thermal properties. As is the case in most British cruisers, no means of heating the living spaces had been provided, and on deck we were exposed to real Lunnon weather, drizzle and sleet by day and frost by night, and between decks everything was kept damp by the condensation of moisture on the steel of the ship. The only way to keep warm during the day was to keep moving, especially as we were accustomed to the fine weather of the Riviera. At dinner we gathered around the tables in regulation overcoats, with collars, and, out of respect to our surroundings, trousers turned up. It was at night, however, that the bravery of our fellows was shown, for it required rare courage to plunge into the cold beds, and rarer still to turn out. "El Medico," as the Portuguese label styled him, saved lives and earned the good will of his messmates by discovering that a portable electric lamp was as good as a hot-water bottle. The "Major," who had two lamps, was considered the luckiest man aboard, as he enjoyed the unusual sensation of heat penetrating the soles of his feet and creeping up his spinal column at the same time. A requisition was made on the paymaster for two of the largest stoves in all England, and visions of huge crackling logs filled our minds. When the stoves appeared, our executive swore they were only drummers' samples, as they bore about the same proportion to an old fashioned base burner as the British Isles do to the United States. While they were being set up, our chief engineer did some rapid figuring on the ratio of grate surface to heating surface, and there was no scarcity of firemen to carry his theory into practice. What the stoves lacked in size was compensated for by the enthusiasm of the stokers, who worked watch and watch at a 30-knot gait all through the voyage. But other troubles were coming. Fresh water got so scarce that we couldn't afford a chaser [doubtless some Portuguese word, out of the chief engineer's dictionary!], and the more the engineers distilled, the less there was in sight. Some one suggested that the weight of the water distilled was forcing it out through the bottom of the ship; so an ensign was sent into the bilges to hunt for a hole. Before he crawled out, a list to starboard caused an investigation which showed that some of the double bottoms were filled with fresh water. How it got there, even the chief engineer, with his invaluable dictionary, couldn't tell.

After ten days of constant hard work all the coal and ammunition was on board, and on March 27th, with a homeward pennant 170 feet long, the *Amazonas* followed the motions of the flagship and was soon headed for the western ocean. The first few days out, while passing through the channel, the weather was fine with smooth seas. Running at what was an economical speed for the *San Francisco*, about 265 miles a day were logged, and it was calculated that we should reach New York about Easter Day. But there are some things not down in the regulations, and on April 4th we ran into a northwest gale which continued with but slight remissions for a week.

The *Amazonas* has a low freeboard, and with even a moderate sea running, the decks are constantly wet. As the storm increased the seas would sweep down the deck and bring up against the steel bulkhead of the wardroom, which opens on the quarter deck by two sliding steel doors. One evening as our executive stepped in in his oilskins, he brought with him a generous portion of the Atlantic, and for a time the ward room was an improved swimming tank, with several amateur divers contesting for the driest spots. An unusually heavy roll (26° to port and 40° to starboard) deposited about everything movable, including bureau draws and contents, ink bottles, and officers of various grades, on the deck in one confused heap. It was several days before the Chinese laundry appearance of the ward room wore off. Meanwhile, the gale was increasing and making things pleasant on deck. One tremendous sea came over the forecastle, nearly carried the captain overboard, stove in and partially carried away the starboard life boat, wrecked the hand-steering wheel, and expended the last of its strength on the ward room doors. The starboard one slid open and again there were impromptu aquatic sports. If there was one thing our boat excelled in, it was the unexpected motion; for just where you expected it to be is exactly where it was not. We all took such an interest in these demonstrations that meals were forgotten until exhaustion made eating a necessity if not a pleasure. One gunnery enthusiast took occasion to deliver illustrated discourses on the flight of projectiles whenever we sat down to meals. Toward the end of the voyage provisions ran low, and cold corned beef, hardtack, prunes, and coffee were made into a wonderful variety of combinations, which, though spelled differently, tasted alike. All hands were greatly disappointed when on the ninth the flagship signaled to change course and proceed to Halifax, — a change of plan that was necessitated by a shortage of coal on the flagship.

While at sea, and cut off from all news of the prospective war, we gradually thought and talked less and less about it. But as we approached land, our curiosity became more and more excited, and when the pilot and health officer boarded us, they were rushed for news of the war. We got a lot of pleasant attention, too, from the good folk of Halifax.

The run from Halifax to New York gave a chance to clean up and on April 15th we dropped anchor off Tompkinsville. On the eighteenth we went up to the Navy Yard between lines of screeching tugs and ferryboats, and the cruise of the *Amazonas* was finished. Renamed, remanned, and partially reconstructed, she is now, under the name of the *New Orleans*, one of the Flying Squadron, and she will doubtless prove herself a great acquisition to the United States Navy. — *Marine Engineering.*

Prophetic Cockroaches.

Stories of seemingly impossible prescience in animals and insects are always interesting. Some of them may be true, too, for it cannot be supposed that we have yet learned *all* of Nature's wonders. We should not like to express a favorable opinion of the following one, which a Mr. Nicolas Shishkov contributes to the *Scientific American*, although it must be admitted that it reads very well.

"Three days ago," says Mr. Shishkov, "one of our maids came to tell us that the cockroaches were streaming out of the houses in one of the streets of our village, marching in whole companies across the backyards and gardens toward the shores of the lake.

The village where we live [*i. e.* Archangelskoe, near Simbursk, Russia,] consists of about 400 cottages, mostly built of logs and thatched with straw. They are built on both sides of a street about two miles long and 400 feet broad, in nests of four homesteads each, separated by cross streets some 40 feet broad. The village is divided into two unequal halves by the gardens and courts surrounding our house, the house of another gentleman whose property adjoins ours, and by a large common or square, where the village church, schoolhouse, and a few other buildings are situated. On the south, the long line of homesteads is bordered by an open field; on the north, by the shores of a long, but shallow lake. We have had a very dry spring this year, no rain having fallen for nearly three weeks, so that everything was very dry. The weather has been unusually hot (up to 122° Fahr. in the sun), and only during the last three or four days a north wind has rather cooled down the atmosphere.

"The strange migration of cockroaches that I have mentioned took place at about 11 A.M. on the 31st of May. These nocturnal insects infest the wooden cottages of our peasants in vast numbers, hiding in the chinks and crevices of the walls and ceilings or behind the large stoves, and sallying out at night in search of food. Whether from a kind of respect for their usefulness as scavengers, or rather from a general dislike of killing any living thing that is so characteristic of the Russian peasant, our villagers never destroy these pests, and it is a perfect torture for any one of a sensitive constitution to pass a night in a peasant's cottage, because of the swarms of cockroaches that race over the floor, walls, and furniture as soon as night sets in. Constant intimacy with these insects has made our peasants thoroughly acquainted with their habits, likes and dislikes, and they have come to put a faith in many of their observations that seems mere superstition to less habitual observers. Among these beliefs the most common is, that cockroaches have an infallible prescience of the immediate fortunes of the homestead they choose to inhabit. Any unusual activity in the cockroach colony, or a sudden reduction of their numbers, is interpreted as a certain sign of some impending danger to the family or the home. When, however, a general migration of cockroaches takes place — especially in the day time — our peasants have always understood it to portend nothing else than a destructive fire. Consequently, when I was told that the roaches were marching to the lake in broad daylight three days ago, we had a lively discussion of the subject at our family lunch, and the general opinion was, that such a superstition could have no real foundation, unlike the well-known one of rats leaving an unsafe ship in port; for a fire, especially in summer, is generally the result of an accident that has no preceding or gradually developing cause. Still, I was interested enough to inquire in what particular part of the village this migration had been observed. I was informed that the stampede was by no means general, but was confined to a row of cottages in the extreme eastern end of the main street. To-day, June 2, at 4.30 P.M., we hurried out of our house at the cry that fire had broken out in the village, and the great bell of our church was tolling its rapid and violent appeal for help as I drove our fire-engine in the direction of a great column of black smoke ascending in the eastern end of our village.

"After a battle with the flames that lasted about three hours, our four engines managed to arrest and control the conflagration; and as I write, the embers of more than thirty houses, barns, and farmyards are yet sending up lurid clouds of smoke and steam in the soft summer night. The cockroaches had left precisely those cottages that have just been destroyed, and are now enjoying the fruits of their foresight in other houses, many of the dwelling-houses on my own estate being perfectly infested with them. As a constant reader of the *Scientific American*, I thought this communication might be of general interest. Perhaps others may have heard or witnessed facts that may help to determine whether the belief of the peasants is a mere superstition, in which case the coincidence here noted was purely accidental, or whether the cockroaches did have a real instinctive premonition of the fire. I must add that the cause of the fire has not yet been ascertained; but as it originated in the porch of a cottage where an old woman was left in charge of six small children (the rest of the family being at work in the fields), it was very probably due to some of the children playing with fire."

Incorporated 1866.

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The Grooving of Tube Ends.

Some of the troubles that come up in boiler practice are easily traceable to their causes, even by those inexperienced in such matters. For example, when a boiler scales badly, it does not take a Solomon to guess that the feed-water carries a good deal of solid matter in solution, or that the boiler is improperly handled. This and various other difficulties are so common and familiar that no great amount of experience is required in determining their origin. There are a great many other ways, however, in which boilers go wrong, when the reason is far less patent. The cause may be close at hand, where a man skilled in such matters would see it at once; and yet the engineer, to whom the case is a new one, may be entirely at a loss for an explanation, and may even doubt the adequacy of the real cause, when it is pointed out to him.

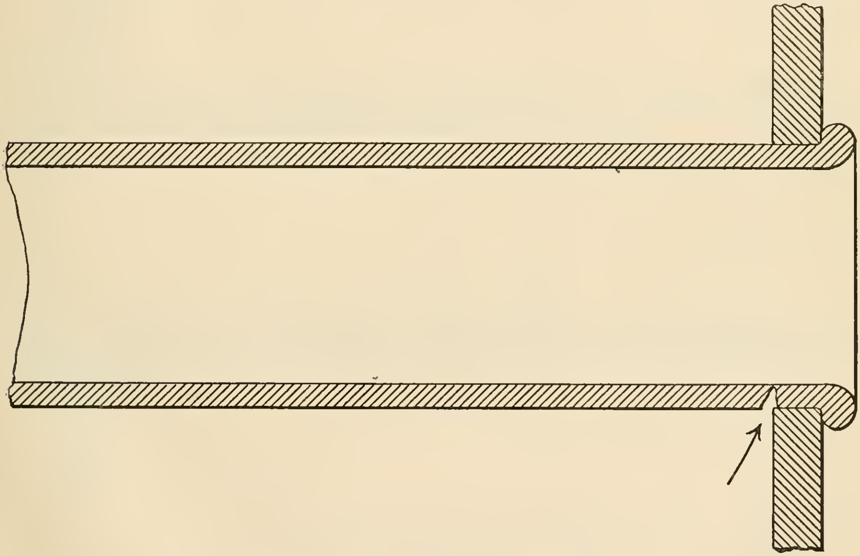

Fig. 1. — A Grooved Tube-End.

A common trouble of this kind is shown in Fig. 1. It occurs quite frequently, even though the boilers are made of good material and by a thoroughly honest builder. The defect in question consists in a cutting or grooving of the tubes close up to the tube-sheet, usually on the lower part of the lowest tubes. This defect, like any other one. may occasionally be found where it would not be expected; and when this is the case, the cause can only be discovered by a careful analysis of the conditions under which the particular boiler in which it occurs is run. In the great majority of cases, however, it is found in boilers that are fed at the bottom of the shell, and is due to the chilling action of the water so introduced.

There has been a great deal of literature written, and advice given, concerning the distress caused in boilers by introducing feed-water in this way, but, notwithstanding this fact, there are many persons who still insist upon feeding at the bottom of the shell. (For an experimental proof of the strains due to a bottom feed, the reader may refer to THE LOCOMOTIVE for May, 1894. A more abstract discussion of the matter will also be found in the issue of March, 1893). Feed water, after passing through a first-class heater, will not have a temperature higher than 212° Fahr. It is commonly taken for granted that water as hot as this cannot produce contraction strains, because it is assumed to be too hot to "chill" the boiler. But any steam table will show that at 80 pounds (which is about the average pressure in use) the temperature of the water in the boiler is something like 324° Fahr.; so that the feed water, hot as it is, is 112° colder than the coldest part of the boiler. That is, there is more difference in temperature between the feed water and the boiler than there is between a cake of ice and the direct heat from the blazing sun, in the hottest day in summer. This is assuming the feed water heater to be perfect, so that it delivers the feed at 212°. If it is not perfect, the feed will have a lower temperature than 212°, and the effect on the boiler will be correspondingly worse. If no heater is used at all, the stresses will be still greater; for the colder the feed water is, the more severe will its effects be.

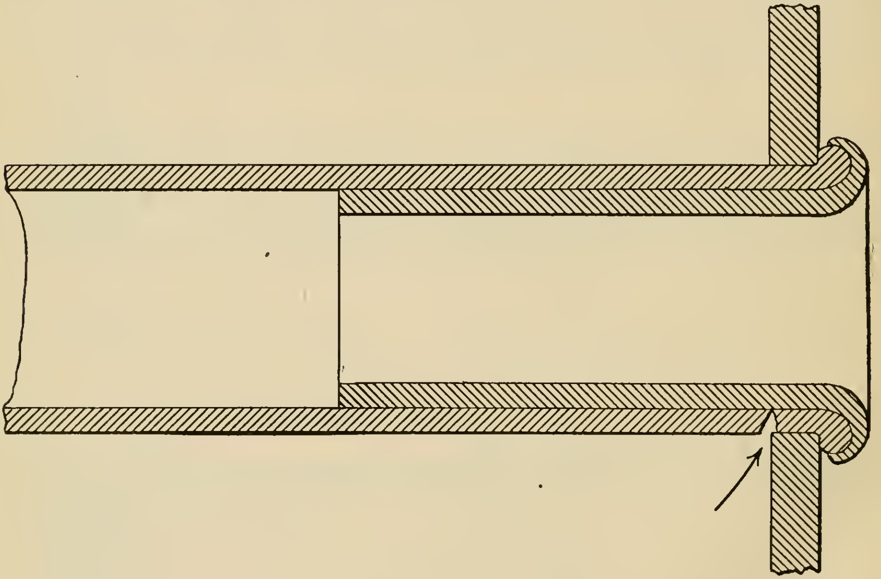

FIG. 2. — A THIMBLED TUBE-END.

We have known numerous cases in which the feed, when discharged at the bottom of the boiler, has produced strains in the shell that were severe enough to fracture the plate between the rivet holes at the girth joints; but it is more usual to see signs of distress in the tubes, against which the entering feed strikes.

The action of the bottom feed, in producing the defect shown in Fig. 1, appears to be as follows: The comparatively cool water, by striking against the under side of the tube, chills the tube so that it contracts. This gives rise to severe contraction stresses in the chilled part, which tend to open up the fibers of the iron to the corrosive action of the water. In the main body of the tube this tendency is rarely evident. It usually shows itself at the end of the tube, close up to the tube-sheet. At this point the skin of the tube has already been disturbed, in the manufacture of the boiler, by the action of the expanding tool, and the fibers of the iron, exposed to the chilling feed ten or twenty times a day, are less able to resist the corrosive influence of the water, as they are moved back and forth, and continually opened up by the alternating stresses to which they are exposed. We therefore find a local corrosive action at these points, which eats into the tube over the lower half of its circumference, until the tube is perforated, and gives notice of its weakness by leaking. If the feed enters the bottom of the boiler close to the back head, the tubes give way at the back end; if it enters near the front head, the tubes fail also at the front head. The first tubes to give out are those in the lowest row, which are most directly exposed to the inflowing feed; but others around them become involved after a time.

The rapidity of this tube-destruction varies greatly under different circumstances, as might be expected. Sometimes it is not observed at all, where one might confidently look for it; and again we have known cases in which the tubes gave out from this cause within a year after the boiler was first fired up.

The usual method of repairing a tube that has been perforated by this action is by inserting a thimble, as shown in Fig. 2. (The thickness of the tube has been exaggerated in both cuts, for the sake of clearness.) The thimble is made with a slight taper, and is driven into the tube and then expanded and beaded over. This method of making repairs may do, temporarily, for one or two tubes, until they can be conveniently replaced, but it should not be used for a greater number of tubes, especially if they are adjacent. It is not uncommon to find from six to a dozen tubes thimbled in this way in the same boiler; but this is poor practice. The thimble merely serves to stop the leak. It does not add a particle to the strength of the tube. The importance of this point will be appreciated when it is remembered that the pressure against the lower half of the head has nothing to sustain it against the steam pressure, except the tension on the tubes; and if any considerable number of these are wasted away or grooved by corrosion, the boiler cannot be considered to be in good condition, even when the leaky places are beautifully thimbled.

The only radical cure for tube-grooving from feed-water strains, is to introduce the feed-water through a long, interior pipe, in the manner recommended by the Hartford Steam Boiler Inspection and Insurance Company, and illustrated in various past issues of The Locomotive. Spray feeds, throwing the water into the steam space, are sometimes used successfully, where the conditions are right, but under most circumstances our preference is decidedly in favor of the long, interior feed-pipe, which the entering water has to traverse before it is finally discharged. By this means the water becomes heated up until it is much nearer to the actual boiler temperature, while it is still in the feed-pipe; and the stresses due to its discharge are correspondingly reduced. (The course of the feed-pipe, as recommended by this company, is shown in the issue of The Locomotive for March, 1897. In the issue for January, 1893, the feed-pipe question is discussed more fully, and several examples of dangerous feed connections, as found by our inspectors, are shown. The arrangement recommended by this company is also fully shown and described. The reader may also refer to our issue for April, 1895, where a perspective view of a correct feed-pipe is given. A form of top feed, which works well when the conditions are right for it, is shown in The Locomotive for March, 1891.)

Inspectors' Report.

June, 1898.

During this month our inspectors made 8,618 inspection trips, visited 16,812 boilers, inspected 7,437 both internally and externally, and subjected 845 to hydrostatic pressure. The whole number of defects reported reached 10,760, of which 617 were considered dangerous; 42 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	987	26
Cases of incrustation and scale,	2,181	36
Cases of internal grooving,	86	5
Cases of internal corrosion,	900	43
Cases of external corrosion,	601	24
Broken and loose braces and stays,	159	39
Settings defective,	247	23
Furnaces out of shape,	355	17
Fractured plates,	224	25
Burned plates,	185	5
Blistered plates,	180	23
Cases of defective riveting,	1,293	48
Defective heads,	120	11
Serious leakage around tube ends,	1,966	128
Serious leakage at seams,	318	13
Defective water-gauges,	176	45
Defective blow-offs,	119	30
Cases of deficiency of water,	18	5
Safety-valves overloaded,	34	13
Safety-valves defective in construction,	80	17
Pressure-gauges defective,	403	23
Boilers without pressure-gauges,	13	13
Unclassified defects,	115	5
Total,	10,760	617

Boiler Explosions.

July, 1898.

(152.) — A boiler exploded, on July 4th, in the Cold Spring Creamery, at Bergen, N. Y. The accident occurred at noon, and nobody was hurt.

(153.) — On July 4th a boiler exploded near McDonald station, on the Panhandle road, in the vicinity of Pittsburgh, Pa. The accident took place early in the forenoon, at the pump station of the Forest Oil Company, at a small place called Primrose, about a mile and a half from McDonald. The only persons in the boiler-house at the time were an unknown boy and a man named Robert Goe, both of whom were looking for work. The boy was instantly killed, and Goe was injured so badly that he had to be taken to a hospital in Pittsburgh. The pump station was completely destroyed, and the machinery was ruined.

(154.) — On July 4th the boiler of an Erie Railroad passenger locomotive exploded at Essex Falls, N. J., on the Caldwell branch of the Greenwood Lake Railroad. After the explosion Engineer J. E. Mitchell was found sitting at his post, unconscious, and Fireman W. E. Marks lay on the tender, also unconscious. They were carried from the wrecked engine, and soon revived. They will recover. William Lockwood, the baggage-master, also received severe injuries. The locomotive was destroyed, little of it being left except the wheels and trucks. Nearly every piece of iron forward of the cab was twisted out of shape. The smokestack was blown 100 feet into the air. Other heavy portions of the engine were hurled about within a radius of 200 yards, and rails and ties were driven nearly a foot into the ground.

(155.) — A boiler exploded, on July 4th, on the Ensminger oil lease, just south of Portage, near Bowling Green, Ohio. The lease is owned by Jefferson Ducat and Daniel Starr. Starr and two other men had just left the boiler-house and started for the well, when the explosion occurred, and the air was filled with flying débris. Mr. Ducat, who was sitting in front of the boiler-house door, was blown about fifty feet, his chair accompanying him; but he was not injured. The boiler, which gave out by the failure of the crown sheet, was hurled up through the roof, and landed about 200 feet away.

(156.) — Harvey Snyder was seriously injured, on July 8th, by the explosion of a boiler at Greenville, Pa.

(157.) — A boiler exploded, on July 9th, in the Edison electric light plant in Cincinnati, Ohio. The explosion was followed by a fire, which resulted in the destruction of the entire plant. The dynamos, however, escaped serious injury.

(158.) — On July 9th a boiler exploded at the works of the Atlantic Crushed Coke Company, Latrobe, Pa. Fireman Joseph McMasters, who was the only person in the building at the time, was badly bruised by falling bricks, and was also scalded. The building was considerably damaged. The property loss was about $4,000.

(159.) — On the morning of July 9th one of the boilers exploded in the Hughes & Guthrie Lumber Company's plant at Homer City, near Punxsutawney, Pa., on the Indiana branch railroad. The fire had been banked in the furnace the evening before, and everything appeared to be in good condition. When Engineer Thomas Neal arrived at the mill in the morning, he proceeded to get up steam as usual, and was working near the boiler when it exploded with a terrific noise, and scalding hot water was thrown in every direction. Mr. Neal was fearfully burned about the head, face, and arms, so that he died from the effects of his injuries on the next day. Mr. Sloan Nelson, who was standing some distance from the unfortunate engineer, escaped being scalded, but was hurled violently against a pile of lumber and was dangerously hurt. At last accounts he was resting easily, and was expected to recover. Charles Mikesel and William McNutt, two other employés, received lesser injuries. The mill, which was one of the largest in Indiana county, had a capacity of 40,000 feet a day, and was running full time. It was almost totally wrecked by the explosion. One side of it was entirely blown out, and the interior was badly damaged.

(160.) — A boiler bursted, on July 10th, in the Ashland Steam Laundry, at Ashland, Ky., and the building in which it stood immediately took fire and was burned to the ground. The fire spread also to adjacent buildings, and the fire department had to call for assistance from the neighboring towns of Ironton and Huntington before the flames could be controlled. The loss was probably about $75,000.

(161.) — On July 11th a boiler exploded in the Mansfield Union Shoe Company's shop, at Mansfield, Mass. The explosion occurred at night, about twenty minutes after the engineer had left the boiler-room. The engineer stated that he left his fires banked, with two gauges of water in the boiler. The boiler was supposed to be in good condition. The building was considerably damaged, and the stock in the shop was saturated with the escaping water and steam, leaving hardly anything uninjured except the machinery.

(162.) — A boiler exploded, on July 11th, in P. H. Mushroe's brickyard at Robious, Chesterfield county, Va., some ten miles southwest of Richmond. Engineer George W. Payne and a laborer named Thomas Hicks were instantly killed. One end of the boiler-house was blown out.

(163.) — On July 11th a boiler exploded in Sweeney's Creek, not far from Curl's Neck's, on the James river, near Richmond, Va. Engineer John Sweeney and a workman named Charles Brown had their legs broken, and Louis Enroughty was badly bruised and scalded.

(164.) — A threshing-machine boiler exploded, on July 12th, on the farm of Adam Walker, in Van Buren county, near Niles, Mich. The machine was wrecked. John Reice was instantly killed, Frank Johnson was fatally hurt, and three other men were injured badly. As is too common in such cases, it is hinted, darkly and without evidence, that "dynamite had been placed in a sheaf of wheat by some enemy of Walker's."

(165.) — Two men, both named Michael Flavin, were killed, and three were seriously injured, on July 12th, by the giving way of a number of piles of the bridge that is building between the Charles river bridge and the Warren bridge, in Boston, Mass. The men were all at work near a staging built upon the piles, when the foundation separated, from some unknown causes, and a stationary engine which stood upon it dropped into the river. As the engine struck the water, its boiler burst with a terrific explosion, and sank to the bottom.

(166.) — On July 14th a boiler exploded in the Niagara Starch Manufacturing Company's works, at Buffalo, N. Y. Caspar Walter, Henry Schiffarstein, William Kelly, Charles Interwan, Mrs. J. W. Hoyt and her infant child, and a baby named Sloss were instantly killed, and about thirty other persons were injured. The general character of the explosion may be gathered from the following extract from the Buffalo *Courier:* "There was nothing to tell of the impending doom. There was no warning sound. All was still and peaceful. Then came the hiss of escaping steam ; then a roar, growing louder and louder for a brief five seconds, until it seemed as though all nature was at war. The roar was terrible, and the cloud that followed made it seem as though the end of all was near. Then came a quiet, — startling in itself, — and as stunned men and women gazed, the great black cloud raised slowly and passed away, a sombre shroud for the lost. The people in the neighborhood looked with wild fear and amazement at the spot. An instant before all was black there ; but now it was clear, and where the great building of the starch works had formerly stood was a pyramid of bricks and bent iron, of broken roofing and twisted machinery and tangled steel bars and boiler tubes. Across every street wreck and destruction were visible. For rods about the streets were covered with bricks, sections of the big boiler which had burst, broken boards and pieces of heavy timber and tons of broken glass." Fire broke out in the ruins, but the fire department soon had it under control. Mrs. Hoyt and her infant daughter, who were among the killed, were on the street near the factory, and were buried under the ruins. The Sloss baby was killed by a piece of iron pipe weighing 175 pounds, which crashed down through the roof of the dwelling in which the Slosses lived. As will be inferred from the foregoing account, the entire plant was totally destroyed. It is difficult to estimate the loss, but it is believed to be about $150,000. When the ruins had been cleared away, it was found that the boiler had opened longitudinally, and the shell was straightened out into a single flat sheet. Many of the rivets were said to have sheared, along the joint where the initial fracture occurred.

(167.)—On July 15th a boiler exploded in a small village called Sycamore, near Leamington, Ont. John Rambeau and James Payne were instantly killed. Charles Betts, who owned the mill, was removed from the ruins in an unconscious condition, and died within a few hours. Joseph Lee was also fatally injured. A man named Colleson was fearfully hurt, but it is believed that he will recover. H. Smith and Frank Davis also received minor injuries. The mill was burned a short time ago, and had just been rebuilt.

(168.) — A slight boiler explosion occurred, on July 15th, at the Parkersburg Gas, Electric Light & Street Railway Company's power-house, Parkersburg, W. Va. The damage was not great.

(169.) — James West was instantly killed, on July 15th, and Hayes Ganger, Frederick Seidl, Edward Boland, John Brown, Richard Jones, and Samuel Jones were seriously injured, by the explosion of a threshing-machine boiler on the Varina farm, twelve miles from Richmond, Va.

(170.) — A boiler exploded, on July 18th, in John B. Gerow's grist mill at Plattekill, near Marlborough, N. Y. The explosion occurred while the engineer was at dinner, and, although the mill was considerably damaged, nobody was injured.

(171.) — On July 19th a boiler exploded in the railroad pump-house at Dickinson, Texas. Patrick Keaton was severely scalded and otherwise injured. It is doubtful if he survives.

(172.) — A boiler exploded, on July 20th, on the Bell Farm, about a mile from East Sandy, near Oil City, Pa. Walter and William Buck were severely injured.

(173.) — On July 22d the boiler of locomotive No. 1,993, on the Central Pacific railroad, exploded while drawing an east-bound extra, at Dutch Flat, Placer County, Cal. Engineer Thomas Kelly, Fireman L. A. Perry, and a coal passer whose name is not known, were instantly killed. Mrs. J. R. Faller, Raymond Faller, Lawrence Faller, and Henry Disque were seriously injured. One car was thrown from the track.

(174.) — A threshing-machine boiler exploded, on July 23d, at Bernard, near Maysville, Ky., badly scalding Engineer Joseph Cole.

(175.) — The boiler of a threshing-machine exploded, on July 23d, on the farm of James Kreps, at Conococheague, near Hagerstown, Md. Nobody was hurt.

(176.) — A boiler used for hoisting purposes by a contractor, in Cleveland, Ohio, exploded on July 25th. The fireman was slightly injured.

(177.) — On July 26th a boiler exploded in Nathaniel Keller's grist-mill, at Lime Rock, Penn township, Lancaster County, Pa. Fireman John Stauffer had a narrow escape from death.

(178.) — A boiler exploded, on July 27th, in Dawson's creamery at Newark, Del. We have not learned further particulars.

(179.) — On July 27th a boiler exploded in Eben Youmans' saw-mill, near Augusta, Ga. David Gigger and one other man, whose name could not be learned, were instantly killed, and the entire mill was completely demolished.

(180.) — A boiler exploded, on July 27th, in the Arnold Brewing Company's plant, at Hazleton, Pa. The explosion occurred between two and three o'clock in the morning, and nobody was hurt.

(181.) — A boiler exploded, on July 28th, in the power-house of the Citizen's Electric Light Company, at Kokomo, Ind. The plant was badly wrecked, and the town was left in darkness. George Dunning, the engineer, was instantly killed. We have seen no estimate of the property loss.

(182.) — One of the boilers in the marble quarry at Avondale, near Norristown, Pa., exploded on July 28th. Fireman Joseph Peters was injured, but will recover.

(183.) — There is a small steamboat on the Passaic river, above Singac, which runs to Wilkie's Driving Park, near Paterson, N. J., on race-days. On July 28th there were at least twenty-five men in the craft. They had reached Little Falls, and were in the middle of the stream when the boiler exploded. The two men nearest the boiler were thrown into the river and slightly hurt. The boat, with the rest of its passengers, all badly scared, was towed to the nearest dock.

(184.) — On July 30th the boiler of a threshing-machine outfit, belonging to a Mr. Fultz, exploded on the farm of Mr. Henry Young, at Rushville, near Lancaster, Ohio. The engine was demolished, and the engineer, whose name we do not know, was severely scalded.

(185.) — The boiler of freight engine No. 554, of the Norfolk & Western railroad, exploded, on July 30th, at Valley Crossing, some seven miles south of Columbus, Ohio. The crown sheet and the side sheets of the fire-box were blown out. Nobody was injured.

(186.) — A boiler exploded on July 30th, in the Jermyn Electric Light Company's plant, at Jermyn, near Scranton, Pa. Benjamin Carey was instantly killed, and the brick power-house was almost entirely demolished. William Jenkins was slightly injured. The boiler was thrown about 150 feet, and the debris of the building were scattered over a considerable area.

Non-Inflammable Wood.

Apropos of non-inflammable wood, one variety of which is now being very strongly advocated for use in United States naval vessels, it would seem pertinent to add to what was recently said on the subject in these pages, that, according to official reports of such trials as have been made with the material on American warships, the wood was liable to dampness and rot, and the decks consisting of it wore down, showing that it was soft and had no life. It was believed also that it was friable and would splinter badly under fire; and this last-mentioned defect, if existent, would alone constitute a very serious drawback to its use. It would, indeed, emphasize the desirability, not of fireproofed wood, but of no wood at all. What would appear to be more preferable in many respects is asbestos, or some similar material, either as cardboard for lining metal surfaces, or built up in a grooved or cellular form for bulkheads. Such material would, of course, be absolutely uninflammable, and a shot through it would make a clean hole, with no splinters whatever.

With the later report that all wood to be used in the new vessels of the United States Navy will be fire-proofed, comes also a daily newspaper interview with Chief Constructor Philip Hichborn, U. S. N., — the only one, by the way, of the four members of the United States Board of Naval Construction who advocates the use of such fire-proofed wood,— according to which he says that the process to be followed of rendering wood non-inflammable, "simply stated, consists in withdrawing all sap and moisture from the lumber in a vacuum, and then filling the pores with phosphate of ammonium." But this is substantially the Pepper process, doubtless with valuable improvements in detail, while adhering to the phosphate of ammonium, which was found, on the whole, to give the best results in making wood non-inflammable. This particular virtue of phosphate of ammonium has been known for years, yet the British, French, and German navies have been able to make little or no use of it, though all three have spent considerable amounts of money in trying to discover an efficient non-inflammable wood for their warships. It might be urged that its practical rejection hitherto for warships was due altogether to the fact that these navies want a non-splintering as well as a non-inflammable wood. But this contention falls to the ground when it is remembered that the British mercantile marine, which need have no fear of wood-splinters from shell fire, has been equally ardent in its search for a satisfactory non-inflammable wood, without, apparently, finding it. Moreover, so far as is known, all the salts of ammonium are soluble in water,— most of them extremely so,— and if phosphate of ammonium is an exception to the rule, Roscoe forgets to mention it. Nothing could be more calculated to set the minds of naval officers and men at ease during a battle than the consciousness that, happen what might, their ship could not take fire; but nothing could be more expressly planned to start a panic among men engaged in action, than the sudden discovery that the so-called non-inflammable wood was on fire owing to its chemical constituents having become leached out.—*Cassier's Magazine.*

Effect of Paper and Metals upon Photographic Plates.

The images left by uranium upon a sensitive photographic plate locked up with it in the dark, may be regarded as an effect of the fluorescent property that that metal is known to possess. Dr. Russell has, however, described to the Royal Society experiments from which it appears that mercury, zinc, magnesium, cadmium, aluminum, nickel, pewter, bismuth, lead, tin, antimony, and cobalt give out radiations capable of affecting the sensitive plate, and will leave images of themselves after standing upon such a plate in the dark for about a week, although they possess no evident luminosity. Gold, platinum, and iron exhibit little or no power of the kind. A figure scratched upon the polished face of a sheet of zinc repeated itself. The interposition of a coat of varnish between the metal and the plate served to increase the effect, while glass, which makes no difference when uranium is applied, stopped the action with the other metals. Some non-metallic substances, such as straw, wood, charcoal, and printers' ink, presented the same property of leaving images. A section of young larch wood printed its formation clearly on a plate, so that the rings and bark could be made out. In many cases the activity was increased by heating the body, and diminished by cooling it. —*Popular Science Monthly.*

[These experiments touch upon phenomena that were already more or less familiar to amateur photographers. Thus the amateur soon learns that it is a bad practice to wrap up his exposed but undeveloped plates in paper in such a way that the paper is left in contact with the film. When the plate is afterwards developed, it is very likely to come out foggy, on account of the reducing effect that the paper has had upon the silver emulsion. The effect of printers' ink has also been discovered by the amateur, to his exceeding sorrow, by his finding some sensational murder trial imprinted upon the image of his sweetheart's brow, merely because he had wrapped her undeveloped negative up in a generous section of a daily newspaper. The reducing effect of paper has usually been attributed to the presence of the sulphurous salts that are used in its manufacture. The fact that certain metals will act in a similar way has also been known for a considerable time, and we have seen very good images of coins that were obtained by developing a sensitive plate upon which they had lain for some time. We do not wish to detract from such credit as may be due to Dr. Russell, for the subject needs investigation, and interesting results are sure to be obtained.]

The Locomotive.

HARTFORD, SEPTEMBER 15, 1898.

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

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The Metric System.

The book on *The Metric System of Weights and Measures*, which was announced a short time ago as being in course of preparation by the Hartford Steam Boiler Inspection and Insurance Company, is now completed. President J. M. Allen's object in publishing it is stated in the preface in the following words : "The metric system of weights and measures is used so universally in foreign books and periodicals, that much time is consumed, and no little annoyance incurred by the American reader, in translating these units into their English and American equivalents, by the aid of any of the reduction tables that have yet been published. It therefore occurred to the undersigned that a handy pocket volume, for facilitating comparisons of this kind, might be acceptable to engineers and scientific workers generally." It is believed that the book will be found to fulfill its purpose thus stated, quite satisfactorily.

It contains 196 pages, of which the first 36 are devoted to a brief history of the Metric system, and to an explanation of the use of the tables that follow. The remaining pages consist of tables in which the English and Metric units are compared with each other. The arrangement and general design of the tables will be best understood by selecting a particular table for description; for they are all arranged in accordance with the same general plan. If the book be opened at pages 48 and 49, for example, we find that both of these pages are occupied by the table for reducing meters to feet. On the left-hand page the table begins with 1 meter = 3.281 feet, 2 meters = 6.562 feet, 3 meters = 9.843 feet, and so on up to 50 meters = 164.042 feet, which is the last entry on the page. Looking across to the right-hand page, we see that this page begins with 51 meters = 167.323 feet, 52 meters = 170.604 feet, and so on up to 100 meters, the last entry on the page being 100 meters = 328.084 feet. By opening the book once, at pages 48 and 49, we therefore have before us the value of every number of meters from 1 up to 100, expressed in feet, to three places of decimals. If we now turn over one leaf, so as to open the book at pages 50 and 51, we find a complementary table for reducing feet to meters. Thus the left-hand page begins with 1 foot = 0.3048 meter, 2 feet = 0.6096 meter, and so on, just as before, up to 50 feet = 15.2400 meters ; and the right-hand page begins with 51 feet = 15.5448 meters, 52 feet = 15.8496 meters, etc., up to 100 feet = 30.4800 meters. These two pages therefore show at a glance the value of every number of feet, from 1 up to 100, expressed in meters, to four places of decimals. All of the other tables are arranged, as we have said, on precisely this same plan, so that it is not necessary to say more about the details of the separate pages. In every case there are two pages giving the English values of the first one hundred multiples of some particular metric unit, and immediately following these there are two pages devoted to the inverse operation of expressing the first one hundred multiples of the corresponding English unit, in metric equivalents. The tables are grouped in the following way: First come tables of long measure, in which we find a comparison of the units used in measuring lengths, such as the inch, foot, yard, mile, centimeter, meter, and kilometer. Then come the tables that contain the units that are used in measuring areas, such as square inches, square miles, acres, and the like. Next we find the units that are used in expressing the cubical contents of boxes, tanks, etc., such as cubic inches, cubic feet, and cubic yards. After this we come to units that are used in the measurement of fluids, such as fluid ounces, and British and American quarts and gallons. Next come the analogous units that are used in dry measure — the dry quart and the bushel. These are followed by the units, such as the ounce, gramme, and ton, that are used in the estimation of weight. Lastly, there are upwards of forty pages devoted to miscellaneous units, such as heat units, foot pounds, horse power, pounds per square inch, etc., and the tables close with a comparison of Centigrade and Fahrenheit thermometer scales. It is believed that this systematic arrangement of the tables will contribute greatly to the convenience of using the volume, as, after one has become a little familiar with it, it can be opened readily at any table that may be desired. A very full index has also been provided, so that no one should have the least difficulty in finding quickly anything that the book contains.

The volume is convenient in size for the pocket, and for general reference, the pages being 3½″ wide and 5¾″ long. It is printed upon excellent paper, with red edges, and is bound in sheepskin, with the title in gold. It will be sent by mail to any address, postpaid, upon receipt of the price, which is $1.25. In this form it is neat and durable and convenient to use; but for the benefit of those who desire it in a still more substantial form, we have prepared an edition that is printed upon bond paper, and bound in heavier leather with full gilt edges. We can furnish the book in this edition postpaid, for $1.50. All orders should be addressed to the

Hartford Steam Boiler Inspection and Insurance Company,
Hartford, Conn.

In connection with the foregoing notice, we desire to say a few words about the metric system itself. A great deal has been written, both in this country and in England, about the merits and demerits of the metric system,— so much, in fact, that it is impossible for us to examine, in this place, more than the smallest fraction of it. Much of this literature has been controversial and exceedingly *positive*, the writer who favors the system representing it as the one wholly perfect thing that the human mind has yet produced, while his opponents, who hold that the foot, quart, and pound that were good enough for our daddies are good enough for us, exhibit the metric system in the guise of a giant carcinoma that has crept over the earth, involving one nation after another, until it is now at our own borders, and must be kept out at any cost. It would be strange indeed if one of these views were wholly right and the other one wholly wrong; and the truth is (as we see it), that something can fairly be said *for* the metric system, and something *against* it.

To assist us in surveying the question, let us take, as a sort of text, the able article on "The English and Metric Systems," which was written for *Locomotive Engineering*, by Mr. Chas. T. Porter, and which may be had in pamphlet form from the Angus Sinclair

Company, of 256 Broadway, New York, for five or six cents. Mr. Porter gives his readers unequivocal notice, at the very outset, of what they are going to get if they read his article. "I am filled with astonishment and indignation," he says, "to see the cause of our good old English system of linear measurement so meekly given away; to see the pretensions to superiority which are arrogantly put forth on behalf of the metric system admitted, directly or tacitly, by those who are in the actual enjoyment of a system which is incomparably its superior. . . . I hold myself bound to prove the proposition I have above laid down, in its most literal and absolute sense, and I undertake to do it to the complete satisfaction of every man who can read the English language." Mr. Porter's article, it will be seen, is well worth the nickel that is charged for it, as a study in vigorous English composition, whether the reader cordially disagrees with him, or not.

Now what are Mr. Porter's real objections to the proposed system? They are a little obscured by certain references to "six-tenths of a kilogram of cheese," "eight hundred and fifty-six millimeters of calico," and the like. True, there are many other more weighty things in the article, but these subtle rhetorical features command more attention than we want to spare them. We find our editorial eye fastened upon them with embarrassing frequency; and whenever we draw it away to look at something else, it speedily finds them out again, as water returns to its own level. But after doing our best, we have distinguished the following main points:

1. The use of the earth's quadrant as a basis for the unit of length was ridiculous and absurd. The idea was "big and empty," and "excessively French."

2. The Metric Commission didn't get the standard platinum meter right, anyhow, because it is something like the fiftieth part of one per cent. shorter than it was meant to be. Therefore, although it answers the purpose of a standard, it is, in fact, merely an arbitrary one.

3. "It was decreed that the kilogram should be the weight of a cubic decimeter of water." It is absurd to derive the unit of weight (*i. e.* of mass) from the unit of length in this way, because it is impossible to measure water with precision, so as to know when we have an exact cubic decimeter of it. The standard platinum kilogram of the Paris archives is therefore also ridiculous; "and we know that any other block of metal, of any size whatever, of a nature to retain its original weight, and made by law the standard, would have answered just as well."

4. The decimal method of defining the multiples and submultiples of the various units is no good, and it is better to use halves, quarters, eighths, sixteenths, thirty-seconds, and sixty-fourths.

5. The metric system is not in universal use by scientific men. "The divisions of the circle, as before, continue to be expressed in degrees, minutes, and seconds. The minute, measured on the equator, at the level of the sea, is the nautical mile, and this is the unit for astronomical measurements."

6. It is confusing and inconvenient to use the metric system for marking dimensions on mechanical drawings. We must "think, too, of the chances of error, from the wrong position of the decimal point, or wrong number of ciphers, and the constant watching against this that is demanded."

Now let us examine these points a little, taking them up in order.

1. There is much truth in what Mr. Porter says here. There was a certain amount of "playing to the galleries," no doubt, in the selection of the earth's quadrant as the basis of the system. But that all happened a century ago, and the Frenchman had the fun and the work, and, so far as we know, he paid the bills. At any rate *we* didn't

pay them, so it doesn't appear necessary to worry too much about the logic of the quadrant idea.

2. It is true that the standard meter at Paris is not *precisely* what it was intended to be. But it makes no real practical difference whether this bar represents the ten millionth part of the earth's quadrant, or the length of the thigh bone of King Henry the Fourth. The real point is, that that bar is now serving as a standard for most of the nations of the earth; and the question before us is, whether *we* shall adopt it, also.

3. Owing to the imperfection of man, the kilogram of the Paris archives must differ, to some extent, from the ideal that the commissioners had in mind when they constructed it, and which they tried to reproduce in solid platinum. But it is near enough to serve the purpose that the commission had in mind,— a purpose which we shall presently illustrate, and which we fear Mr. Porter entirely failed to understand, if it is fair to judge him by the quoted words with which we conclude paragraph No. 3, above.

4. The binary scale of subdivision certainly has its advantages, just as the decimal scale has. We can see no great objection to using halves and quarters of a meter, or a liter, or a gram, as well as tenths and hundredths. But we do not think that it would be found necessary or desirable to use binary fractions smaller than quarters.

5. In our opinion, the decimal system *is* in almost universal use by scientific men. We do not understand what Mr. Porter says about the astronomical unit, for we never knew of the "knot" being used for this purpose, except, perhaps, in addressing persons who might not know what a meter or a kilometer is. We read, in popular books on astronomy, that the earth is so many "miles" in diameter, or that it is so many "miles" from the earth to the sun; but these distances are not often estimated in this way in practical astronomical work. The reason for preserving the sexigesimal division of the circle is, that an enormous and practically prohibitory amount of labor would be required to recalculate the extensive trigonometrical tables that we now have, so as to adapt them to a decimal graduation of the circle.

6. These things are inconvenient, because we are not yet accustomed to them. A Frenchman or a German finds our system equally confusing. We do not think that a competent workman would be much troubled if he found a shaft marked as 25 millimeters in diameter, when 250 was intended. He wouldn't put in a one-inch shaft where a ten-inch one was wanted. Our own system is not altogether free from liability to error, and the errors to which it leads us are unfortunately much less likely to be detected by the workman, than those incident to the metric system are.

Mr. Porter's essay is bright, and very readable and interesting; but it doesn't convince us that he is right, and we feel free to say so, on account of the charmingly bellicose atmosphere that hangs over it, from beginning to end. He seems to invite criticism,— nay, almost to demand it; and hence, as we have said, we have felt free to use his article as a text.

One of the best-known opponents of the metric system was Mr. Herbert Spencer, the English philosopher. His argument against the system is given in Appleton's *Popular Science Monthly* for June, 1896 (page 186). It strikes us as singularly weak, and it has been abundantly answered by Dr. T. C. Mendenhall, in the October (1896) issue of the same magazine. A much weightier arraignment of the metric system, from Dr. Coleman Sellers, will be found in the first volume of the *Transactions* of the American Society of Mechanical Engineers, under the title, "The Metric System — Is It Wise to Introduce It into our Machine Shops?" We heartily commend this paper to the attention of over-zealous advocates of the compulsory adoption of the metric system, for it shows up numerous difficulties of exceeding importance. Some of the points that he makes, however, do not appear as grave to us as they do to Dr. Sellers; and we are still inclined strongly to the belief that when the metric system has once come into universal use, its good points will be found to incomparably outweigh its bad ones.

One of the most convenient things about the metric system is the feature which we ventured to assume, earlier in this article, that Mr. Porter had not appreciated. We refer to the way in which the metric units of weight and volume are related to the unit of length. The liter, for measuring liquids, is, for all practical purposes, equal to the volume of a cube, each of whose edges is ten centimeters long; and the kilogram, which corresponds to our pound, is the weight of a similar cube of water, at a standard temperature. In our units the gallon is 231 cubic inches, and a pound of water, at 39 degrees Fahr., occupies 27.7 cubic inches. By way of illustrating the advantage of the metric system, in certain kinds of work, let us select a particular type of problem, which, in our own line of work, we have to solve with great frequency; and let us solve it in both systems, and compare the work. We may take the following: An upright cylindrical tank is given, which is 76 inches (or 193 centimeters) in diameter, and is filled with water to a depth of 83 inches (or 211 centimeters). We wish to know how many gallons (or liters) of water the tank contains.

U. S. SYSTEM.	METRIC SYSTEM.
76	193
76	193
456	579
532	1737
5776	193
.785	37249
28880	.785
46208	186245
40432	297992
4534.160	260743
83	29240.465
13602	211
36272	29240
231) 376322 (1,629 gallons,	29240
231 (answer).	58480
1453	6169.640. liters, (answer).
1386	
672	
462	
2102	
2079	
23	

(The heavy decimal point indicates the division by 1,000, to reduce cubic centimeters to liters.)

It will be seen that 91 figures are required in one case, while 75 are sufficient in the other; and to place ourselves beyond suspicion of unduly favoring the metric system, we have preserved more significant figures in that half of the calculation than are really required. It will be observed, too, that the division by 231, in the one case, is entirely avoided in the other, being replaced by a mere shift of the decimal point three places to the left. If, now, we wished in addition to know the *weight* of the water, we must, in the U. S. system, either divide 376,322 by 27.7, or multiply 1,629 by $8\frac{1}{3}$; but in the metric system no work at all is required, since the weight of the water, in kilograms, is sensibly the same as its bulk in liters. Moreover, we have to remember two constants in the U. S. system, while in the metric system we do not have to remember anything, except what the system is.

The length of this article forbids the discussion of numerous interesting questions upon which we have not touched; but we cannot close without referring to one point which we have rarely or never seen mentioned in connection with the proposed adoption of the metric system, but which appears to us to be of some importance. The growth of electrical science has been phenomenal in the past few years, and there is every reason to suppose that in the future its progress will be equally rapid, and perhaps more so. Electricity is bound to creep into our lives, and it will lend its aid to our industries until we shall find it everywhere, so that we shall all be forced to know a great deal about it. Now the units that are used in electrical science are all metrical units, being based directly on the centimeter, the second, and the gramme; so that we are introducing the metric system insidiously with the growth of our electrical industries. We have actually two systems of fundamental units in practical use, at the present time. We do not realize this, perhaps, until we stop to think it out, because electrical mechanics is still too widely separated from the older branches of mechanics. But when the two have grown more closely together, so that electrical tests and electrical calculations have become the everyday matters that they must become, we shall find ourselves keenly conscious that the metric system has its advantages, and that it has come to stay. Perhaps this would even be the easiest way to adopt the system, — to wait until electrical science has forced it upon us, and educated us into using it more freely.

ROBERT FULTON'S TORPEDOES.— Before he turned his attention to navigation by steam, Robert Fulton invented a marine torpedo which he endeavored to dispose of to the United States government. Succeeding in interesting James Madison, then Secretary of State, in the matter, he obtained a small appropriation from the government for the purpose of conducting some public experiments. In the summer of 1806 he invited the high dignitaries and a number of prominent citizens of New York to Governor's Island to see the torpedoes and machinery with which his experiments were to be made. While he was lecturing on his blank torpedoes, which were large, empty copper cylinders, his numerous auditors crowded around him. After a while he turned to a copper case of the same description, which was placed under the gateway of old Castle William, and to which was attached a clockwork lock.

Drawing out a peg, Fulton set the clock in motion, and then he said in solemn tones to his attentive audience: "Gentlemen, this is a charged torpedo, with which, precisely in its present state, I mean to blow up a vessel. It contains one hundred and seventy pounds of gunpowder, and if I were to suffer the clockwork to run fifteen minutes, I have no doubt that it would blow this fortification to atoms."

The circle of humanity which had closed around the inventor began to spread out and grow thinner, and before five of the fifteen minutes had passed there were but two or three persons remaining under the gateway. Some, indeed, lost no time in getting at the greatest possible distance from the torpedo, and they did not again appear on the ground until they were assured that the engine of destruction was safely lodged in the magazine, whence it had been taken. The local historian of that period remarks :

"The conduct of Mr. Fulton's auditors was not very extraordinary or unnatural; but his own composure indicated the confidence with which he handled these terrible instruments of destruction and the reliance he had on the accuracy of the performance of his machinery. The apprehensions of his friends surprised and amused him, and he took occasion to remark how true it was that fear frequently arose from ignorance." — *Scientific American.*

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The Locomotive.

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A Dynamite Boiler Explosion.

From time to time we have taken occasion, in the pages of The Locomotive, to express our views concerning the intentional blowing up of steam boilers. We strongly doubt if one per cent. of the explosions reputed to be intentional, are so in reality. Most of the reports of this kind arise among persons who are not familiar with the tremendous destructive energy of expanding steam, and to such persons a resort to some form of dynamite theory appears to be necessary, in order to account for the observed facts. Nearly all of the cases in which dynamite is suspected will admit of full and satisfactory explanation by more probable causes. Nevertheless, there is occasionally an explosion in which the attendant circumstances are such that the intentional use of dynamite or some other equivalent explosive substance can hardly be denied. A case of this kind recently came under our notice, where the observed results point to dynamite (or its equivalent) so plainly that we have thought that some account of it would be of general interest.

Fig. 1.—Supposed to be the Bomb that was Used.

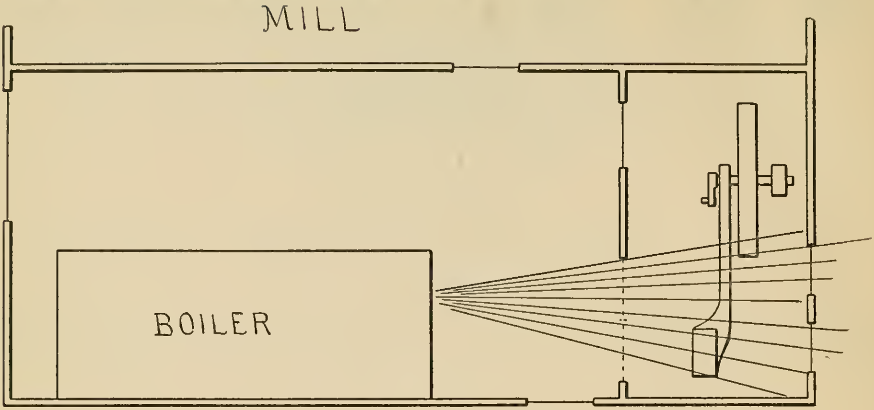


FIG. 2.— GENERAL PLAN OF THE BOILER AND ENGINE ROOMS.

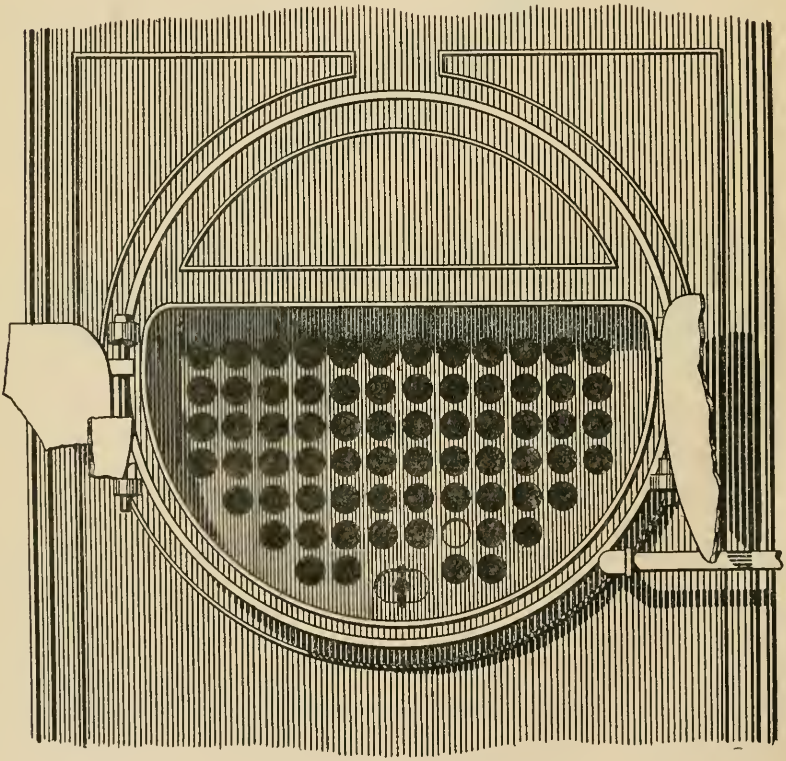
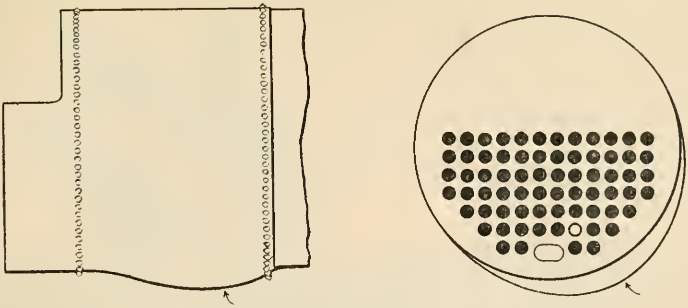


FIG. 3.— SHOWING THE BROKEN DOORS.



Figs. 4 and 5.— Showing the Bulge on the Shell.

The boiler in question was situated in a shoe shop. It was 54 inches in diameter, and 15 feet long. It had an easy duty, and had never been overworked, so far as we could learn. The safety-valve and all other appliances were in good condition previous to the accident, and the shell and tubes were fairly clean. There was no evidence of previous distress, nor of low water. The boiler was worked only during the usual

Fig. 6.—Fragments of the Destroyed Tube and of the Bomb.

daylight hours, and on the night of the explosion the engineer banked the fire just before six o'clock, and left just after stopping the engine. He states that there were about 50 pounds of steam on the boiler when he left, that the water showed a little more than halfway up in the gauge glass, and that everything appeared to be in the usual condition, and in good order. The usual working pressure was about 60 pounds, the safety-valve (a four-inch lever valve of the usual pattern) being set at 65 pounds. The engineer had washed up and was eating his supper when he was summoned by a neighbor who said that steam and water were escaping from the mill. The door of the boiler-room was open upon his arrival, though we cannot say that it was not opened by some authorized person.

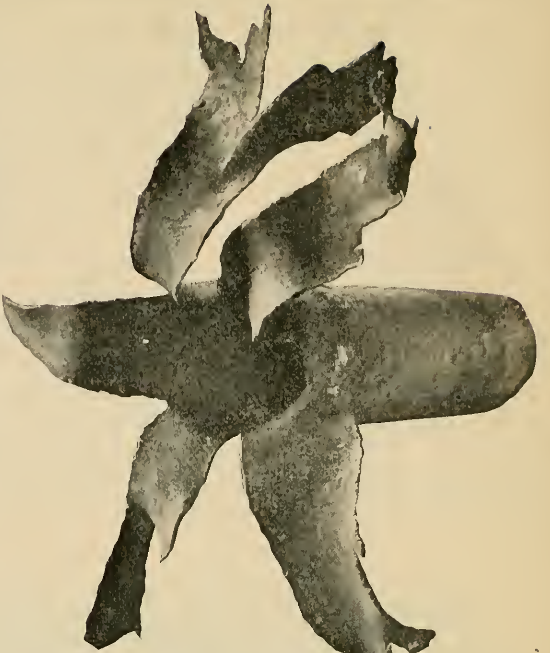


Fig. 7.—The End of the Shattered Tube.

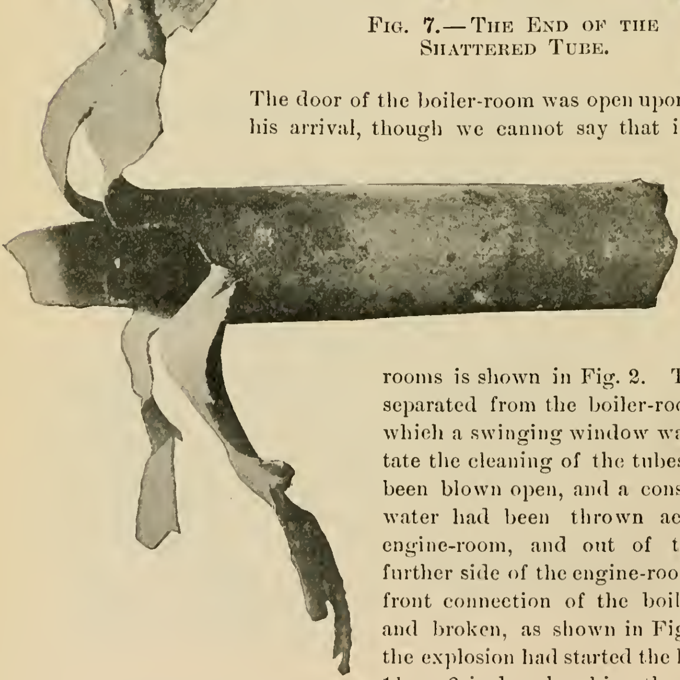


Fig. 8.—The End of the Shattered Tube.

The general arrangement of the boiler and engine rooms is shown in Fig. 2. The engine-room was separated from the boiler-room by a partition, in which a swinging window was arranged, to facilitate the cleaning of the tubes. This window had been blown open, and a considerable quantity of water had been thrown across the boiler and engine-room, and out of the windows on the further side of the engine-room. The doors of the front connection of the boiler were thrown open and broken, as shown in Fig. 3. The shock of the explosion had started the boiler backward some 1½ or 2 inches, breaking the water column. The main steam pipe was connected to the same nozzle with the safety-valve. The valve casting was broken at the neck, and much water had been thrown upward through the opening thus made, and through the floor above. There were three lugs on each side of the boiler, and it was found that the forward one on each side had been wrenched nearly free, the lower rivets being broken off on the inside. An examination of the shell showed that the first sheet of the furnace, and part of the second one had been bulged outward to a distance of from 2½ to 3 inches, somewhat as suggested in Figs. 4 and 5. This bulge involved the girth joint, and this had been so strained and distorted that many of the rivets could be turned with the thumb and finger.

The lower portion of the front head just to the right of the center was deflected inward to a distance of about two inches at the center of the deflection. Six tubes were pulled out of the head, and twenty-seven others were loosened, the ends of some being drawn partly through the head, and the ends of others projecting a short distance outward. All of the tubes were bent and most of them were collapsed. The center of the disturbance was plainly in the tube shown unshaded in Figs. 3 and 5. This tube had been shattered to pieces for a distance of about three feet, beginning at about one foot from the front head. Some of the fragments were collected and photographed, with the result shown in Fig. 6. The ends of this tube were stripped into ribbons, which had been bent outward against the steam pressure in the boiler, thus proving that the disrupting force was *within* the tube, and hence could not have been steam. Something over a foot of the front end of this tube still remained fast in the head. This was cut out and removed from the boiler, and it was then photographed in the two positions shown in Figs. 7 and 8.

Fig. 9.— Flash-Light Photograph of Interior of Boiler.

Projecting from the shattered end of the boiler tube that we have just described, a piece of 1¼ inch pipe was found, which was similarly torn and split. This is shown in Fig. 1. This piece of pipe was certainly not a part of the boiler, and the way in which it was torn showed very plainly that the destructive center was not only inside of the boiler tube, but also *inside of this piece of 1¼-inch pipe.* A glance at Fig. 1 will satisfy the reader of this, and the fact is still more evident when the pipe itself is examined at first hand. Some of the fragments shown in Fig. 6 came from this pipe, as is proved by their sharp curvature.

After the end of the shattered boiler tube had been removed, a camera was set up at the tube hole, and a flash-light photograph of the interior of the boiler was taken, the flash-powder being inserted and fired through the hand-hole. The picture so obtained is shown in Fig. 9. The lower row of tubes was driven to the bottom of the shell, and the other tubes had all been blown directly away from the destroyed one, so as to leave a clear circle around it perhaps two feet in diameter. The tubes in the neighborhood of the shattered one were all crushed in on the side towards the center of the explosion. One of these tubes is shown in two views, in Figs. 10 and 11. The violence of the explosion may be inferred from the fact that some of the tubes were turned nearly inside out over a portion of their length, the back side of the tube being collapsed and driven through the front side as suggested in Fig. 12. This effect can be seen quite clearly in Fig. 11.

FIG. 10.—ONE OF THE CRUSHED TUBES.

FIG. 11.—REVERSE VIEW OF THE SAME TUBE.

The facts pointing to the use of dynamite in this instance may be summarized as follows : (1) The boiler did not burst ; it was strained and distorted in many places, but the actual destruction of material was mostly confined to a single tube. (2) The destroyed portion of this tube was blasted to atoms, in a way that points almost certainly to the action of some explosive more sudden in its action than steam. (3) The torn ends of the wrecked tube were bent outward, *against the steam pressure*, proving that the disrupting force was *within* the tube. (4) A piece of shattered pipe which did not belong to the boiler, and which had every appearance of having been used as a bomb, was found inside of the boiler, projecting from the shattered end of the tube that was destroyed. (5) The frayed ends of this pipe also extended outward, showing that the disrupting force was *within this pipe*. (6) The tubes around the destroyed one were all crushed in on the side towards the conjectured bomb, and in such a manner that the use of an explosive more violent than steam can hardly be denied.

If the reader will carefully examine the photo-engravings that accompany this article, and weigh the data that are given in the text, we feel sure that he will admit that this is a genuine case of the intentional destruction of a boiler with dynamite or other equivalent high explosive. We have no suggestions to offer concerning the perpetrator or the motive, and will merely add that the boiler-room is surrounded by trees and shrubs, so that it would be an easy matter to gain access to it without detection.

FIG. 12.

The Locomotive.

HARTFORD, OCTOBER 15, 1898.

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

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Obituary.

MR. WILLIAM G. PIKE.

We regret to record that Mr. William G. Pike, who has been connected with this company for thirty years, died on September 21st, at his home in Philadelphia, Pa., in the eighty-first year of his age. Mr. Pike was born at Saco, Maine, on April 28, 1818. He received a common school education, and afterward learned the machinist's trade with the Boston Manufacturing Co., of Waltham, Mass., where he was an associate and fellow apprentice with the late Gen. N. P. Banks, of Massachusetts. In 1846 he became superintendent of the Knitting Machine Co., at Danvers, Mass. He superintended the construction of the first steam shovel used by Otis & Company in building the Boston & Worcester railroad, and later he became master mechanic in charge of the construction and repair shops of the Passumpsic River railroad, at White River Junction, Vt. In 1852 he left this position and went to Boston, where he engaged in the steam piping and engineering business, under the firm name of William G. Pike & Co., and later on he organized a similar business in Philadelphia, under the name of Pike, Green & Co. He was a pioneer in the low pressure steam heating of buildings, and he furnished the heating apparatus for many of the prominent buildings of his time. In the panic of 1857 he met with financial reverses, and in 1863 went out of business. He became associated with the Hartford Steam Boiler Inspection and Insurance Company in 1867, and has been in its service continuously ever since. He was chief inspector in our Pennsylvania Department until 1891, when he retired from the active management of the inspection department, and became consulting engineer, a position for which his wide experience and ripe judgment gave him peculiar fitness. He was deeply respected by a wide circle of personal friends and business acquaintances, and his sound and ready counsel, which was freely extended to all, will be greatly missed.

Regnault's First Memoir.

The first volume of Regnault's famous memoirs was published in 1847, and the papers that it contains are exceedingly important, since they form the foundation upon which much of our present knowledge of theoretical steam engineering rests. The first memoir in this volume relates to the expansion of air and other gases, and the experiments that it contains are of especial interest and value, because our modern methods for the precise measurement of temperature are based upon them. On account of this fact we have undertaken a careful revision of all the data which the memoir contains, and have recalculated his results with the utmost care. As might be expected, our conclusions are not greatly different from his own, but such small differences as we have introduced appear to be distinct improvements. We have detected and corrected some minor arithmetical errors, and have everywhere made use of our present increased knowledge of physics, in making the necessary reductions of the experimental data. Two examples will serve to make the nature of these changes clear. An approximate knowledge of the coefficient of expansion of mercury is required, in reducing the data of this memoir; and at the time when Regnault made his calculations, this coefficient was only roughly known. Subsequently he himself made and published (in his fifth memoir) a long series of experiments for the accurate determination of this coefficient; and we have used the results of this fifth memoir, in recalculating the first one. Regnault says in a foot-note that in his own reductions, he used "the coefficient of expansion of mercury which physicists usually employed, from the experiments of Dulong and Petit. The experiments which I have made for the determination of this coefficient," he adds, "and which will be found described in a subsequent memoir, give a value sensibly larger; . . . but the change has so small an influence on the concluded coefficient of expansion of air, that I have not considered it necessary to change all the calculations that were made with the old coefficient." We have substituted the improved value of the coefficient, and have performed the laborious re-calculations from which Regnault shrank. Again, the deviation of air from absolute conformity with Boyle's law had not been investigated, at the time that this memoir was completed, with an accuracy sufficient to enable Regnault to take proper account of it. He therefore assumes, in his reductions, that air conforms rigorously to Boyle's law, and that the volume of a given mass of air is precisely inversely proportional to the pressure, so long as the temperature remains constant. In his sixth memoir he shows that this is not quite true; but he does not modify the first memoir, to bring it into accordance with his later observations. In our calculations, we have taken full account of the actual deviation of air from strict obedience to Boyle's law, using, for this purpose, the data published by A. W. Witkowski in the *Philosophical Magazine* for April, 1896.

With these introductory remarks on the care with which we have recalculated the data that Regnault gives, we proceed to consider the memoir itself, which is divided into three main sections and several sub-sections, as follows:

§ I.— On the Expansion of Air at or near Ordinary Atmospheric Pressure.
  1st Method, in which the pressure and volume both change.
  2d Method, in which the volume changes but little.
  3d Method, in which the volume remains rigorously constant.
  4th Method, closely similar to the preceding one.
  5th Method, in which the pressure remains nearly constant.

§ II.— On the Expansion of Certain Other Gases, at Pressures near to the Atmospheric Pressure.

§ III.— On the Expansion of Gases at Various Other Pressures.

We shall take these different sections up in order, beginning with —

§ I.— THE EXPANSION OF AIR AT OR NEAR ORDINARY ATMOSPHERIC PRESSURE.

First Method. — In general terms, this method consists in filling a glass bulb of known capacity with air at 100° C. (212° Fahr.), and then causing the air in the bulb to cool down to 0° C. (32° Fahr.), with its stem dipped into mercury. The air contracts in cooling, and the amount of its contraction is estimated by weighing the quantity of mercury that enters the bulb during the cooling process. Simple as this program may appear, its execution, with any high degree of precision, demands great care and patient attention to detail; and Regnault's success in obtaining accurate results was due to the minute study that he bestowed upon every step in the process, however trivial it might be. There is a certain charm about his method of working that fascinates the student of his memoirs, and stimulates him to strive for an equal order of accuracy in his own experiments. We can hardly hope to reproduce this charm in our review of his labor, but we shall endeavor, at any rate, to give a fair idea of the pains that he took to avoid any source of error, however slight, that might affect his results in a sensible degree. The bulb that was to serve as the air reservoir is shown at *A B* in Fig. 1. It was cylindrical in shape, with rounded ends, and was large enough to hold nearly two pounds of mercury, when full. From one end of this bulb, or reservoir, projected a tube of very small caliber, *A D*, which was bent at a right angle near the end, and was drawn out, at the tip, to a fine point. The first step in the experiment was to fill this bulb with air at a temperature of 100° C. (212° Fahr.). For this purpose it was suspended in the tin vessel that is shown on the right of Fig. 1, and steam from boiling water was caused to flow up around it as indicated by the arrows. To make sure that the bulb actually acquired the temperature of the rising steam, the upper part of the tin vessel was made double, so as to form a sort of jacket, through which the steam descended before finally escaping into the air. Fearing that the tortuous course of the steam might cause the pressure inside the vessel to be slightly higher than the atmospheric pressure outside, so that the temperature of the bulb would be slightly greater than the temperature due to the pressure of the outer air as read by the barometer, Regnault provided a water gauge, *F*, by means of which he could assure himself at any moment that the pressure inside the tin vessel was sensibly the same as that on the outside. When the water in the tin vessel was boiling freely, the stem, *A D*, of the air bulb was connected, by means of a rubber tube, to a drying apparatus, *G G P*. This consisted of an air pump, *P*, and some *U*-shaped tubes, *G G*, filled with pumice stone moistened with strong sulphuric acid. The object of this apparatus was, to make sure that the air in the bulb *A B* was perfectly dry. With this end in view the air was withdrawn from *A B* and the tubes *G G* by means of the pump *P*, and was then allowed to flow back slowly, so that the sulphuric acid with which the pumice was wetted could abstract such moisture as the entering air might chance to contain. One operation of this kind would doubtless remove the greater part of the moisture from the bulb, but to make sure that the air that was to be experimented upon was *entirely* free from moisture, the process of exhausting and refilling was repeated 25 or 30 times. Then the cocks of the air pump

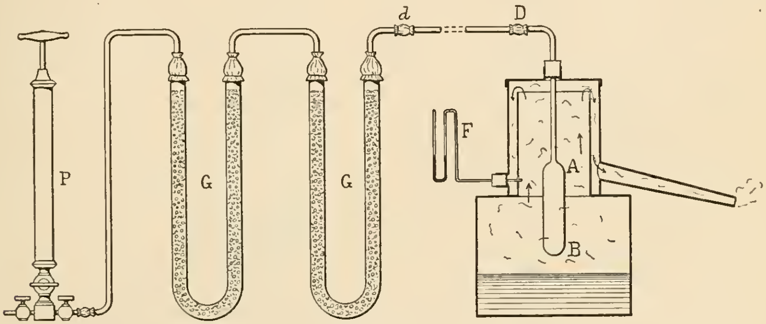

Fig. 1.— Drying and Heating Apparatus.

were opened, and the apparatus was left to itself for from half an hour to an hour, in order to be reasonably sure that the pressure of the air in the bulb had come into equilibrium with that of the atmosphere outside. The drying apparatus, *G G P*, was then detached. It was still possible, however, that the pumice stone and sulphuric acid in the drying tubes had opposed a sufficient resistance to the final inflow of air, to prevent the pressure in *A B* from rising to the precise pressure of the atmosphere. If this were the case, as soon as the rubber connection *D* were removed, a slight amount of undried air would immediately enter *A B*, to bring the pressure there up to the full atmospheric pressure. To guard against this, Regnault detached his drying apparatus, not at *D*, but at *d;* so that if any air were drawn into the bulb from the cause just outlined, it would be the dried air in the tube *d D*, which would do no harm. After the drying apparatus had been detached at *d*, the rubber connection at *D* was also removed, and the precautionary tube *d D* was taken away. The apparatus was then allowed to stand for a few minutes (the water in the tin heating-vessel being kept in full ebullition all this time). The finely drawn out tip of the little tube *A D* was then quickly sealed up by a blow pipe, and, at the same time, the height of the laboratory barometer was taken. (Regnault, in his formulas, denotes this height by the letter *H*, and the temperature of saturated steam at this pressure he calls *T*.) By the process that we have just described, the bulb has been filled with dry air at a known pressure and temperature, the pressure being approximately that due to 30 inches of mercury, and the temperature approximately 100° C. (212° Fahr.). It may add to the clearness of the description, if we give the numerical results of some one of his experiments, throughout; and we shall select, for this purpose, the second of the fourteen experiments that he made by this method. When he sealed the bulb up on this occasion, the barometer in his laboratory stood at 759.67 millimeters (29.908 inches), the corresponding temperature of the steam in the tin heating-vessel being 99.99° C.(211.98° Fahr.); so that he knew that the air in the bulb had this temperature and pressure when it was sealed up. The next step was, to find out how much this air would contract (provided it were free to do so) upon being cooled to the temperature of melting ice. For this purpose the sealed bulb, *A B*, was removed from the tin heating-vessel, and secured, in an inverted position, to the apparatus shown on the left of Fig. 2. The bulb rested on three little legs (shown at *A*), which were attached to the circular table *E*. It was also secured, at the top, by a little metal cup that was held against it by a screw. The stem of the bulb passed down through the table *E*, through an opening fitted with a cork, O, and dipped some two or three inches below the surface of a mass of mercury contained in a cylindrical vessel as shown. The bulb stem having been previously marked close to its extremity with a light scratch, its sealed tip is next broken off by a pair of small pincers; and the bulb having in the meantime cooled down nearly to the temperature of the atmosphere, so that the pressure of the air inside of it has become materially reduced, the mercury flows up through the stem, until it fills the bulb *A B* up to a certain height. Snow or finely-crushed ice is next piled up on the table *E*, so as to entirely surround the air-bulb, and the apparatus is allowed to stand for an hour or an hour and a half, so that the air and such mercury as may enter the bulb shall become cooled to 0° C. (32° Fahr.), or the temperature of the melting ice or snow. From time to time, during this period, the apparatus is tapped lightly to overcome any slight resistance in the bulb stem or elsewhere that might prevent the mercury from rising into the bulb sufficiently to bring about an exact equilibrium of pressures. After an hour or two, when it is considered that the desired equilibrium of pressure and temperature has been attained, the broken tip of the bulb-stem is carefully closed by means of a plug of wax which is attached to the adjustable arm m, and has been previously submerged in the mercury dish, and brought opposite to the tip of the bulb-stem. At the same moment the laboratory barometer is again consulted. (Regnault denotes this barometer reading by the symbol H'.) In the second experiment, the numerical data of which we are giving for the sake of illustration, the height of the barometer at this moment was 755.72 millimeters (29.753 inches). This pressure, however, is not the pressure to which the air in the bulb is exposed ; it is merely the pressure that the atmosphere exerts upon the free surface of the mercury in the dish under the table E, and the pressure on the air *in the bulb* is less than this amount by the head due to the column of mercury that stands in the bulb and its stem. To find the length of this column, Regnault proceeded as follows: He had provided a small screw, t, with conical but slightly rounded ends, and he now brought the lower end of this screw into exact contact with the mercury in the dish. The ice was then removed from the table E, and the apparatus was allowed to regain the temperature of the surrounding atmosphere. The pressure in the bulb increased, of course, as the bulb warmed up, but no mercury could flow out of the bulb, because the tip of its stem had been plugged with wax. When the apparatus had attained the temperature of the room in which it stood, the difference in level between the mercury in $A\ B$ and the upper end of the screw t was measured by means of a telescope, $T\ T'$, which could slide up and down along a vertical graduated scale, $S\ S$. To this observed difference in height, h, he then added the known length, k, of the screw t, and the sum was the difference in level between the mercury in the bulb, $A\ B$, and that in the dish below. Sometimes he varied this method by removing the mercury dish and its contents, and then measuring, directly, by means of the telescope, $T\ T'$, the difference in height between the surface of the mercury in $A\ B$, and the *lower* end of the screw t. The difference in level between the mercury in the bulb and that in the dish (after being corrected to the value it would have if the mercury were at the freezing point of water, so as to have it comparable with the barometer readings, which are also reduced to this standard temperature) Regnault denotes by the letter h. In his second experiment this difference in level was 98.67 millimeters (3.885 inches). Hence when the bulb was sealed up by the wax plug, the air that was introduced into it at the boiling point and at at-

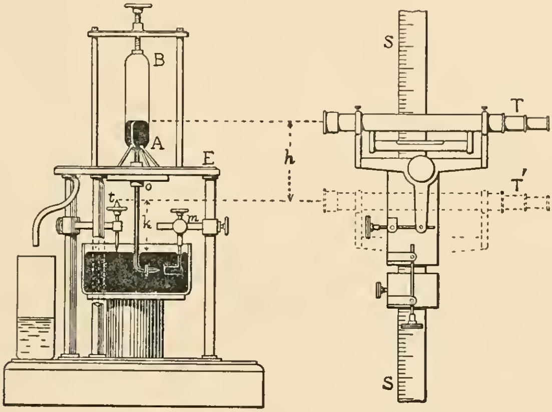

Fig. 2.—Apparatus for Cooling the Air to the Freezing Point.

mospheric pressure had contracted by a certain amount (still to be determined), and now partially filled the bulb, at a temperature of 0° C. (32° Fahr.) and at a pressure due to a column of mercury of the height 755.72 — 98.67 = 657.05 millimeters (25.868 inches). Before passing on to the remaining part of the experiment, we must call attention to one point that illustrates Regnault's care of minute details. Knowing that mercury does not actually wet a glass surface that is immersed in it, he feared that a thin layer of air might lie along the surface of the bulb-stem in Fig. 2, separating the glass from the mercury in such a way as to allow a small quantity of air to be drawn down between the mercury and the glass so as to enter the bulb when the tip was broken off. In fact, he thought he saw evidences that this actually happened in his earlier experiments. To guard against it he therefore applied to the bent part of the stem of the air bulb (*i. e.* the part that is horizontal in Fig. 2), some small rings of brass, scraped bright. The mercury wetted these, and effectually broke the continuity of any air film that may have existed there. To guard against this source of error even more securely, when the pincers were in position to break off the tip of the bulb stem, he poured a layer of concentrated sulphuric acid over the mercury in the dish. The tip was then broken off and removed, but the acid was left until the bulb and its contents had been thoroughly cooled by the ice. The sulphuric acid was then removed, the surface of the mercury in the dish was cleaned, the screw *t* was brought into place, and the experiment proceeded as described above. Regnault also says that it is impossible to prevent the adhesion of a small bubble of air to the pincers that are used to break the glass tube; and to prevent this bubble from being drawn up into the bulb, he says that the tube-tip should be grasped as far as possible beyond the scratch where it is to break.

We will now return to the air bulb, and trace its subsequent history. We have next to determine what fraction of its volume is filled with air after the ice treatment, and what fraction with mercury. For this purpose the bulb is taken out of the apparatus shown in Fig. 2, and is weighed, together with its contents. The weight of the *mercury* it contains is obtained by subtracting from the total weight the weight of the original glass bulb and stem (which has been determined before the experiment began), allowance being made for the broken tip and for the little plug of wax. This weight of mercury, which was 116.780 grammes (4.1193 oz.) in the particular experiment selected for illustration, Regnault denotes, in general, by the letter P. The bulb is then completely filled with mercury that has been boiled to expel such air and moisture as it might contain, and it is then surrounded once more by finely crushed ice, the bent tip of its stem being allowed to dip into a small capsule of mercury, so that as the mercury in the bulb cools and contracts, more mercury can enter, to keep the bulb full. After being left in the ice for an hour and a half or two hours, the tip of the tube is removed from the capsule, and if the mercury at the tip remains perfectly stationary, the bulb and its contents have acquired the temperature of the ice, so that the bulb is now filled with mercury at 0° C. (32° Fahr.). The ice is then removed, and the bulb and its contents are allowed to warm up to the temperature of the room. The mercury meanwhile expands, and some of it runs out at the end of the bulb-stem, where it is caught in a little dish. The bulb and its contents are then suspended again in the tin heating apparatus shown on the right of Fig. 1, and heated to the boiling point of water, as before, the mercury that flows out being still collected in the little dish. When no more mercury comes out, the bulb has acquired the temperature of the steam that surrounds it, and the barometer is read, just as in the first part of the experiment, in order to find the exact temperature of the steam. (Regnault calls this reading of the barometer H_1, and the corresponding temperature of saturated steam he calls T_1.) In the second experiment, the barometer stood at 753.75 millimetres (29.675 inches); and the temperature of the saturated steam around the bulb was therefore 99.77° C. (211.59° Fahr.). The mercury that has run out as the bulb was heated from the freezing point to the boiling point is then weighed. Regnault calls this "p"; in the example that we are taking, it was 11.665 grammes (0.4115 ounce). After the bulb has cooled from the boiling point down to the temperature of the room, it is weighed, and the weight of mercury that just filled it when it was in the heating apparatus is determined. This weight would be represented by $P'-p$ in Regnault's notation; in the example under consideration, it was 758.800 grammes (26.7659 ounces). All of the data required for deducing a value of the coefficient of expansion of air have now been obtained, and the remainder of the present article will be devoted to showing how the necessary computation is performed. The entire routine that we have described up to this point constitutes one single experiment in Regnault's series. He went through with fourteen such experiments in applying his "first method"; and although the labor was great, his reward was also great — not materially but intellectually — for he not only gave the world data that it needed and did not have, but incidentally he built for himself an undying reputation.

In calculating the expansion of the air, the first thing that we need to know is, how much the glass bulb itself expands, when it is heated from the freezing to the boiling point. We have the data for doing this, because we know the weight of mercury that filled the bulb when it was cold, and also when it was hot; and we also know, from Regnault's later experiments, how much the mercury expands when it is heated through this range. Thus the bulb contained 758.800 grammes when it was hot, and 758.800 + 11.665 = 770.465 grammes when it was cold. Hence our data are

Bulb, at temp. 99.77° C., held 758.800 grammes of mercury at temp. 99.77° C.
Bulb, at temp. 0° C., held 770.465 grammes of mercury at temp. 0° C.

Now from Regnault's memoir on the expansion of mercury, which we propose to discuss in course of time, we learn that at 99.77° C. one gramme of mercury occupies 1.018111 times as much bulk as it would at the temperature 0° C.; so that if we could keep the bulb itself at the temperature 99.77° C. while we filled it with mercury at the temperature 0° C., we should find that the quantity of mercury required would be 758.800 × 1.018111 = 772.54 grammes. Our data may therefore be revised and put in this form:

Bulb, at 99.77° C., would hold 772.54 grammes of mercury at 0° C.
Bulb, at 0° C., did hold 770.465 grammes of mercury at 0° C.

We have now eliminated the effect of the expansion of the mercury, and the difference between 770.465 and 772.54 represents the actual expansion of the glass bulb, between the temperatures 0° C. and 99.77° C. In passing through this range of temperature the bulb has enlarged enough to admit 772.54 — 770.465 = 2.075 grammes of mercury at 0° C. This is a gain of .0208 gramme per degree; so that if the bulb had been heated .23 of a degree more, so as to attain a temperature of exactly 100° C., it would have expanded enough to admit .23 × .0208 = .005 (in round numbers) of a gramme more, and its total capacity would then have been 772.54 .005 = 772.545 grammes of mercury at 0° C. Revising our data once more, we therefore have

Bulb, at 100° C., would hold 772.545 grammes of mercury at 0° C.
Bulb, at 0° C., did hold 770.465 grammes of mercury at 0° C.

Now if we take the volume of the bulb at 0° C. as our *unit of volume*, then the volume of the bulb at 100° C. is

$$772.545 \div 770.465 = 1.00270,$$

and for each degree increase in temperature the bulb gains in volume by .000027 of its volume at 0° C.

Having now determined the expansion of the glass bulb, we are prepared to investigate the expansion of the air that it contains. Still taking the volume of the bulb at 0° C. as our unit of volume, we may find the space occupied by the air at 0° C. by means of the weighings that have been made. Thus at zero our unit of volume (that is, the whole bulb) contained 770.465 grammes of mercury; and when the bulb had been packed in ice in the apparatus shown in Fig. 2, it was found to contain 116.780 grammes of mercury. Hence the volume of the mercury in the bulb in Fig. 2 (at 0° C.) was $116.780 \div 770.465 = 0.15157$ (the whole volume of the bulb at 0° C. being unity), and the volume of the part filled with air was $1 - 0.15157 = 0.84843$. This gives us the volume of the air in the bulb when the bulb is at 0° C. in the apparatus in Fig. 2; the air within it being exposed, at this time (as we have already found), to the pressure due to a column of mercury 657.05 millimeters high. When the bulb was first filled with air, its entire volume was occupied by air at a temperature of 99.99° C. and a pressure of 759.67 millimeters of mercury. Now according to our determination of the expansion of the glass bulb, the volume of the bulb at 100° C. was 1.00270; and at 99.99°, its volume would be less than this by $.01° \times .000027 = .00000027$ which is so small that we may neglect it, and consider the volume of the bulb at this temperature to be 1.00270. Our data for the expansion of the air are then as follows:

Vol. of air in bulb at 99.99° C. and 759.67 millimeters was 1.00270
Vol. of air in bulb at 0° C. and 657.05 millimeters was 0.84843

Now if we should increase the pressure on the air in the first line from 759.67 millimeters to 760 millimeters (this being the pressure that is defined as "one atmosphere" in scientific work generally), there can be no doubt that over such a small range of pressure as this Boyle's law would hold good, and the volume would be diminished just in proportion as the pressure was increased. Thus the volume at the pressure 760 millimeters would be given by the proportion

760: 759.67:: 1.00270 : volume required.

Hence the "volume required" is

$$759.67 \times 1.00270 \div 760 = 1.00226,$$

and the first line of our "data" may be written:

Vol. of air in bulb at 99.99° C. and 760 millimeters would be 1.00226.

Regnault makes the assumption that Boyle's law is also true for the second line of our "data," and having given the fact that the volume of the air in the bulb was 0.84843 at 0° and 657.05 millimeters pressure, he proceeds to find what its volume would be at 0° and 760 millimeters by the proportion,

760 : 657.05 :: 0.84843 : volume required;

whence we find that the "volume required" is

$$657.05 \times 0.84843 \div 760 = 0.73350.$$

But while we may admit, without sensible error, that the pressure is inversely proportional to the volume through very small ranges of pressure, when we come to the comparatively large range of pressure here contemplated (*i. e.*, from 657 to 760 millimeters), we are not justified in assuming the strict accuracy of Boyle's law. In fact, it appears from Witkowski's experiments on the compressibility of air at 0° C. (*Philosophical Magazine* for April, 1896), that in the present case the inaccuracy of Boyle's law becomes sensible, and, to allow for it, we must divide the volume (0.73350) just found by 1.00007. Thus, $0.73350 \div 1.00007 = 0.73345$, which is the volume that the air in the bulb would have at 0° C. and 760 millimeters pressure. Our modified data have therefore taken the following form:

Vol. of air in bulb at 99.99° C. and 760 millimeters would be 1.00226.

Vol. of air in bulb at 0° C. and 760 millimeters would be 0.73345.

Upon being heated from 0° C. to 99.99° C. at the constant pressure of 760 millimeters of mercury (which is "one atmosphere" according to the scientific definition), the volume of the air would therefore increase from 0.73345 to 1.00226; which is the same as saying that a unit volume of air at 0° C. and 760 millimeters would increase to 1.00226÷0.73345 =1.36650 unit volumes, at 99.99° C. and 760 millimeters. Upon being heated through a range of 99.99 Centigrade degrees, a unit volume of air therefore increases by .36650. Hence the increase in volume *per degree* (assuming that the expansion is uniform) is

.36650÷99.99=.0036653;

so that (if it be still assumed that the expansion is uniform), this experiment indicates that a unit volume of air at 0° C. and atmospheric pressure expands by .0036653 of its own volume for every Centigrade degree that it is heated, at constant atmospheric pressure. Whether the expansion of the air *is* uniform or not depends altogether upon the kind of a thermometer that is used to measure the temperature. This question Regnault reserves for discussion in his fourth memoir; but whether the expansion is uniform or not, the number just found is certainly the *average* coefficient of expansion between 0° C. and 100° C., because the freezing point of water is 0° C. by definition, and the boiling point, when the barometer stands at 760 millimeters, is 100° C. by definition. What has really been proved, therefore, is that a unit volume of air at 0° C. and atmospheric pressure (*i. e.*, 760 millimeters of mercury) increases to the volume 1.36653 when it is heated, at constant atmospheric pressure, up to 100° C.

Having thoroughly explained the way in which one of Regnault's experiments is reduced and made to yield its result, it will be sufficient to give merely the results of the remaining experiments of the first series. The fourteen experiments that were made by this method give the following values:

(1) [1.36469]
(2) 1.36653
(3) 1.36676
(4) 1.36608
(5) 1.36655
(6) 1.36563
(7) 1.36701
(8) 1.36657
(9) 1.36718
(10) 1.36640
(11) 1.36701
(12) 1.36613
(13) 1.36665
(14) 1.36704

The first of these results should be rejected, since there is undoubtedly an error (probably a typographical error) in the data for it as given by Regnault. This fact is shown, not only by the wide departure of this result from the others in the foregoing table — which might not be sufficient to justify the rejection if there were no further evidence — but also because it is impossible to get Regnault's own result, or anything like it, from the data that he gives, even when using the exact reduction formulæ that he used. Omitting the first observation, therefore, we find that the average of the remaining thirteen is 1.36658. The final result of Regnault's first method of experiment, therefore, is that a unit volume of air, at 0° C. and a pressure of 1 atmosphere (760 mm. of mercury), increases to the volume 1.36658 when it is heated, without change of pressure, to 100° C.

If the air be assumed to expand uniformly, this means that a mass of air, originally at the freezing point of water, and at a pressure of one atmosphere, expands when it is heated without change of pressure, in such a way that for every increase of 1° on the Centigrade scale the air increases in bulk by .0036658 of its original volume at the freezing point; or, which is the same thing, it expands so that for every increase of 1° on the Fahrenheit scale it increases in bulk by .0020366 of its original volume at the freezing point.

The Locomotive.

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Concerning Blow-off Pipes.

When the blow-off pipe of a boiler is wrongly arranged or improperly handled, it is likely to give rise to a plentiful supply of trouble. It is such a simple and innocent looking contrivance, that it is hard to teach the average boiler attendant to care for it properly; yet there is no other attachment (except the safety-valve and water gauge) which is of such paramount importance.

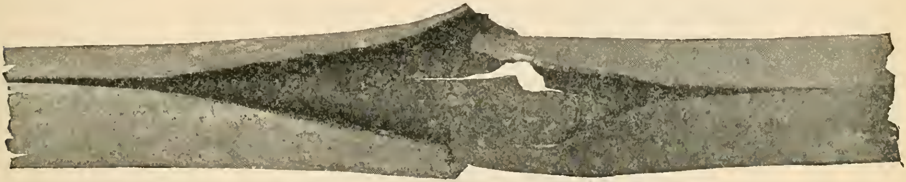

Fig. 1. — A Blow-off Pipe Burned by Neglect.

In practice, blow-offs are arranged in various ways, and are attached at various parts of the shell. Frequently they enter the front or back head below the tubes, as indicated in Fig. 3. We do not consider this to be good practice; for although a blow-off attached at either of these points will draw off the greater part of the water in the boiler, that is about the limit of its useful performance. Pipes attached in this way do not burn off (except under extraordinary conditions), since sediment will not lodge in them in sufficient quantity to allow them to become overheated; but, on the other hand, they are not efficient in removing deposit from the shell, and this is one of the chief functions of a blow-off pipe, when it is properly located. A blow-off pipe that is secured to the front or back head does not entirely empty the boiler, for when the water is drawn off down to the lowest point of the entrance of the blow-off, there will still be three or four inches of water in the bottom of the shell; and unless this water is

Fig. 2. — Another View of the Same Pipe.

syphoned off through the hand hole, it is impossible to properly clean the deposit from the bottom of the shell. It not infrequently happens that the shell plate bulges over the fire shortly after the boiler has been opened and cleaned out, owing to the accumulation of loose deposit upon the sheets. When the blow-off is properly located, it will drain the boiler quite dry, so that this deposit can be thoroughly washed out; but when there is considerable water left standing in the bottom of the shell, it is next to impossible to remove such deposit. Even if the attendant syphons off the water that does not pass away through the blow-pipe, it is still very difficult to effect the cleaning properly, because the boiler will fill up again to the same point as soon as the attendant turns the hose into it, and it is practically impossible to wash the loose scale and sediment from one handhole to the other, with three or four inches of water standing in the bottom of the shell.

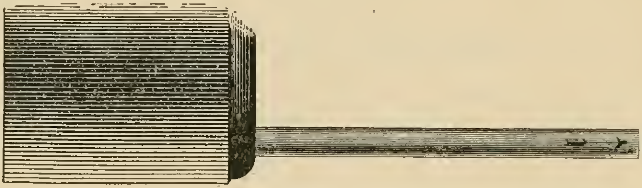

Fig. 3. — Blow-off Entering the Back Head.

It is much commoner, at the present time, to tap the blow-off pipe into the bottom of the boiler at the rear end. about eight inches from the back head, with a re-enforcing plate on the shell. This method is indicated in Fig. 4. According to our ideas of good practice, this is the correct place for attaching the blow-off to the shell. The correct attachment of the blow-off to the boiler is not the only point to be determined, however; for there are several other features that also demand careful consideration. It is common, for example, to use a short nipple from the shell, so that the pipe turns within a few inches of the boiler, and passes straight out through the brickwork of the setting. This mode of arrangement is open to certain serious objections. For example, it leaves the cast-iron elbow in the direct line of passage of the flame and furnace gases, which is certainly not first-class practice, unless the elbow is protected in some way. Again, the short nipple is liable to throw a considerable strain on the elbow, in case the boiler set-

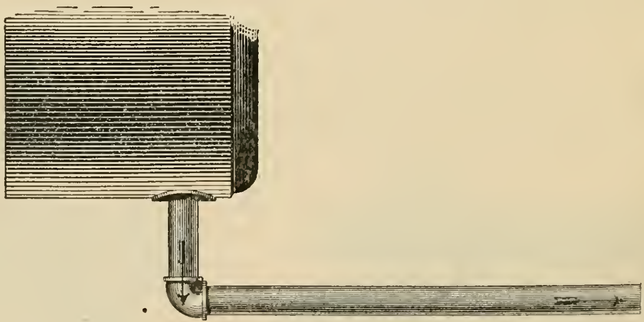

Fig. 4. — Blow-off Entering at the Bottom of the Shell.

tles, or moves to a sensible extent under the varying conditions of temperature and pressure to which it is exposed, the horizontal pipe being usually held fast in the brickwork of the setting. A number of serious accidents that have come to our notice have been traceable to this rigid construction, as a probable cause. The short nipple leaves the horizontal part of the blow-off in the direct line of the flame, as well as the elbow; and it takes but a small amount of deposit in this pipe to cause burning, unless great care is exercised to free the entire pipe *every day* by blowing out an inch or two of water from the boiler. Most of these pipes are protected by a sleeve made of pipe two or three sizes larger than the blow-off. In many cases these sleeves are merely slipped over the blow-off, inside of the setting, as indicated in Fig. 5. A sleeve of this sort is doubtless of some value, since it protects the blow-off from the direct contact of the furnace gases. It does not keep the blow-pipe cool, however, but leaves it exposed to substantially the same temperature that it would have if the sleeve were absent. The sleeve, too, soon burns off, and after that it is necessary either to run it without any sleeve at all, or to disconnect it and slip a new sleeve on. A sleeve, when properly put

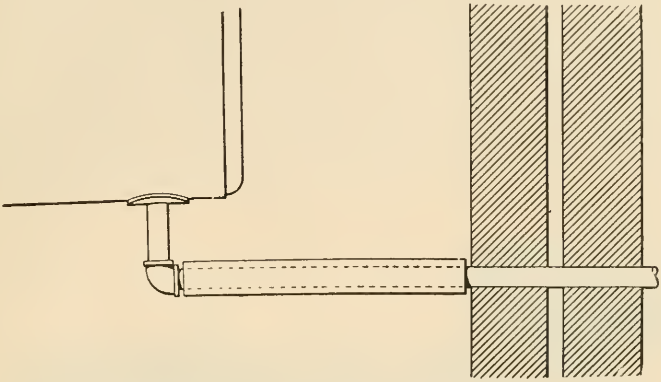

Fig. 5. — Incorrect Method of Applying a Sleeve.

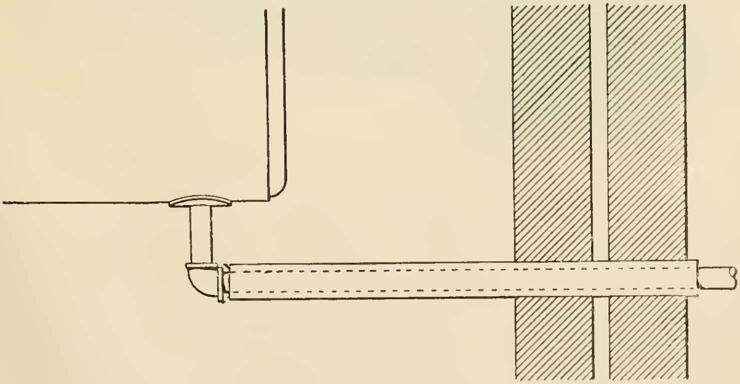

Fig. 6. — Correct Method of Applying a Sleeve.

on, should extend out through the brickwork, and allow a current of cool air to pass in between the sleeve and the blow-pipe, as in Fig. 6. Even a very slight air current of this sort will suffice to keep the sleeve from burning and the pipe from over-heating. The blow-off may easily be made to come central in the sleeve at the outer end, and at the end nearest the boiler it is a common practice to cut several little tongues in the end of the sleeve, which can be bent inward quite readily so as to rest against the blow-pipe, and keep the sleeve central with the pipe that it is to protect. The value of this air-circulation feature is well illustrated by a case that recently came to our attention. On two horizontal tubular boilers, that were almost new, the blow-off pipes were set with short nipples to the shell, and each pipe was provided with a good sleeve which extended outside of the brickwork, as we recommend. One of the blow off pipes burned off in a short time, the sleeve that was supposed to protect it being also burned away at the same time. One of our inspectors was called, and when he reached the plant he found that a new pipe and sleeve had been put in, and that the boiler was running again. It happened that the rear wall of each boiler was provided with a peephole, from which the blow-off pipes could be seen. An examination made in this way showed that the sleeves upon both pipes were almost white hot. Further investigation showed that the attendant in charge, not understanding the purpose of the open space between the sleeves and the blow-pipe, had plugged it up with paper pulp, because he fancied that the air passing in through these chinks might interfere with his draft. Upon removing the plugs of pulp so as to admit a small current of air, the sleeve at once cooled off, so that inside of a minute it was entirely black again. No more trouble has been experienced at this mill with the burning of the blow-off pipes or sleeves.

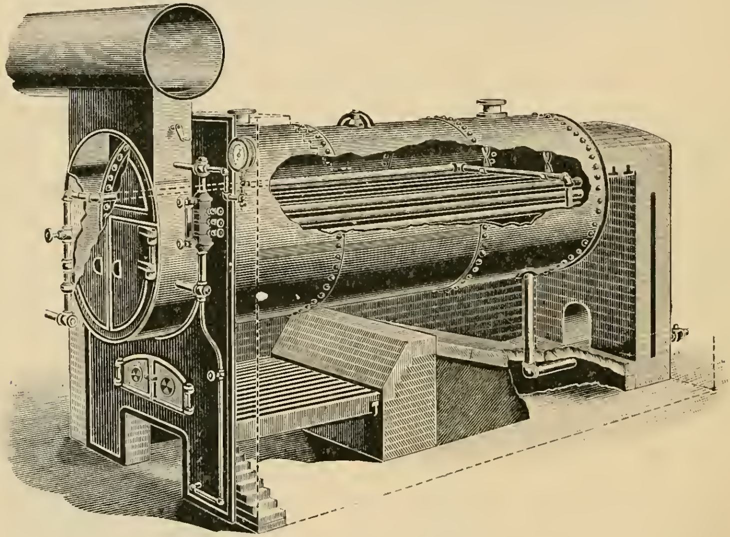

Fig. 7. — Showing the Blow-off Passing out Below the Floor of the Combustion Chamber.

The short-nipple blow-off, when provided with a proper sleeve, usually gives fair satisfaction; but in putting in new work, we believe that the blow-off pipe should always be provided with a long vertical pipe in the place of the short nipple, so as to carry the horizontal pipe well down to the bottom of the pit, or combustion chamber. The elbow and the horizontal pipe will then be below the heat, and hence will not be liable to burn out, nor to be strained unduly by the motion of the boiler under varying temperature and pressure. The horizontal pipe may be carried down far enough to come below the floor of the pit, as shown in Fig. 7, or it may be run along the upper surface of the floor, as suggested in Fig. 8. In the former case, the pipe should not be bricked in too tightly, for if it is held rigidly by the bricks, the slight motions of the boiler may throw an undue strain upon it. In the latter case — that is, when the pipe runs along the top of the floor as in Fig. 8 — it will become buried in soot after the boiler has been running for a short time, and this will serve to protect it quite effectually from subsequent damage by heat. When the method of Fig. 8 is adopted, it is sometimes necessary to raise the cleaning door a little, so that the blow-pipe may not interfere with it. When the long vertical pipe is used, we recommend that this pipe be protected by a sleeve, as suggested by the dotted lines in Fig. 7, and indicated more clearly in Fig. 8.

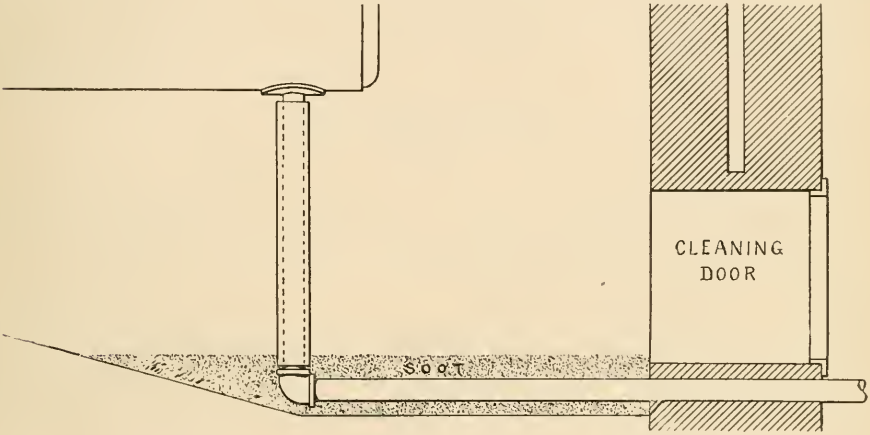

Fig. 8. — Blow-off Pipe Protected by Soot.

All blow-off pipes, no matter where connected, should be opened at least once in every twenty-four hours, long enough to blow out an inch or so of the water in the boiler. It is very hard to impress this idea upon the mind of the average boiler attendant, who is too apt to regard the blow-off as nothing but a sort of drain pipe, which is to be used only when he wants to run the water off. Many boiler attendants neglect to blow down each day, either because they don't understand the importance of it, or for some other inscrutable reason. Some of them, we are sorry to say, appear to be disciples of the famed Ananias; for they will swear that they opened the valve not more than four hours ago, when, as a matter of fact, they haven't touched it for weeks. The following example will show how this mode of doing things may be expected to work. One of our inspectors was called upon to inspect a battery of four boilers, and upon reaching the boiler-room he found water standing in them up to the level of the hand holes. He noted this at once, because he was familiar with the plant, and knew that the boilers were fitted with blow-offs on the bottom of the shell, so that they should be entirely emptied. He suggested to the engineer that the blow-off pipes were probably stopped up, and asked if there was any difficulty in blowing off. He was answered in the negative; but upon making an examination, one of the boilers was found to have its blow-off burned almost entirely in two, only a small section of the pipe remaining on the upper side. Figs. 1 and 2 are made from photographs of this pipe, and they show its condition very well, except that in taking the pipe out and transporting it to this office, the last shreds of metal that held it together were broken off, and much of the deposit that was in them was knocked out. The deposit, when the pipe was first found, was as hard as cement, and the boiler had been running at 60 pounds pressure, with nothing to hold the steam and water in the boiler but the plug of sediment with which the blow-off was filled. The blow-off on one of the other boilers of the battery was also found to be stopped up and burned, but not so badly as the one that we have here selected for illustration. Both of these boilers had been emptied through the front handhole, because nothing would pass out through the blow; yet the watchman told his employers in the presence of the inspector that he blew down these boilers every night, and that the boiler with the burned blow-off was blown down Thursday night (the inspection being on the following Sunday). If our readers can find anything in the memoirs of Baron Munchausen that is less probable than the statement of this watchman, then we will gladly apologize to the entire profession for hinting that there is a boiler attendant anywhere who does not tell the whole unmodified truth about his blow-off, without any mental reservation or purpose of evasion whatsoever. Many other cases of the same sort could be related. We recall one in which a pair of new boilers was put in, and after running about three months one of the blow-off pipes was found to be burned off. The inspector stated that in his opinion the blow-offs were not opened regularly; but this was denied by the fireman with the utmost positiveness and directness. In about three weeks more the other blow-off was burned off in a similar manner, and after this the owner of the plant gave the superintendent positive orders to go to the boiler-room every morning, and see with his own eyes that the blow-cocks were opened. This incident occurred five years ago, and since that time there has been no trouble with the burning off of the blow-off pipes.

Extinguishing Fires on Shipboard.

For many years steam jets have been considered excellent means for extinguishing fires in inclosed spaces, and examples of their good services have been abundant. The theory of their action, of course, is, like that of the several kinds of fire-extinguishing powders which have been proposed at different times, that the steam in the one case, and the stifling fumes from the powders in the other, displace the air in any particular space under consideration, and with it the oxygen as well, by which alone combustion can be sustained. In at least one instance, however, the position was taken that if the steam jets did not extinguish a fire promptly, they soon became a source of danger. For example, such jets were held accountable, about a year ago, for the loss of a cargo steamer carrying several hundred tons of coal and as many more of miscellaneous chemicals and old rope. Fire broke out in one of the holds, which were fitted with steam-jet fixtures, and the jets were at once turned on. On the day following it was proposed to try a hose, in addition to the jets, and one of the upper hatches was taken off for this purpose. The almost immediate result was a violent explosion, killing one of the officers and seriously injuring another. All the other hatches were blown off at the same time, and the ship began to leak so badly that she soon had to be abandoned. One explanation of the explosion that was advanced was, that the steam from the jet, passing over the incandescent coal, formed water gas; and that this, when mixed with a certain proportion of air from the opened hatch, took fire and exploded with the results noted above.

Instead of steam, or other usual fire extinguishing agents, liquid carbonic acid gas, discharged into ships' holds or other spaces through pipe systems, was proposed several years ago by Professor Doremus. The Board of Marine Underwriters of New York is said to have once reported favorably on the plan, but nothing further was ever done with the suggestion. Fire, of course, cannot maintain itself where there is a sufficient quantity of carbonic acid gas, and Professor Doremus' plan of simply having a stop-cock to turn, so as to let the gas escape from the pipes into any compartment on fire, appears to have all the merits of simplicity and effectiveness. An 8-inch steel cylinder, 5 or 6 feet long, would hold enough liquid carbonic acid to fill a very large space with sufficient gas to put out a fire. The cost of equipment and maintenance, too, would not be great, and even if it did run up to a figure of some magnitude, it would probably represent but an insignificant proportion of the saving that the method might effect.—*Cassier's Magazine.*

Inspectors' Report.

JULY, 1898.

During this month our inspectors made 8,635 inspection trips, visited 17,225 boilers, inspected 8,912 both internally and externally, and subjected 914 to hydrostatic pressure. The whole number of defects reported reached 13,307, of which 994 were considered dangerous; 44 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,173	16
Cases of incrustation and scale,	2,907	91
Cases of internal grooving,	124	9
Cases of internal corrosion,	1,128	36
Cases of external corrosion,	799	41
Broken and loose braces and stays,	111	22
Settings defective,	364	31
Furnaces out of shape,	462	19
Fractured plates,	229	38
Burned plates,	248	26
Blistered plates,	215	9
Cases of defective riveting,	1,470	115
Defective heads,	138	23
Serious leakage around tube ends,	2,112	299
Serious leakage at seams,	360	46
Defective water-gauges,	246	44
Defective blow-offs,	184	47
Cases of deficiency of water,	7	4
Safety-valves overloaded,	35	12
Safety-valves defective in construction,	66	18
Pressure-gauges defective,	484	30
Boilers without pressure-gauges,	8	8
Unclassified defects,	437	10
Total,	13,307	994

The Locomotive.

HARTFORD, NOVEMBER 15, 1898.

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

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Boiler Explosions.

AUGUST, 1898.

(187.) — A boiler exploded at Gayoso, near Benton, Mo., on July 26th, killing two men. [News of this explosion was received too late to include it in the July list.]

(188.) — On August 3d, a boiler exploded on the premises of C. L. Blair, at Peapack, N. J. The boiler-house was totally demolished, and the boiler was thrown 400 feet. Fireman Frank Gulick, who was standing in the doorway of the boiler-house, was severely injured.

(189.) — A boiler exploded, on August 3d, in Crane's mill, at Dixie, near Quitman, Ga. Mr. G. B. Crane, the owner of the mill, was severely injured, but it is believed that he will recover. His son, Joseph Crane, was killed.

(190.) — A hoisting boiler exploded, on August 4th, at the mine of Jones, King & Co., in Jackson Hollow, a short distance from Jackson station, near Falena, Kan. The engineer, Frank Stanley, was oiling the engine at the time, and was within ten feet of the boiler. Ernest Stanley, the hoisterman, was in the hoister-house, about 20 feet from the ground. The explosion demolished the derrick, hoister-house, and pump, throwing Ernest Stanley down the shaft about 20 feet, where he caught on the cribbing and saved himself a fall of 86 feet to the bottom of the shaft. He was not seriously injured. The engineer was struck on the top of the head by a fragment of the boiler, but was not badly hurt. The boiler was thrown 372 feet.

(191.) — A boiler belonging to Boock Bros., of Brokaw, near Bloomington, Ill., exploded on August 4th, blowing out the front head. We have not learned of any personal injuries.

(192.) — On August 5th, a boiler exploded in the Indiana Iron Works, at Muncie, Ind. Albert R. Knapp, a shearer, who was fifty feet away from the boiler-house at the time, was fatally injured, being badly scalded and bruised. Thomas Jones, a puddler, was seriously injured by flying bricks. One of the heads of the boiler fell in an open field, fully 1,000 feet from its original position, passing through a cupola on its way. Scalding water was showered around for a distance of a hundred feet or more. The pump-house was wrecked, and the bricks were scattered about over a radius of five hundred feet. Glass was broken in houses half a mile away. In addition to the boiler which exploded, three others were wrecked, and considerable other machinery was damaged beyond repair. Seven hundred persons were employed about the works, and as the explosion occurred just as the men were changing shifts, it is wonderful that a large number of them were not killed and injured.

(193.) — A boiler exploded, on August 6th, at the Christy coal mine, four miles southeast of Des Moines, Iowa. Fireman Edward Fredigill was scalded to death, and John Moses, Hugh Wheaton, and one other man whose name we have not learned, were injured. The exploded boiler was one of a battery of four, and the three that did not explode were blown from their settings in various directions. One end of the exploded boiler was found in the woods, about a hundred and fifty yards distant. The main portion of the shell passed out through the side of the building, cutting off the timbers of the pit-head, and smashing six-inch joists into splinters. The foundations and walls of the boiler-house were utterly destroyed, so that one could not even guess where the walls had stood. Up above, the iron roof and timbers hung in torn fragments. The upper part of the pit-house was also destroyed. Some 250 men were down in the mine, but all reached the surface in safety.

(194.) — On August 8th, a boiler exploded in Buchanan County, near Tazewell, Va., killing four men. We have not learned further particulars.

(195.) — A boiler exploded, on August 11th, in McGovern's mill near Broxton, Ga. John Cannon and David Hersey were instantly killed, and John Hersey was seriously injured. Mr. Cannon's body was thrown sixty feet. We have not learned the extent of the property damage.

(196.) — A locomotive boiler exploded on August 11th, on the Catawissa branch of the Philadelphia & Reading Railroad, about one mile east of Ringtown, near Shamokin, Pa. Locomotive No. 125, drawing a train of soft coal, was on its way from Newberry Junction to Tamaqua, and just after passing Ringtown station a hissing was heard in the furnace. Robert H. Seiwell, the front brakeman, was assisting Fireman Noragong, and was standing with his back to the furnace door. An instant after the hissing was heard, the fire door was blown open, and Seiwell and Noragong were struck by a powerful blast of steam and scalding water and live coals. Both men scrambled back to the first car behind the tender, from which they were thrown to the ground. Engineer Joseph Shadle, with the assistance of the other trainmen, soon stopped the train, and the two injured men were found lying beside the track, unconscious. They were terribly scalded, and cannot recover. A subsequent examination of the wrecked locomotive showed that the accident was due to the collapse of a tube. The engineer, although remaining in the cab, was only slightly injured.

(197.) — On August 12th, a threshing-machine boiler, belonging to Daniel Long, exploded on the farm of Peter Benchi, at Clarence, near Buffalo, N. Y. Engineer Frank Jones was thrown a considerable distance and had his arms badly burned. Mr. Daniel Long Jr., was thrown against the water tank and was severely bruised. A barn near which the machine stood took fire from the coals that were thrown into it, and was quickly destroyed.

(198.) — Three hundred men were thrown out of employment, on August 13th, by the explosion of one of a battery of six boilers in the Crookston Lumber Company's plant, at Crookston, Minn. One man was scalded, and two others were injured by flying debris. We have seen no estimate of the property loss.

(199.) — The boiler of a portable engine belonging to Stewart & Newell, of Chester, Ohio, exploded, on August 16th on the John Stewart farm, some three miles out of

Chester. The pressure, at the time of the explosion, was eighty pounds. The head of the boiler was blown out. Fortunately nobody was injured.

(200.) — On August 16th the boiler of locomotive No. 2, of the Santa Fé, Prescott & Phœnix Railroad, exploded in the roundhouse at Prescott, Ariz. Joseph Brown, a machinist, was standing on the boiler at the time, adjusting the pop-valve. He was badly crushed about the head, and died in a short time. E. M. Seamans had two of his limbs blown off, and was otherwise badly bruised. He cannot recover. Engineer Charles C. Chambers was in the cab of the locomotive, and was dangerously injured. One report that we have received states that Chambers died, but this is not confirmed. The roundhouse and machine-shop were destroyed, and the property loss was heavy; one newspaper estimates it at $100,000, but this is probably somewhat too high. One section of the boiler, including a firebox and part of the shell, and weighing four or five tons, was thrown 1,200 feet, knocking the end out of the Bashford–Burmeister company's warehouse in its flight, and landed in the street in front of the post-office, a quarter of a mile from the scene of the explosion, tearing an enormous hole in the ground, but fortunately injuring no one.

(201.) — A boiler exploded, on August 21st, in the creosote department of the Williamsport Wooden Pipe Company's plant at Cammal, Pa. Levi Kyre, overseer of the creosote department, was severely burned, and Charles Smith was also injured to a lesser extent. The creosote department took fire and was destroyed. The total loss is estimated at $21,000.

(202.) — A boiler exploded, on August 22d, in the American Steam Laundry at Carson, Nev. The plant was destroyed, together with the residence of H. B. Millard, the proprietor.

(203.) — On August 2d a threshing-machine boiler exploded on Solomon Wald's farm, at Georgetown, near Shamokin, Pa. Iron fragments and scalding water were thrown in every direction. Mr. Wald was scalded about the head and hands, William Kebash was cut on the face and head, and Daniel Tschop was seriously hurt by fragments of iron, several of his ribs being broken or dislocated. The barn took fire and was destroyed, with a loss of $2,000 or so.

(204.) — A boiler exploded, on August 23d, in the Pen Argyle Valley slate quarry, in Northampton County, near Easton, Pa. Engineer John Cann was scalded to death. As nearly as can be learned, Mr. Cann went to work at 4.45 A.M., cleaned up his fires, and made ready to start the pumps. While he was at work one of the longitudinal joints of the boiler gave way, and he was deluged with steam and boiling water. He was not killed instantly, but endeavored, ineffectually, to escape from the boiler-room by a side door. He was unconscious when found. Subsequently, while clearing up the wreckage of the destroyed boiler-house, a workman, named William Parsons, was killed by a falling derrick.

(205.) — On August 23d a threshing-machine boiler exploded on Thomas Harkins' farm at Ringgold, Montague County, Texas. The machine was destroyed, and William Brown and another man named Wicks were injured.

(206.) — On August 23d a boiler belonging to Reuben Foulkrod exploded at Sunbury, Pa. Mr. Foulkrod, who was near the boiler at the time, was fearfully scalded, and was also struck by a fire door and severely injured internally, so that he died on the following day.

(207.) — A boiler belonging to Kirk, McBee & Lemley, of Eugene, Ore., exploded on August 25th. Ellory Kirk was killed, and John Lemley and Anthony Bryant were fatally injured. Joseph Gibson, Roy Hurlburt, Jesse Hurlburt, James Bryant, Frederick Hitt, Chester Kirk, and Claude McBee were also injured, though it is believed that they will all recover.

(208.) — A boiler exploded at Brandon, Minn., on August 26th, injuring Elias Olson and John Johnson.

(209.) — On August 26th a boiler exploded on the steamer *Montclair*, on Greenwood Lake, near Goshen, N. Y., while she was making a trip up the lake from Sterling Forest. The engineer, fireman, deck hands, and a few passengers were aboard, but all escaped injury.

(210.) — On August 27th, a boiler exploded in a sawmill near Keyesport, Ill. The mill was new, and the explosion occurred on the first day that it was run. The mill and all the machinery were wrecked, and the concussion was felt for many miles around. Martin Gosney was injured so badly that he died a few hours later, and Frank Wilson was also badly hurt, so that it is believed that he cannot recover.

(211.) — A boiler belonging to George Ray, of Thompson, N. D., exploded on August 29th. Fireman Michael Hawley was thrown 160 feet and instantly killed, and Edward Hahan and George Ray were scalded and otherwise injured, so that their recovery is doubtful. Matthew Schumaker, F. Kownick, F. Brennan, and W. Bedale were also badly hurt.

(212.) — On August 30th a boiler exploded in Charles Correll's shingle mill at Drake, some seven miles southeast of Fostoria, Mich. Mr. Correll and a man named Burleigh were in the boiler-room at the time, and were seriously injured.

(213.) — A boiler belonging to John Clarke, a brick and tile manufacturer of Evansville, Ind., exploded on August 31st, and Mr. Clarke and several other men were injured, Mr. Clarke being hurt so severely that he may not recover.

(214.) — On August 31st the boiler of a broom-corn threshing machine, belonging to Jesse Shields, exploded on the farm of ex-Sheriff J. H. Handley, about a mile west of Warrenton, near Paris, Ill. Homer Daley was injured so badly that his physicians state that he cannot recover. The engineer also received injuries of less importance.

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(215.) — A threshing-machine boiler exploded, on September 1st, on Dr. H. A. Fiester's farm, about five miles west of Newton Falls, near Warren, Ohio. The front head struck Wesley Gano, and killed him instantly. (One account received here says that "his brains were gathered on a pie tin"!) Owen R. Jones, John Hodnor, and Penry Musser were injured. The thresher was wrecked, and the barn was destroyed by fire.

(216.) — It is reported that a boiler exploded in the power house of the electric light company at Paris, Texas, on September 1st, totally wrecking the main building, and killing and injuring several persons.

(217.) — On September 1st a boiler exploded in George Mackenzie's planing mill, on Southern Boulevard, Bronx, New York city. Engineer Karl Karlsen was buried under the brick setting, and received injuries from which he cannot recover.

(218.) — A boiler used for operating a pile driver at Santa Barbara, Cal., exploded on September 2d. The engine was blown fifty feet into the air and totally wrecked.

(219.) — A tube failed, on September 3d, in a boiler in the Cherry Valley Rolling Mill, at Leetonia, Ohio. George Holland, a heater, was very badly burned.

(220.) — On September 5th a cotton-gin boiler exploded at Bokchito, fifteen miles northeast of Durant, in the B. I. T., near Denison, Texas. The engineer was severely scalded, and also injured about the head by flying débris. One end of the boiler passed entirely through a dwelling-house, wrecking the house and its furniture.

(221.) — A cotton-gin boiler exploded, on September 5th, at Nitta Yuma, on Yazoo & Mississippi Valley Railroad, some thirty miles from Greenville, Miss. Four men were killed outright, and six others were seriously injured.

(222.) — On September 5th David V. Frakes, night engineer in a hotel at Terre Haute, Ind., was badly scalded by a boiler explosion. We do not know the precise nature of the explosion, but we understand that Frakes observed a slight leakage somewhere about the front head, that he undertook to tighten something under pressure, and that the head blew out while he was at work upon it.

(223.) — A boiler exploded, on September 6th, at Hindsboro, Ill. "Some one had turned off the steam gauge," says our account, "and this left no indication of the amount of steam that was on. The engineer, not knowing this, kept firing up, and when there was about 280 pounds of steam on, the boiler bursted in the rear." We don't wonder that it bursted in the rear. In fact, we shouldn't have thought it strange if it had bursted all over. We don't see how the ultimate pressure was known to be 280 pounds when the steam gauge was shut off, unless, perhaps, the safety-valve was weighted to that pressure. Anyhow, we guess the engineer, who was providentially spared to us this time, will have an eye on the cock in his gauge pipe hereafter.

(224.) — The boiler of a pumping engine on the Union Pacific Railroad exploded, on September 6th, at Luray, near Salina, Kan. The pumper, whose name is Bascom, was badly scalded, but will probably recover.

(225.) — On September 6th a boiler exploded at the Ohio Oil Company's McCook wells, on the Brew farm, in the Gould oil field, near Steubenville, Ohio. Engineer Fred P. Long was instantly killed, and his body was hurled about 100 feet. James Cunningham, who was sleeping in a little building near by, was slightly injured.

(226.) — A boiler in Frank Entricken's brickyard, just east of Tavistock, Ont., on the 15th line of East Zorra, exploded on September 7th, killing the fireman, S. Aikens, instantly.

(227.) — A boiler exploded, on September 8th, at the homestead of James Rusk, at Carrington, N. D. One man was killed and six others were seriously injured. Among the injured are J. Burton, who lost an eye and was badly bruised and cut, and B. H. Plegman, both of whose legs were broken. We have not learned the names of the others.

(228.) — On September 8th a boiler exploded in A. W. Koock's cotton gin, at Mason, Texas. Fortunately, nobody was hurt. The men were just preparing to go to work, and if the explosion had occurred a short time later several lives would probably have been lost.

(229.) — On September 8th the boiler of Frank Howrey's threshing machine exploded at Leeds, Benson County, N. D. Mr. H. M. Smith was instantly killed. David and Thomas Howrey were seriously injured, and it is feared that one of them will die. Frank Leach, Albert Knapp, and three other men named Swift, Nelson, and Techman were also badly hurt.

(230.) — A threshing-machine boiler exploded, on September 8th, some five miles west of Standish, Mich., killing Charles Pacholke and completely destroying the machine.

(231.) — A boiler exploded, on September 9th, in Jones' foundry, at Dallas, Texas. Mr. J. M. O'Neil, who had called at the foundry on business, was struck by a flying fragment of the boiler just below the knee of the left leg, and one of the bones of the leg was fractured.

(232.) — On September 10th a boiler exploded in John R. Miller & Co.'s hat factory, at Reading, Pa. The boiler-house was wrecked, and the entire north end of the factory was blown out. Peter Engel, Lucy Brown, Thomas Whistman, William Green, and William Nicholas were injured. It is thought that all of the injured will recover. Fragments of flying débris riddled the residence of Jacob Trout, and fell all around a child sleeping in a crib. The little one, however, escaped injury.

(233.) — The plant of the Consumers Coal and Wood Company, at South Baltimore, Md., took fire on September 10th, and shortly afterwards the boiler exploded. The total loss was someting like $10,000.

(234.) — On September 10th a boiler exploded in Theriot's corn mill, at Abbeville, La. Nobody was hurt.

(235) — Locomotive No. 592, on the Santa Fé Railroad, bursted her boiler, on September 14th, at Quenemo, a little town some fourteen miles south of Ottawa, Kan. Fireman John J. Murray was instantly killed, and Edward Weist, the head brakeman, who was in the cab at the time, was fatally injured. Engineer Thomas J. Grady was hurled into a field; one of his shoulders was crushed and two of his ribs were fractured, and it was thought that he could not recover. Later advices, however, indicate that he is slowly improving. The track was torn up for a distance of 150 feet, and a hole as big as an ordinary house was blown out of the road-bed. The locomotive was destroyed so completely that no conclusion can be drawn concerning the cause of the explosion. The tender and two cars loaded with cattle were also torn into fragments.

(236.) — On September 15th a blow-off pipe bursted in C. D. Brooks' shingle mill at Omer, near Standish, Mich. Steam and hot water were thrown over Joseph Poquette, who was working near by, scalding him so badly that it is thought that he cannot recover.

(237.) — A boiler exploded, on September 15th, in Lawrence's cider mill, at Chester, about eight miles from Dover, N. J. Smith Carlisle was badly cut about the head, and was also severely bruised and scalded. James Burns was also very badly scalded. Both men died on the following day. One end of the mill was blown out, and the boiler landed about 150 feet from its original position.

(238.) — On September 16th a boiler exploded in Francis & Purdue's mill at Mount Union, a few miles east of Evergreen, Ala. Engineer Archer was instantly killed, and so also were his wife and child, and his wife's sister. Four other persons were injured.

(239.) — On September 16th a boiler exploded in the Kansas City Milling Company's plant, at Kansas City, Mo. The machinery of the mill was wrecked, and a hole ten feet square was torn in each side of the engine-room. The explosion occurred at 6.30 P.M., and nobody was hurt.

(240.) — While W. H. Bascom, in charge of the pumps and engine, was filling the tank of a Union Pacific locomotive at Luray, Russell County, Kan., on September 17th, the boiler in the pump-house exploded, and Bascom was hurled fifty feet. His arms were broken, one ankle was dislocated, and his body was seriously bruised. His recovery is doubtful.

(241.) — The boiler of an Erie locomotive exploded, on September 18th, at Binghamton, N. Y. None of the trainmen were injured.

(242.) — A boiler exploded, on September 19th, in Vanleer's cannery, at Bridgeton, N. J., causing a panic among the many women employed there. Fortunately, nobody was seriously injured.

(243.) — On September 19th the boiler of a broom-corn threshing-machine exploded on the farm of Samuel Wyeth, at Charleston, Ill. No one was injured, although a number of men were at work about the boiler at the time.

(244.) — On September 19th a threshing-machine boiler exploded on John Pollock's farm, some twelve miles north of Sheldon, N. D. Engineer Eugene Shields was killed. Charles Everson and Herbert Dingman were badly scalded and otherwise injured.

(245.) — The boiler of a threshing-machine exploded, on September 20th, on the Orfut farm, about ten miles south of Olympia, Wash. J. T. Ellis was fatally injured. Charles O'Neil, Nellie O'Neil, and Andrew Nelson were also injured, but less seriously.

(246.) — A boiler exploded, on September 20th, in the gas and electric light plant at Waukesha, Wis. We have not learned further particulars.

(247.) — On September 21st a threshing-machine boiler exploded on the Collins farm, some ten miles out of Portland, Ore., seriously injuring four persons.

(248.) — On September 21st a threshing-machine boiler belonging to R. J. Walker, of Maza, near Devil's Lake, N. D., exploded, instantly killing Fireman John Wilson, and injuring Theodore Walker and three other men. Five horses were also killed, and fragments of the boiler were scattered in every direction.

(249.) — A boiler exploded, on September 22d, in Reeves & Ackerman's mill, at Walterboro, S. C. The fireman and three other persons were injured.

(250.) — The tugboat *Ira O. Smith* took fire, on September 22d, on Lake Michigan, near Chicago. The flames could not be controlled, and the crew headed the boat, under full steam, for the Lake View water-works intake crib. As she grazed the crib, every man jumped to safety, and the tug was abandoned to continue her career alone, at full speed. A few minutes after passing the crib, her boiler exploded. The fire had been seen from the shore, and the fireboat *Yosemite* gave chase. She overhauled the *Smith* just as the latter's boiler exploded, and turned a deluge of water into her. The fire on the *Smith* was greatly discouraged by this treatment, and soon the *Yosemite* headed for Chicago with the smouldering *Smith* in tow. Water was entering the *Smith's* hold rapidly, and despite the efforts of the *Yosemite*, she sunk when just inside the breakwater, parting the cable that connected her with the *Yosemite*.

(251.) — On September 23d a threshing-machine boiler exploded on Thomas Guinan's farm, some two miles south of Canton, N. D. Henry Rice was instantly killed. Fireman John Rogers was struck on the head, and it is doubtful if he can live. Four other men were also injured.

(252.) — One of the boilers in the Fleischmann Distilling Company's plant at Blissville, L. I., exploded on September 23d. James Carroll, one of the boiler attendants, cannot be found, and it is believed that he was killed. John Groubar and James Moran were seriously cut and burned, and six other men were also injured.

(253.) — On September 23d a portable boiler exploded on Mr. Frank Lowe's farm, in Harford County, Md., some two miles from Fawn Grove, Pa. A little daughter of Mr. Lowe was seriously injured, but it is believed that she will recover.

(254.) — On September 23d a boiler exploded on the Sea Gull Orange Farm, near Buras, La. Henry McCausland was instantly killed, and Paul Buras and two others were seriously scalded. The boiler was torn into small fragments.

(255.) — A boiler exploded on September 25th, in the Nelson Morris & Co. packing house, at St. Joseph, Mo. Fireman Charles Carson was burned seriously, and, perhaps, fatally.

(256.) — A boiler exploded, on September 26th, in a sawmill at Mahan Station, four miles north of Williamsburg, Ky. A man named Von Cloyd was killed, and Isaac Shoup was fatally injured. John Bryant was also injured seriously, but not fatally.

(257.) — A boiler exploded, on September 26th, at the Anderson No. 3 oil well, two miles from Smithfield, Wetzel County, near Mannington, W. Va. Theodore Double was instantly killed.

(258.) — A flue gave way, on September 28th, in the electric light plant at Winterset, Iowa. Nobody was hurt.

(259.) — A boiler exploded on September 29th, in the Enterprise Waste Mills, at Louisville, Ky. Emanuel Morton, the engineer, was injured so badly that he died later in the day. He was blown seventy-five yards. The building in which the boiler stood was blown into splinters.

(260.) — The boiler of locomotive No. 233, on the Wabash Railroad, exploded, on September 28th, near Shadeland, Ind. Engineer Oscar Johnson was killed, and Fireman Edward Regan was seriously injured. The train, which consisted of three flat cars and a caboose, was derailed, and the track was torn up for a distance of 300 feet. The locomotive was torn to fragments.

(261.) —The boiler of a steamer exploded, on September 30th, at Cavalier, near St. Paul, Minn. The engineer was killed, and a number of the men were injured. We have not received further particulars.

(262.) — On September 30th a boiler exploded at one of the Borcher oil wells, on the Morganza Reform School farm, near Washington, Pa. James Black was injured.

(263.) — On September 30th a boiler exploded in the Colwell mill, at Grand Marais, Mich. The boiler-room was shattered to pieces. No one was in the engine-room or fire-room at the time, but two men were injured by flying dèbris.

The Locomotive.

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Liquid Fuel.

Certain of the advantages that the use of liquid fuel suggests are so obvious that they scarcely need to be mentioned. The great ease with which such fuel can be handled, and the saving in labor in the fire-room, are two of the most obvious items in its favor, and others will readily occur to the reader. But, unfortunately, there are also many disadvantages in connection with liquid fuel, so that the problem before a manufacturer who is considering its use, is by no means a simple one.

In the first place, the expense of the liquid fuel must be carefully compared with that of coal; and this is doubtless where the main difficulty lies, since we cannot suppose that inventors and engineers are shallow enough or stupid enough to permit a form of fuel that is rich in energy and full of promise in other respects, to be passed by for the lack of a suitable burner, or a satisfactory boiler setting, especially when the great number of experiments that have been made in this direction are considered. In comparing the cost of coal with that of liquid fuel, we must, of course, make proper allowances for the relative amounts of energy that the two contain, and must base our estimate upon the cost of the fuel *per heat unit* that can be realized from it; and here we find it necessary to distinguish between the forms of liquid fuel that are available for

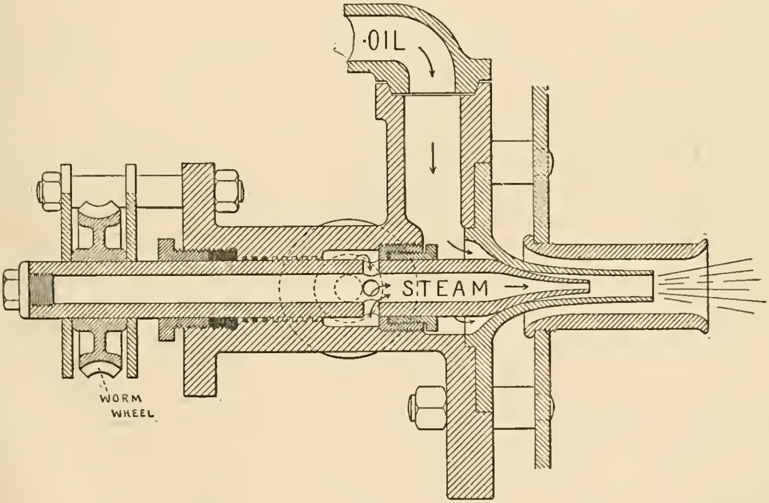

FIG. 1.—URQUHART'S OIL INJECTOR.

use, and to consider these forms separately. Fortunately, a very simple classification will serve for our present purposes; for the only kind of liquid fuel that is available for steam-making in large quantities is petroleum, or some product obtained from petroleum, and the only distinction that we shall find it necessary to make is between the products that are obtainable in Russia and those that are produced in the United States, and are on sale in our own markets.

The fundamental difference between petroleum fuel as used in Europe and in the United States is, that in this country we use the crude petroleum as it comes from the well, while Russia and Italy and other European countries use the refuse that is left, after the lighter constituents of the oil have been removed by a partial distillation. The Russian petroleum, from the Baku region, near the Caspian sea, contains a much smaller proportion of illuminating and lubricating oils than the American petroleum, and the refining processes that have been used there have not been perfected so fully as our own. For these reasons, the proportion of the crude oil that is utilized for the production of naphtha, illuminating oils and lubricating oils, has been far smaller than in the United States, and the refuse from the distilling plants has been correspondingly larger. Colonel Nabor Soliani, Chief Engineer in the Italian Navy, presented an important paper on "The Use of Liquid Fuel for Marine Purposes" before the International Engineering Congress which was held in Chicago in 1893, in connection with the World's Fair, and in the course of this paper he states that only 25 or 30 per cent. of the output of the Russian wells has been utilized heretofore, the balance being practically wasted. With the improved methods of distilling that have now been introduced, the showing is somewhat improved, but the proportion that is wasted is still very large. The present production, in the Caspian region, of oil that is suitable for fuel, is probably about 1,000,000 tons per annum, and of this amount only about one-third is used; so that the present waste of fuel oil (or "naphtha refuse," as it is called,) amounts at least to 600,000 tons per annum. It will be readily understood that, under these circumstances, the incentive to use liquid fuel under boilers is far greater than it is in our own country, where entirely different conditions prevail.

"The first steamers that ran on the Caspian Sea and along the Volga River," says Colonel Soliani, "used wood as fuel. But wood being scarce, especially along the Caspian coast, and being costly and bulky, the advantage was soon found of using naphtha refuse instead; and from the very beginning the attempt was successful, although the instruments employed were naturally imperfect. Progress was rapid, and very soon naphtha refuse displaced wood entirely. Subsequently the use of this kind of fuel was extended with success to locomotives, and to all other kinds of boilers, furnaces, and appliances, for the working of which fuel is required. In boilers, whether land or marine, the oil fuel is burned through a little instrument called a *pulverizer*, in which the oil, pouring from it, is pulverized [or atomized] by a jet of steam, and projected in a finely-divided state inside the furnace, where, mixing with the air, it burns, when lighted, with a large and long fan of flame that fills the furnace, and keeps unaltered as long as the conditions of the jet remain unaltered. The fire is very powerful, and easy to regulate and control. A simple match is sufficient to light it, and a simple stop-valve to extinguish it." Colonel Soliani goes on to say that on the Caspian Sea and in the Volga region, petroleum refuse is now the only fuel used for steaming purposes, the boilers being all fitted up for oil alone, without any provision for the use of any other kind of fuel, simultaneously or alternately. The "pulverizers" that are used are all worked by steam, chiefly because it is easier to provide a blast of steam than a blast of air. After referring to the vast number of forms of "pulverizer" that have been tried, suggested, or patented, wherever the thought of oil fuel has occurred to anybody, Colonel Soliani says: "With all pulverizers the steam-jet [or air-jet] has the effect, not only of pulverizing the oil, but also of drawing in a current of air, which assists combustion. Some pulverizers are especially arranged for increasing this current of air, and causing it to mix itself thoroughly with the pulverized fuel. As regards efficiency, they are all, more or less, on the same footing, and for practical working it appears that the pulverizers with round apertures are generally preferable to those with linear apertures, on account of the greater liability of the latter to get choked. Of course, the linear aperture is more objectionable for the oil than for steam, the former being much less fluid than the latter, and liable to be dried up and coked by the heat of the fire. Moreover, the oil may contain impurities and sediments which cannot easily be forced through, under the low pressure due to the head of the oil, from the oil-feeding tank to the pulverizer. For this reason, other conditions being equal, the pulverizers of the injector type, with the oil tube in the center, appear preferable to those having the oil tube outside; but it should be said that, if the outside tube is carried forward so as to project over the inner one, its aperture becomes practically a round hole again, which is easily kept free from crusts of coked oil by the inner jet of steam. Such is the pulverizer which Mr. Urquhart has so successfully adopted for all the locomotives of the Griazi-Tzaritzin Railway, and has fitted to many express locomotives of the Great Eastern Railway."

Mr. Urquhart's pulverizer, which is here referred to, is shown in Fig. 1. The description of this form of pulverizer, as furnished to *Engineering* by Mr. Urquhart, is as follows: "The oil runs down a pipe, which ends in the external nozzle of the injector, while the steam passes through the inner nozzle, which it enters through a ring of holes, the steam and oil cavities being separated by a stuffing-box packed with asbestos. This packing is renewed once a month. The steam supply is regulated by a valve on the pipe and independent of the injector, while the oil supply is increased or diminished by screwing the steam nozzle backwards and forwards in the external nozzle, and varying the section of the annular passage. This is effected by a worm and worm-wheel, the latter of which is connected to the steam nozzle by a feather key, while the former is on a shaft which terminates in a position conveniently accessible to the fireman." Mr. Urquhart's pulverizer is entirely outside of the firebox, so that the carbonizing of the oil at the nozzle is reduced to a minimum. The blast of oil and steam is delivered into the furnace through a tube into which the nose of the injector projects, and through which a supply of air is also drawn by the action of the jet.

According to experiments made by Mr. Urquhart and by Messrs. Nobel Brothers, and others, one pound of Russian petroleum refuse, in burning, yields about 20,000 British heat units. Estimating the maximum heat energy of good coal at 13,900 heat units per pound, we find that when equal weights of coal and petroleum refuse are compared, the heat energy is in favor of the oil in the proportion of 20,000 to 13,900. That is, the heat produced by the combustion of a pound of Russian petroleum refuse is about 1.44 times as great as that produced by the combustion of an equal weight of first-class coal. This difference in favor of the oil is not all realizable for motive power, however, as a certain proportion of the steam that is formed must be used in the pulverizers, for introducing the oil into the furnace. The quantity of steam required for this purpose cannot be stated very definitely, since it appears to vary greatly under different conditions of operation. Thus Urquhart finds that on the Russian railways the steam required for the pulverizers varies from 8 to 13 per cent., the highest percentage being required in the winter. In a series of tests made with American crude petroleum in Minneapolis and St. Paul, Messrs. Wm. A. Pike and T. W. Hugo found that 13.4 per cent. of the total water used was required for the atomizers.* In the course of experiments made with reference to the use of Russian petroleum refuse in the Italian navy, the percentage of steam consumed by the pulverizers was far smaller, the several percentages in eight trials being 1.3, 1.35, 1.75, 2, 2.3, 2.5, 4.1, and 4.4.† We are not aware that percentages as low as these have been obtained elsewhere. If it be assumed, as a basis for calculation, that the average consumption of steam by the pulverizers will be, say, 10 per cent. of the total steam produced, then the comparison of coal and Russian petroleum refuse, that we have made above, will be modified to the extent that one pound of the oil will produce about 1.30 times as much available heat as a pound of first-class coal, it being understood that by "available heat" we mean merely the total heat that is produced by the oil, *minus* that portion which is required to work the atomizer, or pulverizer. There is an additional element in favor of the oil, of course, in that the cost of boiler attendance is less with oil feed than it is with coal; but as the saving so effected will vary to a considerable extent with the conditions of practice, we shall omit it from our present calculation. The price of Russian petroleum refuse varies greatly with the locality, owing to the difficulty of transportation. Five years ago it could be had for from sixty cents to one dollar a ton on the Caspian Sea — say at an average cost of eighty cents a ton — and since a ton of this refuse is equivalent for motive purposes to about 1.30 tons of good coal, it follows that coal, to compete successfully with the oil, would have to be sold at $80 \div 1.30 = 61$ cents per ton. It is plain that under such conditions as these, the problem of liquid fuel *versus* coal is extremely simple; coal simply has no argument in its favor, whatever. As we pass away from the vicinity of the wells, however, we find that the price of the refuse rises rapidly, so that on the Mediterranean Sea it costs from $10 to $13 a ton. (These prices were quoted by Colonel Soliani in 1893. Doubtless the cost is somewhat less now, owing to increased facilities of transportation.) Good coal can be had at Mediterranean ports for less than half these figures, so that here the balance is largely in favor of the use of coal for all ordinary purposes.

Leaving the Russian oil and returning to our own country, we find that the problem of oil *versus* coal is substantially the same here as in Europe, the main differences being those that are introduced by the fact that here it is not the refuse from refineries that is used, but, in most cases at any rate, the crude oil substantially as it comes from the well. Refuse is indeed burned, but the natural possibilities of the oil are so great, and our processes of distillation are so far perfected, that the refuse is far less in proportionate amount than it is in Russia, and the total output of such refuse is entirely inadequate to our wants. This fact was strikingly illustrated by the Pennsylvania Railroad, whose officers, some few years ago, contemplated the adoption of petroleum refuse as fuel, and found that the entire amount of such refuse that is produced in the country would barely suffice to meet their own needs.

The difference between petroleum refuse, and the crude oil as it comes from the well, is first forced upon our attention by the problems of transportation and storage. The Russian refuse is quite safe to handle and store, since all its lighter constituents are supposed to have been removed by distillation, and it is quite possible to secure a good supply of such oil with a flashing point as high as 250° Fahr. The crude oil that is usually used as fuel in the United States, on the other hand, gives off inflammable vapors at almost any temperature, and hence it must be handled with exceeding care, in transporting and storing it. The same may be said of the precautions that are necessary in

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* *Transactions* of the American Society of Mechanical Engineers, Vol. XIV, p. 1111.

† *Proceedings* of the International Engineering Congress, Vol. I, paper No. XXV, pp. 25, 26.

burning the oil under boilers, for many serious accidents have occurred for lack of proper care in the boiler-room, especially in re-lighting the fires, after they have been extinguished either intentionally or unintentionally.

The method of burning crude petroleum in the United States is substantially the same as that employed in Russia and on the Caspian Sea for burning petroleum refuse. An atomizer or "pulverizer" is used for introducing the oil into the furnace, the oil being usually injected by a blast of steam or air, though sometimes it is thrown in by a centrifugal spraying device. We cannot undertake to describe the various forms of burner that have been used for the purpose, as their name is legion, and almost every engineer who has dealt with the oil problem has some favorite type of injector of his own, which he stoutly insists is better than all the other forms. Doubtless, one of these men is right, and the others wrong; but to decide which the right man is, is a task from which the boldest might shrink.

It may be said, in general, that the mechanical difficulties in the way of burning crude petroleum have been successfully overcome in a variety of ways, and that the main point of difficulty is the question of cost. To this question no definite answer can be given, since our country is so large that the relative costs of fuels vary greatly with the locality, and it is these relative costs that form the key of the problem. Messrs. Pike and Hugo, in the course of their tests at Minneapolis and St. Paul, to which we have already referred, found that under the conditions prevailing in their tests, crude oil costing 2.26 cents per gallon was on a par with coal, economically, when the coal cost about $3.83 per ton; the coal being capable of actually evaporating 7½ pounds of water from and at 212° Fahr., and the oil, under similar conditions, having a theoretical evaporative power of 20.63 pounds. In this estimate, if we understand it correctly, all allowances have been made for the steam required to operate the pulverizers, and for the extra cost of labor when running with coal. The plants from which these data were obtained were used for furnishing electric power for street cars, and the load was therefore quite variable. Tests made on a plant where the load was steadier might possibly show different results. A very extensive trial of crude petroleum fuel was made in Chicago, in 1893, in connection with the World's Fair. Fifty-two boilers in the main boiler plant, with an average aggregate capacity of 21,000 horse-power, were run with crude petroleum during the entire Fair. The total quantity of oil used was about 31,000 long tons (of 2,240 lbs. each), and the total work done is estimated at 32,316,000 horse-power hours. This corresponds to 2.15 pounds of crude oil per horse-power per hour. The oil cost, approximately, $6 per ton, so that the expense of the oil fuel, for all the various uses to which the power was put, was about $0.0057 per hour, for each horse-power actually developed. We regret that we have no more definite data at hand concerning this great trial, at the present writing.

The main things to bear in mind in burning crude oil are, (1) the liability to fires and explosions from the ignition of vapor given off by the oil, or from error in the management of the pulverizer and furnace; (2) the liability of loss of efficiency through imperfect combustion; and (3) the danger of injuring the boiler. None of these difficulties are very serious, provided the plant is managed intelligently in all its details. The fierce flame from the burner should not be allowed to impinge directly upon nuts or rivet-heads or the ends of riveted flues or upon other portions of the boiler that might become overheated and burned, and care should also be exercised to prevent drafts of cold air from striking the heated plates, from the fire doors or elsewhere, since a sudden chill of this sort is likely to strain the boiler. Sheets are not infrequently cracked, in the Caspian Sea service, through neglect of this precaution, and while the danger is perhaps less in the stationary practice in this country, it should nevertheless be borne in mind.

In order to ensure perfect combustion, the air supply should be regulated so that the flame-sheet is of a uniform, intense brightness, without bluish streaks. The atomized oil should be thoroughly mingled with the air that is admitted for combustion, and the arrangement of the furnace should be such as to permit the oil to become entirely burned, before it comes in contact with the comparatively cool boiler. If the blast from the burner should be allowed to strike directly against the plates of the boiler (as might easily happen, for example, in a locomotive fire-box), the boiler would not only be liable to injury, but the temperature of the oil jet would also be reduced so greatly as to check the combustion, and allow a considerable fraction of unconsumed gases to escape into the smoke flue, thus materially lowering the efficiency of the furnace. To secure a more perfect mixing of the oil-spray and the air, and also to protect the boiler sheets, and keep the burning gases from becoming chilled, it is usual to discharge the oil jet against a wall of loosely-piled fire-brick; and sometimes this idea is carried out more

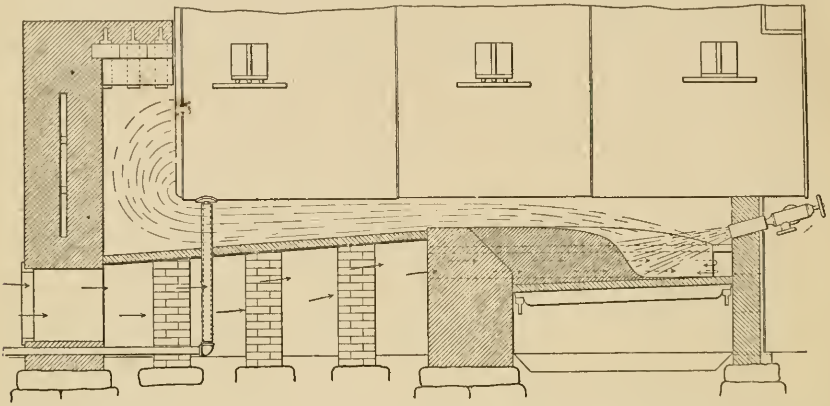

FIG. 2.—SIDE VIEW OF FURNACE ARRANGED FOR BURNING CRUDE PETROLEUM.

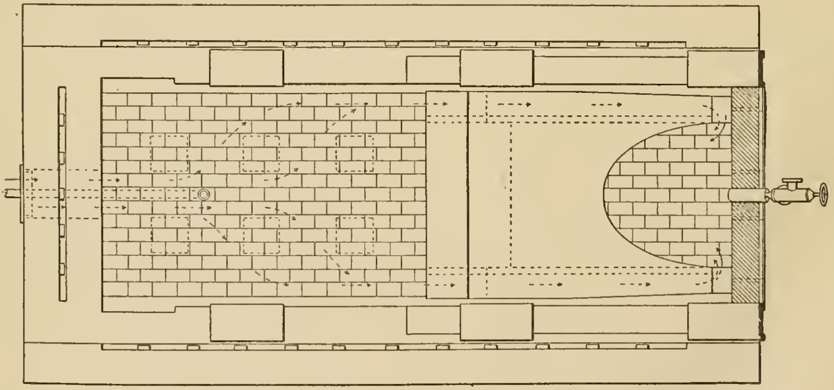

FIG. 3.—PLAN VIEW OF FURNACE, WITH BOILER REMOVED.

elaborately by directing the jet into a firebrick chamber, from which it can emerge only after an entire change in its own direction. Many devices of this sort have been used, and have been illustrated from time to time in the various technical journals, notably in London *Engineering.*

Figs. 2 and 3 illustrate a form of setting that we have found to work very well where crude oil is burned under horizontal tubular boilers. A layer of fire-brick is placed upon the grate bars, and upon the foundation so formed a sort of parabolic or bowl-shaped or basin-shaped structure is built of broken fire-brick or other infusible material, in such a way that the surface exposed to the heat slopes up on a curve to the top of the bridge wall, and also up to the side-walls of the furnace, on both sides. The oil-injector is placed between the fire-doors, and discharges its burning spray against the basin-like mass that rests upon the grates. A number of strips of boiler plate, or their equivalent, extend nearly horizontally from the back of the bridge-wall to the rear wall of the setting, so as to cover the entire length and width of the space back of the bridge. This course of boiler-plate is supported by piers, or in any other convenient manner, and fire-brick are laid upon its upper surface, so as to effectually protect it from the heat of the furnace gases. Air is allowed to enter, as suggested by the arrows in Figs. 2 and 3, through the cleaning door at the rear, and is conducted to the front end of the furnace by means of two conduits or channels, which pass through the bridge wall on either side of the setting, and run forward along the side walls, so as to discharge into the furnace at the front end, on either side of the oil jet. The air entering in this manner becomes thoroughly warmed before it is discharged into the furnace, and its flow may be regulated as desired by means of a controlling device at the cleaning-door in the rear. A part of the floor back of the bridge-wall may be arranged so as to be removable, to give ready access to the back end of the boiler, for inspection or repairs. The blow-off pipe passes down through the fire-brick layer in the rear, and turns near the floor of the setting, so as to pass out under the cleaning-door.

Settings adapted to the various types of boilers that are in use in this country are shown and described by Mr. Clayton O. Billow, in an article on the "Application of Fuel Oil to Steam Generators," published in *Electrical Engineering* for September, 1894.

One of the main difficulties encountered in using crude petroleum as fuel, is the *starting* of the fire, after the plant has been shut down for a time; because the oil atomizers cannot be set in operation until the steam that is required to run them can be had. For overcoming this difficulty, a small auxiliary boiler is often provided, which is fired up with wood or coal to furnish the steam required by the atomizers, until the main boiler plant can be gotten under steam. With the form of setting shown in Figs. 2 and 3, steam can be raised by a wood fire if desired, the air required for combustion being admitted through the fire-doors; but the operation is likely to be long and tedious, and the use of an auxiliary boiler is to be preferred. A good atomizer ought to begin to work before the pressure exceeds four or five pounds, although the combustion will be imperfect until a considerably higher pressure than this is reached.

Especial care should be taken, where oil fuel is used, in starting and stopping the atomizers. The proper way to start them is to light a handful of oil-saturated waste, and place it in the furnace, before the sprinkler. The steam valve of the sprinkler is then opened, and *the oil valve is opened last.* In stopping the atomizer this course is reversed, and *the oil valve is closed first.* If these simple directions are followed, there should be no danger in starting or stopping the fires; but if they are *not* observed, the fireman, in all probability, will sooner or later be badly burned. If oil finds its way into the furnace without being ignited at once, it vaporizes and its vapors mingle with the air, forming an explosive mixture that only requires a spark to produce the most serious consequences. Even when the atomizers are in full operation, they should be carefully watched, because they are liable, from time to time, to "snap out" : that is, to go out suddenly, without warning. This anomalous behavior appears to be due to the presence of water, either in the oil supply, or in the steam. The liability of the fire "snapping out" is much diminished by providing a settling tank on the oil pipe, where the water can sink to the bottom, and a similar chamber, or trap, on the steam pipe, so that entrained water may be caught and drawn off from time to time. Firemen, after working with oil atomizers for a time, are very likely to grow careless with them, and every now and then a fireman pays, with his life, the penalty for such carelessness. For example, when a jet "snaps out," the proper thing to do, is to shut off the oil as quickly as possible, and allow the furnace to ventilate itself until there is no doubt about its being free from oil vapors. A piece of burning waste is then cautiously introduced into the furnace, just as in starting up, and the sprinkler is again set in action by opening the steam valve first, and then the oil valve. This routine soon becomes irksome to a thoughtless fireman, and he is apt to let the oil run, trusting that the highly-heated mass of bricks against which it strikes will speedily ignite it again. This, indeed, it usually does; but ignition in this way is uncertain, and the fireman who is not prepared for an immediate trip to that mysterious country from whose bourne no traveler returns, had better not rely upon it. He had better take a little trouble and do the thing right, and stay with us a while.

THE reference book recently issued by this company under the title, *The Metric System of Weights and Measures*, has received, we are pleased to state, an exceedingly favorable reception, and the sale for it has surpassed our expectations. The book was reviewed at some length in THE LOCOMOTIVE for September, 1898, a copy of which will be sent, free, to anyone who may desire further information concerning it. The book is of convenient size for the pocket, and the ordinary edition (the price of which is $1.25), is substantially bound in flexible sheepskin, with red edges, and the title in gold. All orders should be addressed to THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY, HARTFORD, CONN.

How Dynamos are Sold.

There is, perhaps, no commercial business so susceptible to ingenious twisting of facts as that which has for its object the sale of electrical apparatus, and this may be well illustrated by the common practice of a good dynamo salesman. Let us suppose, for instance, that we have a capitalist who wishes to install in his office building a 500-light dynamo. Relying on his own business shrewdness, which has stood him in stead for many years, he writes to a number of dynamo builders, and is soon surrounded by their agents, who are anxiously bidding to secure the contract. The various prices are submitted, each agent bidding on the nearest size which he manufactures. If the quality of the machines are equal in every case, the bids will be very close indeed, and in a measure proportional to the size of the machines. The capitalist will review the bids carefully and then talk with each of the representatives upon the merits of the machines in order to make a decision.

The lowest bidder does not need to argue very eloquently. He has the initial advantage, but it is not an infrequent occurrence that the highest bidder can readily carry off the palm. The shrewd agent will soon see that his price is high, and will admit as much to his prospective purchaser, but will say: "These other gentlemen are bidding on machines which will carry 500 lights and no more. The machine that I propose to supply you is specially designed to carry an overload of some 50 per cent. for four or five hours. The conditions of your load might be such that you will find this an extremely valuable feature. We rate our machines very liberally and allow ample margin for contingencies; for this reason we think we justly ask better prices." The prospective purchaser will take this matter very much to heart, and the chances are strongly in favor of his buying a 600-light machine disguised under the name of a 500-light machine able to carry overloads. If the agent had said that his machine would carry 600 lights, the buyer would have said, "I do not want 600 lights, 500 lights is ample;" but the idea of getting added capacity for practically the same money is most attractive.

Again, we have the case of the purchaser who has pretentions to electrical knowledge. In no case is the old proverb, "A little learning is a dangerous thing," more forcibly illustrated. The chances are ten to one the agent knows about as much of electricity as the purchaser, and the way they exchange high-flown technical terms to their mutual mystification is amusing in the extreme. To illustrate, an actual case in point may be mentioned — an instance where a certain man had been considering the relative merits of several bids for a dynamo machine for his factory. Some of the agents had been talking knowingly of losses, efficiency, rise of temperature, hysteresis, and other matters relative to the performance of a dynamo. The purchaser gathered that these various quantities were desirable qualities, arguing to himself if they were not, the agents would not have mentioned them; or more probably obtaining his idea from inference rather than argument. When the next bidder appeared and asked for an audience, he proceeded to talk of temperature rise, hysteresis, and like matters. The agent, likewise, at once inferred that these things were much to be desired in a dynamo. He was of German extraction, and he communed within himself, "If Thomas Huston and Edison haf hysteresis in their dynamos, ve must haf some too." He succeeded, however, in arguing so well that he closed the contract, one of the inducements being that he should write to his firm and stipulate particularly that in the dynamo to fill this order there should be an exceptional amount of hysteresis.

Again, we are told of a case which seems hardly worthy of credence, but is said to be an actual fact, — that of two bidders, one making a proposition on an iron machine, and the other submitting a price on a machine with a cast-steel frame; the former secured the contract, arguing that his machine was the heavier by some 400 pounds, and therefore more substantially built, and was not starved of iron or copper, and there was plenty of material there to stand the load, etc., etc.

A good agent will make talking points out of nothing, advantages out of disadvantages, and virtues out of necessity, and will carry off a contract at a high price, while a man of mediocre business ability with a better machine and scrupulously careful of what he says, will fail to secure the order. Capitalists do not seem to appreciate cautious, conservative opinions. They must be superlative or they are adverse. Truly said the great showman : "The American public likes to be fooled," and the capitalist most of all. He will not invest his money unless the facts are highly colored, even to misrepresentation.— *American Electrician.*

The Index to the volume of The Locomotive that is completed by this issue is in preparation, and will be ready shortly. It will be sent, free, upon application, to persons who preserve their copies for binding.

The Locomotive.

HARTFORD, DECEMBER 15, 1898.

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.

AMONG the accounts of boiler explosions that have recently come to our attention, we note one which illustrates the confused state of mind in which a man often finds himself after the boiler that he has attended for a long time suddenly betrays his confidence and blows up. The account says that "the engineer had been waiting for steam to get up sufficiently to start the machinery, and at the time of the explosion the steam gauge registered only 65 pounds; but the engineer now believes that it was 365 pounds instead." Apparently, the poor fellow feels pretty sure that the pointer made several trips around the dial while his back was turned. Anyhow, the pressure *did* get up high enough to "start" the machinery. It "started" it all from its foundations, and moved most of it over into a vacant lot across the road.

A New Boiler Insurance Company.

One of our special agents sends in the following account of an experience he recently had: "I want to tell you of a new view of the old and respectable Hartford company, which will perhaps prove interesting. I called to see the proprietor of a saw-mill in a small lumber town of West Virginia, the other day, and announced my name and the company I represented, to an individual in the office. He told me the proprietor was not in, and I went off, promising to call again — the clerk casting glances of suspicion at me, as I passed out of the door. When I went back, later, I found the proprietor in a bad humor. He gave me a stony stare and said, 'No, sir; I've got no time to talk to representatives of fake boiler inspection companies.' I started forward indignantly. 'Why, sir,' I said, 'you are showing your ignorance. There is no older, stauncher, or more reliable company in the business than the Hartford company.' 'What's that name?' he asked, pricking up his ears. 'The Hartford,' I replied, with some vehemence. The proprietor lay back in his chair and howled with laughter. 'Why,' he exclaimed at length, 'my bookkeeper said you represented the Hot Foot Boiler Inspection Company; and so of course I thought it was one of those wildcat companies that some of these jack-leg boiler-makers get up to victimize us poor fellows back here in the piney woods.' We had a hearty laugh together, and became good friends; and I have no doubt that we will shortly fix the date for inspection. If you hear anything of a new rival in the field, known as the Hot Foot Boiler Inspection and Insurance Company, it will probably be from this section, as the story is getting out, and steam people are enjoying it hugely."

The New Steamship "Deutschland."

The Germans have proved the efficiency of their shipyards by undertaking the construction of the hugest steamship of modern times. This new giant, which is in process of construction in the Vulcan shipyard at Stettin, will be called *Die Deutschland*, and will be the largest and fastest steamer in the world. According to the Hamburg *Boersenblatt*, this floating palace, which is now so well advanced that it will be launched in six months or less, has a length of 622 feet, a beam of 67 feet, and a depth of 44 feet. To form a correct idea of these dimensions, let it be recalled that the *Pennsylvania*, of the Hamburg American line, was the largest steamship in the world at the time of her completion, having a length of 560 feet; yet the *Deutschland* exceeds her in length by 62 feet. With her bunkers and ballast tanks filled, the *Deutschland* will draw 29 feet of water. Her coal bunkers will have a capacity of 5,000 tons. She will be provided with two six-cylindered quadruple-expansion engines, whose aggregate capacity will be 33,000 indicated horse-power. It is difficult to comprehend this enormous power. The express steamer *Prince Bismarck* has 16,500 horse-power, and the big mail steamers *Pennsylvania* and *Pretoria* have only 5,500 horse-power each, with which they attain a speed of 13 or 14 knots. Thus the *Deutschland* will have twice the engine power of the *Prince Bismarck*, and six times that of the *Pennsylvania*. Twelve double boilers, each with eight furnaces, and four single boilers, each with four furnaces, will be provided to furnish the steam for the mighty engines; so that there will be 112 fires in all in the boiler-room. The steam pressure is to be 210 pounds, and the contract calls for an average speed of 23 knots per hour, although it is expected that 25 knots may be attained as a record performance. Five dynamos will be used to run the electric lights. Twenty-six life boats will be provided — 18 of steel, 2 of wood, and the remaining six will be of the collapsible type (made, presumably, of canvas).— *Mittheilungen aus der Praxis des Dampfkessel- und Dampfmaschinen-Betriebes.*

[A better idea of the size and power of the *Deutschland* may be had, perhaps, by comparing her with the *City of New York*, whose engines develop some 18,000 or 20,000 horse-power, or about 60 per cent. of that developed in the *Deutschland*. "It is a very easy matter to talk of 18,000 or 20,000 horse-power," says an article in The Locomotive for March, 1889; "but few persons, we think, realize what it means. Assuming that the engines will require 18 pounds of steam per horse-power per hour, then 160 tons of feed water must be pumped into the boilers every hour, and 160 tons of steam will pass through the engines in the same time. In twenty-four hours the feed water will amount to 3,840 tons. A tank measuring 52 feet on the side would hold one day's consumption; or it would fill a length of 493 feet of a canal 40 feet wide and 7 feet deep. Taking the condensing water at thirty times the feed water, it will amount, for a six-days run across the Atlantic, to not less than 691,200 tons. This would fill a cubical tank 295 feet on the side — a tank into which the biggest church in London, steeple and all, could be put and covered up. The coal consumed will be 400 tons per day. This will require, for its combustion, 8,600 tons of air, occupying a space of 220,000,000 cubic feet. It is impossible for the mind to take in the significance of these latter figures. It may help if we say that if this air were supplied to the ship through a pipe 20 feet in diameter, the air would traverse that pipe at the rate of about 5.6 miles per hour." If the figures here given are all increased by about 70 per cent., some conception may be had of the vast quantities of water and coal and air that must be handled every time the new *Deutschland* crosses the Atlantic.]

IN SEPTEMBER last, the Louisiana Engineering Society, with headquarters at New Orleans, was added to the twelve societies forming the Association of Engineering Societies. In the *Journal* of this Association (published in Philadelphia, under the supervision of Secretary John C. Trautwine, Jr.), for September, 1898, Mr. C. H. Chamberlin, member of the Louisiana Society, contributes a valuable paper describing and illustrating "Deep Bridge Foundations on the Atchafalaya River," where two of the piers were sunk by the pneumatic process. The author remarks, "It is fortunate that this method was adopted from the beginning of the work, because the obstructions encountered in sinking would have been more formidable by any other method. The Atchafalaya River, in high water, is a swiftly flowing stream, as compared with other streams in the alluvial portions of Louisiana. From a stream of very moderate capacity it has, within the memory of men now living, enlarged so that in flood-stages it discharges about half a million cubic feet per second. The instability of the river deposit above the stratum of clay has been the cause of all the trouble in maintaining the approaches." Details of the work are given, and the paper should prove valuable to engineers who have like problems to solve. Mr. A. E. Brooke Ridley, member of the Technical Society of the Pacific Coast, describes and illustrates the "Fraser Electric Elevator" system. No gearing is used in this system, and the motors are never reversed. The speed of the elevator is controlled entirely by varying the strength of the field magnets of the motors. Mr. Lehman B. Hoit, member of the Civil Engineers' Club of Cleveland, in a paper entitled "Test Meters for Boiler Plants," sets forth the advantages of the Worthington meter for this purpose, and states that "it is only the question of a few years when there will be no steam-plant economy without some type of machine for registering the amount of water passing into the boiler, to determine the evaporation." In the October issue of the same journal, we find an exceedingly interesting article on "Roman Construction," by Mr. G. W. Percy of the Technical Society of the Pacific Coast. Mr. Percy says: "There is hardly a known fragment of Roman architecture in existence that has not been carefully measured, drawn, and published to the world during the present century. And yet, with all this widely published knowledge of Roman art and architectural forms, there has been very little attention given in modern times to Roman *methods of construction;* and very few, even among architects and engineers, are aware of the fact that the ancient Romans, especially of the best days of the Roman Empire, devised and perfected a method of construction perfectly adapted to their gigantic works, and possible of execution with unskilled labor, and with the cheapest and most common materials. Nearly all writers who have attempted to describe Roman buildings and the materials with which they were built, have classed them as of cut stone, or of brick faced with marble. Others who have investigated a little beneath the surface have described some Roman walls as a combination of brick and rubble stone-work, with occasional bond courses extending entirely through the walls, consisting of large flat tiles. Vitruvius, the earliest architectural writer whose works have come down to us, . . . gives no hint of what the ruins show to be the true Roman construction of walls and arches, which method became general about his time." Mr. Percy's paper (which is illustrated) then goes on to explain that the commonest mode of construction consists in facing the walls with brick or stone, and filling in the space behind with concrete. The methods used for the economical construction of such walls, are also given. Other papers in this issue are: "Improvement of the Mississippi River Delta," by Thomas L. Raymond; "Municipal Control of Public Works," by H. J. Malochee; and "Sulphuric Acid and the By Products from Iron Pyrites," by R. G. Ewer.

Why We Eat.

It is an old saying that we eat to live. This is true; but it does not convey to an ordinary observer the whole truth. We eat to live, but we also eat to work, and the power to work comes, in the long run, from our food. Food seems to fulfill two distinct offices. In the first place it makes good the material waste from the ordinary wear and tear of the bodily machine. We need the matter which we get from our food to supply the waste of matter, the loss of matter which incessantly goes on in every living thing. The growing child needs food to supply material as well — the timber from which his body must be built. This aspect of the function of food, its material aspect, is evident.

But we need food to live upon. Life does not consist of mere existence. A living body is not a mere mass of fixed chemical compounds. It is not a statue or a machine at rest. Rather, it is a center of change, a focus of transformation, a whirlpool of energy. It contains matter, but matter which is undergoing incessant changes. These changes require energy and involve work. Even those who are thought to do no labor, who do not labor with their hands or obviously with their brains — even these must swallow their food, rise from their beds, walk to their tables, and step into their carriages. They talk, they laugh, they bow. And in doing these things they move their bodies or parts of them, and thus actually work. Meanwhile, also, they breathe, they yawn, they sigh; and their hearts beat on, driving the blood over their pampered bodies. Mere carbon and hydrogen and oxygen and nitrogen will not enable them to do these things. They must have food; food which shall yield to them the power of doing work. Still more must the worker, so called, have such food, the person who works with hand or brain. If the day's toil is to be done; if the task is to be carried through to the bitter end; if the world is to see marble carved and pictures painted, households kept clean, and books written or printed or bound and shipped to the four quarters of the globe, then power must come with matter; food must consist not only of matter, but of matter laden with energy.

We eat, then, not only to live, as the idle seem to do, but also that we may work. Offer to a hungry man a jar containing charcoal, sulphur, oxygen, hydrogen, and nitrogen, and you mock him. Offer him an egg or a fish and you minister to his necessities. Yet these contain the same elemental substances. The difference is in their arrangement. The egg and the fish contain potential energy, and are available for food; the jar of elements is not available. Dynamite contains abundant potential energy, but it is not available for food. Food consists of matter containing available potential energy; or else of matter otherwise useful to the body, such as salts and water.

To prove that our food contains abundant potential energy, we only need to dry it and then burn it. From the oils and fats which we eat, we can kindle hot fires, as everyone knows. From the dried and powdered starches or sugars we may also generate explosive powder, as anyone will see by throwing them on a fire. From the dried white of egg, dried apples, or thoroughly dried meat, we can likewise generate intense heat. In the quiet processes of nutrition we do not see the chemical explosions which go in the living body; but occasionally we hear of outbursts of passion, explosions of anger, and the fierce heat of intense hatred. These no statue can exhibit, no corpse display. It is only the living body feeding on the fuel of its food, which generates these things. Coal before it is ignited shows no more signs of being combustible than beefsteak does, or sugar. Once, on an ocean steamer the coal gave out. The cargo was of hams, and experiment proved that these could well replace the coal. It was a costly experiment, but it served well to demonstrate that, locked up in those unpromising lumps of flesh, was a treasury of power. And precisely as the hams when burnt caused the machinery to work and replenished the furnaces, so, if they had been eaten, they would have replenished human furnaces and enabled human bodies to do their work. We eat not only to live but also to labor. Let us see to it that our food contains the elements which shall make good not merely the inevitable waste of matter, but also the equally inevitable and possibly more fatal expenditure of power.— Prof. W. T. Sedgwick, in the *Pratt Institute Monthly.*

Reasoning Power in the Monkey and the Elephant.

It is true that the lower animals very frequently, so it seems to us, find themselves in difficulties which could be easily overcome by a slight amount of logical reasoning, which effort they seemingly fail to employ; yet in this respect are we really superior to them? Does our own ideation differ so very materially, when we are placed amid kindred or like environments? I think not. Place man amid unknown and unfamiliar surroundings, and he at once, to a certain extent, becomes lost. Many things appear to us abstruse, occult, and beyond the powers of the human mind; many situations seem difficult, inexplicable, unavoidable. And yet, when these things are explained to us and we come to understand them, we wonder at our own stupidity, so simple do they become. It is a lack of *understanding*, and not an absence of ideation, in animals which makes them appear to us to be, on certain occasions, without ratiocinative power.

Ideation, to some extent, is present in all of the lower animals, and correlative, interdependent, commutual *thought* is unquestionably present in the mental operations both of the monkey and of the elephant, as I will now endeavor to show. Several years ago a capuchin monkey at the Fair Grounds in St. Louis, Mo., received an injury to one of his forepaws, and I was asked to dress it. While convalescing, this little creature learned to know me intimately, and would always cry out with pleasure whenever he saw me. His attendant would let him out, whereupon he would caress my face with his paws, uttering meanwhile many low-voiced ejaculations of endearment. One day, in order to see what he would do, the keeper refused to take him from the cage. The monkey appeared completely nonplussed, and sat down, seemingly in deep thought. Suddenly he uttered a loud shriek, as though in great pain, and began to pace up and down his cage. He held the hand which had been injured, but which had now been well for several weeks, in his other hand, and appeared to be examining it with great solicitude. His object was at once apparent both to the keeper and to myself; he was feigning an injury in order to be let out. This monkey remembered that when he had hurt his hand, I was called and dressed the wounded member. He thought that, if he made it appear that he was again injured, he would be placed in my hands at once. The cunning little malingerer ceased to moan as soon as he was placed in my arms, and at once began to search my pockets for the dainties which he knew were there. Beyond question of doubt in this instance there was true correlative ideation. Thought followed thought in orderly and logical sequence, until the full concept was formulated.

In the same monkey house there lived an ateles which also gave unmistakable evidences of being able to think correlatively. This monkey became the proud and jealous owner of a small, round, metal-backed mirror, which she kept securely grasped in one of her hands. She seemed to regard it as a great treasure, and was immensely afraid that the other monkeys would steal it from her. Wishing to see how she would dispose of it during feeding time, I suggested to the keeper that he prepare a basin of milk and bread and place it in the cage. (The ateles conveys its food to its mouth with its hands; consequently, the monkey was handicapped by having one hand already occupied.) She made a dash for the basin, but immediately recognized the fact that with only one hand free she was no match for the other monkeys. She ran about the cage for a moment or two, then, pausing, seemed to think over the matter. Suddenly she darted to the front of the cage, thrust her hand through the bars, and pressed the precious mirror into one of the keeper's hands. Then, free and untrammeled, she rushed to the bread basin, and began to shovel food into her pouches with both hands.

In a recent issue of *La Nature*, M. Paul Mégnin has an interesting article on the intelligence of monkeys. The following excerpt is taken from a paraphrase of the above-mentioned paper: "At Hagenbeck's establishment, in Hamburg, where two hundred monkeys enjoy complete liberty at play in the great rotunda, they are given multitudes of children's toys, balls, hoops, wheelbarrows, joiner's benches, etc., and learn to manage them all without anyone showing them how. In the center of the rotunda is an immense grain-hopper, from which the seeds, corn, walnuts, chestnuts, apple-quarters, etc., run into a trough, when a wheel at the top is turned. The management of this hopper did not have to be explained to our friends the monkeys. While one of them turns the wheel, the others, sitting around the trough, enjoy the delicacies as they come down, till the one at the wheel, thinking his turn has come, stops, gives the signal for some one to take his place, and comes down to get his share." Here is an instance of complex ideation. These animals know that their food is procurable only by turning a certain wheel, a mechanism wholly unknown to their ancestors, hence completely outside the realm of instinctive or inherited knowledge. They know also that unless some one is self-denying for the time being and will turn the wheel, they will get no food. Therefore, that unselfish individual always presents himself. Furthermore, this individual, after he has labored some time for the good of the community, has only to make known his wishes to be relieved, when another will take his place. Here there is a knowledge of cause and effect in which complex correlative ideation is clearly evinced. Moreover, the factor of unselfishness which is present points to an ethical element as well.

An elephant's skin is exceedingly sensitive, notwithstanding its great thickness. Flies, gnats, mosquitoes, etc., cause it considerable annoyance, especially when it is confined to a house and cannot procure dust to sprinkle over its body as a protection against their attacks. In 1882, while standing in the carnivora house at the St. Louis Fair Grounds, I saw an elephant, which was there stabled, seize a mop-broom with its trunk and skillfully brush away some flies that were biting its back at a place not to be reached by its tail or proboscis. It used the broom with as much dexterity as a man would exhibit under like circumstances. Romanes gives an account of an elephant which was seen to break a bamboo picket from a fence. Then, manipulating the bamboo with its trunk, it splintered it beneath one of its fore feet. Apparently not satisfied, it again broke a bamboo picket from the fence and splintered it as before. Then holding the splinter in its proboscis, it scraped with its point between one of its fore-legs and its belly. In a few moments it dislodged a large elephant-leech, which fell to the ground and which was immediately crushed into a shapeless mass beneath the horny toes of the elephant. This animal deliberately manufactured an instrument, through whose agency it was enabled to rid itself of an annoying parasite. Moreover, it was not satisfied with its first scraper, but threw it away and made another, thus showing interdependent, correlative thought as well as discriminating judgment.—JAMES WEIR, JR., M.D., in the *Scientific American*.

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