The Locomotive

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The Navy Experiments on Oil Fuel.

The *Annual Report* of the Chief of the Bureau of Steam Engineering, for 1902, contains, among other things, a good deal of information concerning the

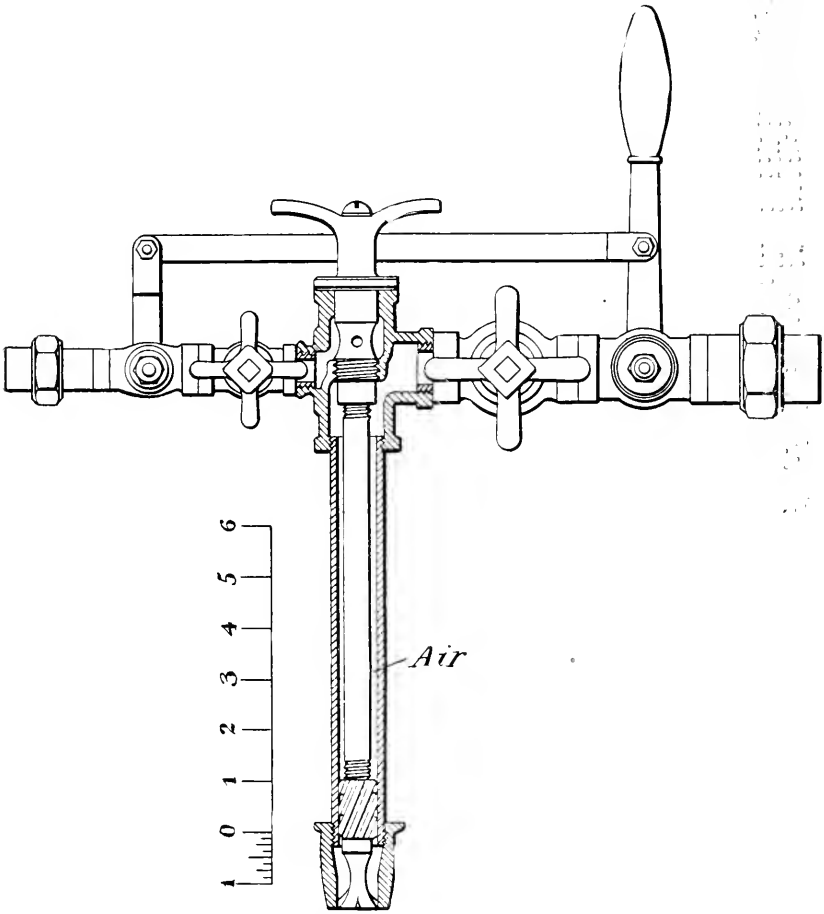
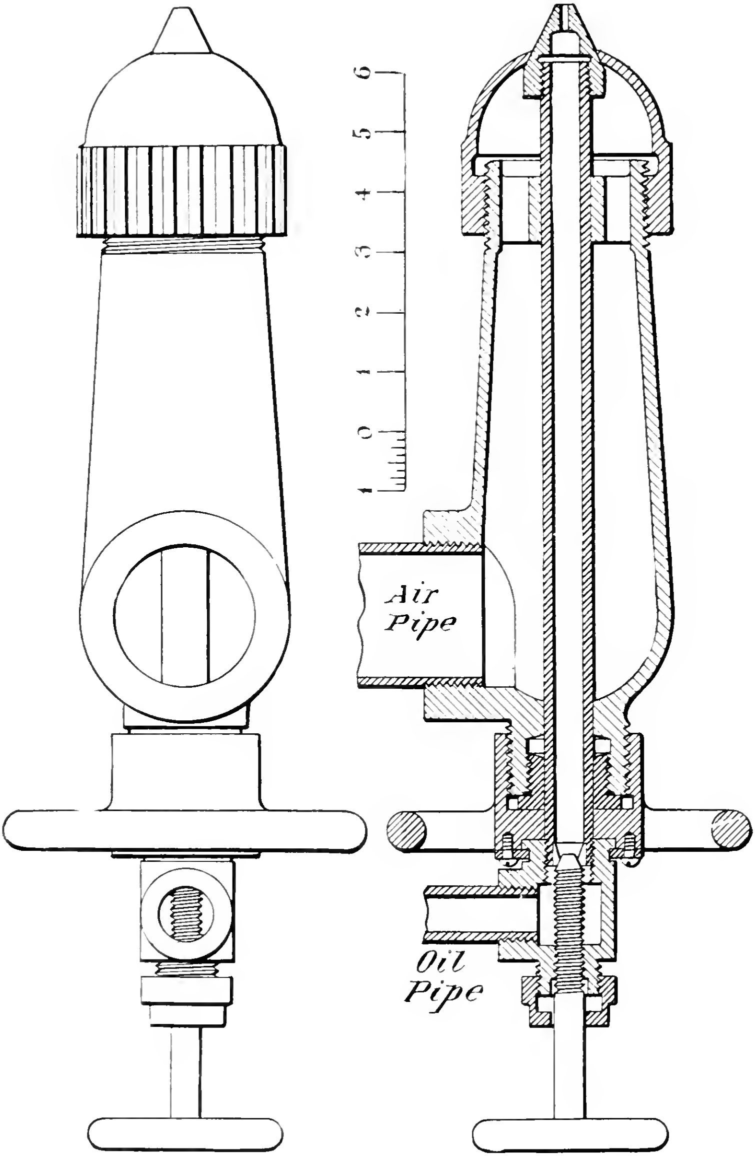


FIG. 1. — THE GRUNDELL-TUCKER BURNER.
(Used on the *Mariposa*.)



FIGS. 2 AND 3.—THE OIL CITY BOILER WORKS AIR BURNER.

(Used in Tests Nos. 1 to 8, inclusive.)

use of oil fuel. This will be welcome to engineers generally, not only because it is one more contribution to a subject about which too little is generally known, but also because the facts given in the *Report*, and the conclusions drawn from them, are presumably uninfluenced by any personal bias on the part of the experimenters. The primary object of the experiments carried out by the Bureau was to determine the fitness of oil fuel *for naval use*, and the conditions essential to its success *in that service*. This problem is different from that which confronts the land engineer who would use oil, and yet there are a sufficient number of fundamental difficulties common to both to make the present experiments valuable to all prospective users of oil. We therefore present, below, such of the general results and conclusions reached by the Bureau as appear likely to prove serviceable to readers of THE LOCOMOTIVE. In some passages we have followed the *Report* textually.

One of the most serious items to be considered is the cost of the oil. This varies greatly in different parts of the country, and the engineer who contemplates the use of oil will have to take into consideration the situation of the proposed installation with respect to coal and oil fields, and the transportation facilities that he can command.

So far as the mechanical features of the problem are concerned, it may be said that the development of oil burning has been rapid from the time that mechanical experts realized that the efficient burning of liquid fuel is greatly dependent upon the

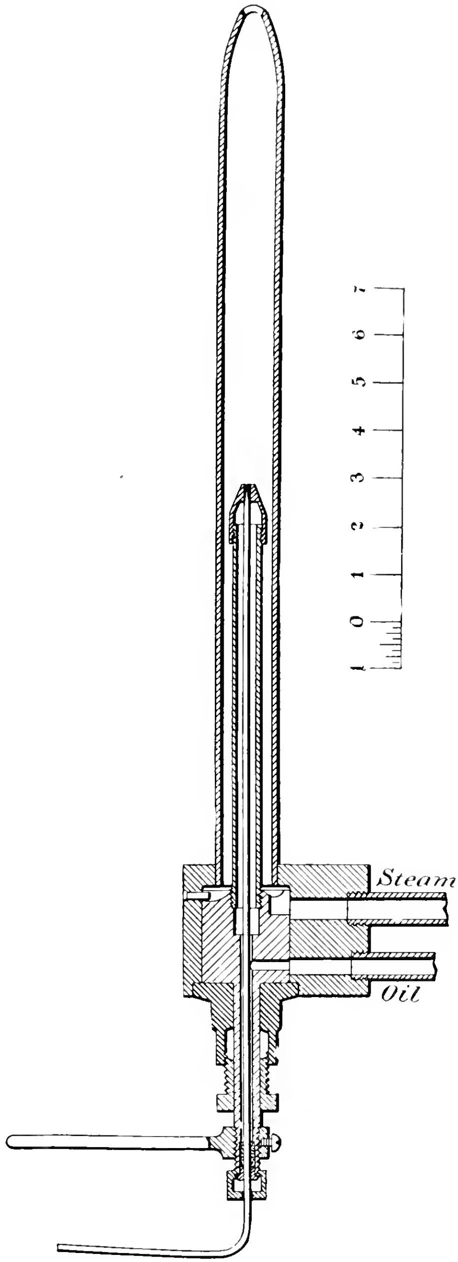


FIG. 4.—THE HAYES BURNER.
(Used in Test No. 9.)

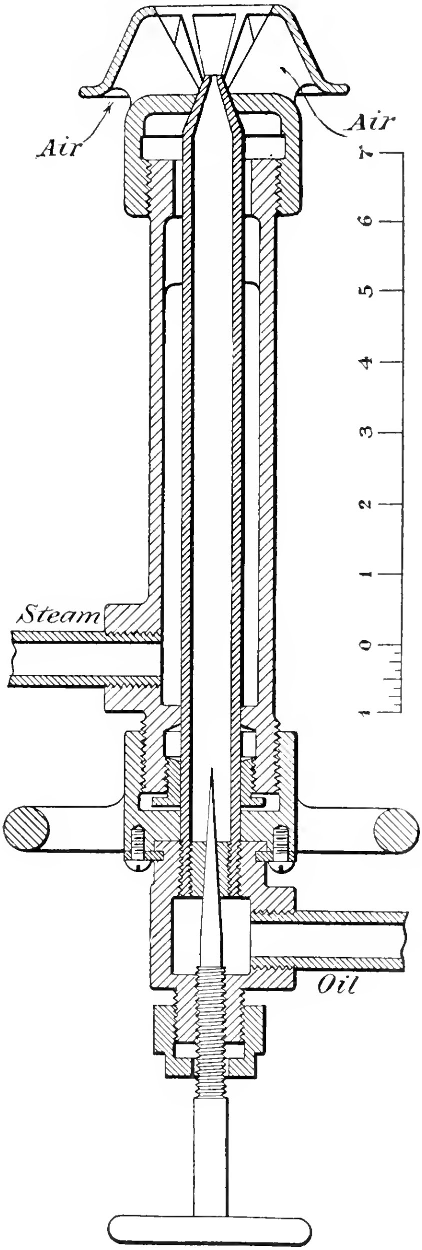


FIG. 5.—THE OIL CITY BOILER WORKS STEAM BURNER.

(Used in Tests Nos. 10, 11, and 12.)

success secured in atomizing the oil. It was only a few years ago when the oil was simply thrown into the furnace by means of an injector, but within the last three years the exceeding importance of atomizing the oil has been recognized. It may be affirmed that the efficiency of the burner is proportional to its power to atomize the oil, and then to turn the minute particles of atomized oil into a mixture of combustible gas and fine particles of carbon, so that complete combustion can be secured. There are many burners which can atomize the oil quite satisfactorily, and as constant and progressive improvement is being made in this lirection, the engineering and mechanical part of the oil problem is nearing solution. The heating of the oil and of the air required for combustion must be provided for, and the necessity of heating the air should be particularly impressed upon all contemplating the use of liquid fuel.

The *Report* contains an account of observations made on the single-screw iron steamer *Mariposa*, of the Oceanic Steamship Company, plying between San Francisco and Tahiti, but the data that were obtained are not as full as could be desired. When the *Mariposa* burned coal, her crew consisted of 81 men; but when the recent change to oil fuel was made it was found possible to reduce the crew to 65. The burner used on the *Mariposa* is shown in Fig. 1. It consists of a hollow plunger for the oil, screwed into a pipe through which the air passes. The outlet for the oil is through a series of small holes nearly at right angles to the axis of the burner. The air traverses spirally arranged passages just before meeting the oil, and the spray issuing from the burner is thrown into a rose-shape by the action of the expanded end of the burner upon the whirling stream of oil and air. The air and oil pipes are provided with globe valves for regulating, and also with plug cocks connected by a handle, so that the burner can be shut off immediately in case of emergency. The air supply pipe is also connected to the steam line, so that steam can be substituted for air if desirable. The air is supplied to the burner at a pressure of about 20 pounds, and a branch pipe from the air supply leads to the tank in which the oil is heated on its way to the burners, so that the oil and air reach the burners at the same pressure. The oil was heated, on the trip on which these observations were made, to a temperature of from 120° to 130° Fahr.

The oil used contained 84.43 per cent. of carbon, 10.99 per cent. of hydrogen, and 3.34 per cent. of oxygen; and its calorific value, by Dulong's formula, was 18,806 heat units per pound. Its specific gravity at 60° Fahr. was 0.962, and its flash point was 228° Fahr.

In starting the fires with everything cold, steam is first raised on the auxiliary boiler (which burns coal), and the air compressor, oil pumps and oil heater are started. The air used for combustion has a temperature of about 350° Fahr. at the moment it comes in contact with the oil, part of this temperature being due to the mechanical compression of the air, and the remainder to its absorption of heat in passing through an air chamber surrounding the burner. It was

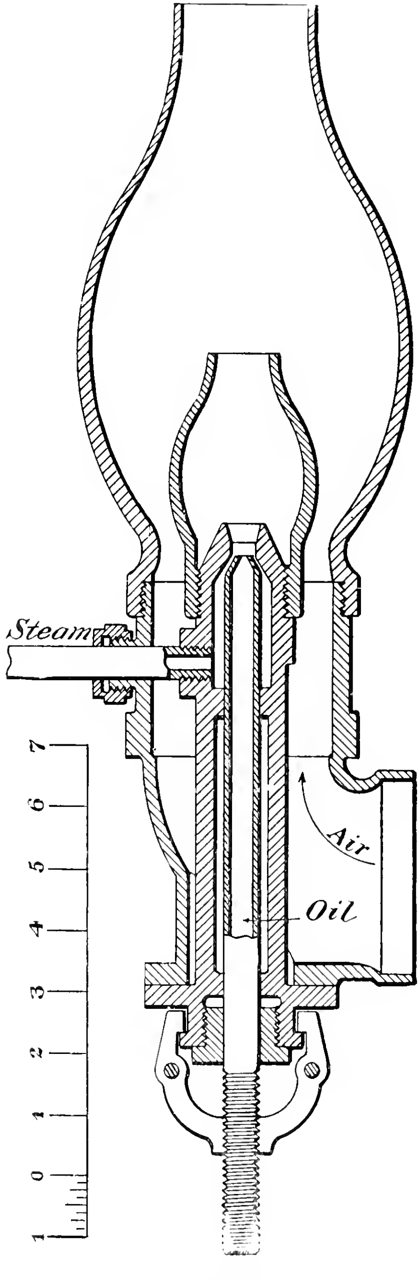


FIG. 6. — THE F. M. REED BURNER.

(Used in Tests Nos. 13 and 14.)

found that the heat communicated to the air by the compressor alone was sufficient to insure the satisfactory working of the burners, and for the first two days of the trip the burners were operated in this manner.

The steam pressure on the *Mariposa* appears to have ranged from 160 to 170 pounds. The average horse power developed on the round trip was 2,481, and the average consumption of oil was 1.503 pounds per indicated horse power per hour.

By way of introducing the data obtained in the experimental plant at Washington, the *Report* says: "Before laying out the work the board realized that there was in existence a wealth of literature bearing upon the subject. Thousands of interested persons had done some experimentation, but many of these people had no inclination to turn their data over to the general public. By the action of the Navy Department in organizing an official board, it was possible to secure data that could have been gathered only with difficulty by private individuals. Upon investigation the board finds that much of the data published is very unreliable, particularly upon the most important features of the problem. As an illustration, it has been asserted that for sustained sea work the boilers of certain merchant vessels consume only one pound of oil per hour, to develop one horse power. When it comes to checking this information by the consumption from the storage tanks it will be found that a much larger quantity is used." The great activity among inventors and other persons interested in the use of liquid fuel may be inferred from the following statement: "There are on file in this Bureau over 2,000 drawings and specifications pertaining to the use of liquid fuel, and it is said that new patents are being issued at the rate of about thirty a week."

The oil used in the experiments described in the *Report* under consideration was from the Beaumont, Texas, field. It was not the crude oil of nature, but had been subjected to "an inexpensive treatment" for removing some of the sulphur and the more volatile hydrocarbons. It had a specific gravity of 0.926 at 60° Fahr., and a flash point of 216° Fahr. It contained 83.26 per cent. of carbon, 12.41 of hydrogen and 3.83 per cent. of oxygen. As calculated by Dulong's formula, it was capable of developing 19,481 heat units per pound of oil. In some of the tests steam was used for atomizing the oil, and in others the atomizing was effected wholly by air. When steam was used, it was furnished by a separate boiler that was installed for this special purpose. "There is quite a widespread misconception," says the *Report*, "regarding the part that the steam which is used for atomizing purposes plays in effecting combustion. It is supposed by many that after atomizing the oil the steam is decomposed, and that the hydrogen and oxygen again unite, thus producing heat and adding to the heat value of the fuel. While it may be true that the presence of steam may change the character and sequence of the chemical reaction, and result in the production of a higher temperature at some part of the flame, such an advantage will be offset by lower temperatures elsewhere between the grate and the base of the stack. All steam that enters will, if combustion is complete, pass up the stack as steam, also carrying with it a certain quantity of waste heat. The amount of this waste heat will depend upon the amount of steam and its temperature upon entering the furnace. The quantity of available heat, measured in thermal units, is undoubtedly diminished by the introduction of steam. In an efficient boiler it is quantity of heat rather than intensity that is wanted. . . . A local intense heat is objectionable on account of its liability to cause leakage around the tubes and seams, from the unequal expansion of the heating surfaces." The board considers that the following facts and principles have been established beyond doubt:

(1.) Oil can be burned in a very uniform manner.

(2.) The evaporative efficiency of nearly every kind of oil, per pound of combustible, is probably the same. While the crude oil may be rich in hydrocarbons, it also contains sulphur; so that after refining, the oil has probably the same calorific value as the crude product.

(3.) A marine steam generator can be forced to even as high a degree with oil as with coal.

(4.) Up to the present time no ill effects have been shown upon the boiler.

(5.) The firemen are disposed to favor oil, and therefore no impediments will be met in this respect.

(6.) The air requisite for combustion should be heated, if possible, before entering the furnace. Such heating undoubtedly assists the gasification of the oil product.

(7.) The oil should be heated, so that it can be atomized more readily.

(8.) When using steam, higher pressures are undoubtedly more advantageous than lower pressures, for atomizing the oil.

(9.) Under heavy forced draft, particularly when using steam, it has not yet been found possible to prevent smoke issuing from the stack, although all connected with the tests made special efforts to secure complete combustion.

(10.) The consumption of liquid fuel probably cannot be forced to as great an extent with steam as the atomizing agent, as it can when compressed air is used for this purpose. This is probably due to the fact that the air used for atomizing purposes, after entering the furnace, supplies oxygen, while in the case of steam the rarefied vapor simply displaces air that is needed to complete the combustion.

(11.) The efficiency of oil fuel plants will be greatly dependent upon the general character of the installation of auxiliaries and fittings; and therefore the work should be entrusted only to those who have given careful study to the matter, and who have had extended experience in burning the crude oil. The form of the burner will play a very small part in increasing the use of crude petroleum; for where the burners are simple in design, and are constructed in accordance with scientific principles, they will differ but little in efficiency. Consumers should see to it, carefully, that they do not purchase appliances that are untried, and have been designed by persons who have had but limited experience in operating oil devices.

The accompanying tables will give some idea of the general nature of the results of the experiments, but for full details the original paper must be consulted. A few words of explanation are needed to make the significance of the tables here presented clear.

"Total pounds of feed water" of course denotes the total water fed to the experimental boiler during the test. The numbers given in the table have been corrected for the difference in level of the water in the boiler, at the times of starting and stopping the tests. The apparent evaporation during the test is equal to the weight of the feed water; but to get the actual weight of *dry* steam produced, it is necessary to make a proper allowance for the moisture that was present in the steam, as it was actually delivered by the boiler. The necessary data for this are given in the column headed "Moisture (per cent)."

The column headed "Pounds steam for burners" gives the weight of steam that was used by the burners, either directly or indirectly;— directly when steam was the atomizing agent, and indirectly when air was used for this purpose. When air was the atomizing agent, the steam charged in this column was used in compressing and heating the air, or in running the blower. The steam entered in this column being produced by a separate boiler, it is necessary to subtract the numbers in this column from those in the column headed " Total

EXPERIMENTAL TRIALS OF OIL FUEL.

(Hohenstein Marine Water-Tube Boiler.)

Number of Trial.	Date (1902).	Duration (hours).	Oil burner used.	Average steam pressure (lbs.).	Average temp. of feed.	Pressure of atomizing medium.
1	June 11	6	O. C. B. W. (air).	273.5	120.7°	3.20
2	" 12	4	" "	273.5	103.2	4.62
3	" 26	8	" "	273.5	128.5	0.78
4	" 27	3	" "	273.5	119.0	3.37
5	Aug. 2	5	" "	273.5	129.0	1.41
6	" 4-9	116	" "	271.5	119.4	1.31
7	" 15	6	" "	272.5	119.7	4.66
8	" 20	3	" "	276.0	119.0	4.68
9	Sept. 12	6	Hayes (steam).	273.5	127.0	32.
10	" 19	8	O. C. B. W. (steam).	273.1	118.3	29.9
11	" 20	8	" "	273.7	120.2	61.4
12	" 22	8	" "	274.2	119.6	91.
13	" 27	8	Reed (air and steam).	276.7	121.9	92.
14	" 29	8	" " "	277.4	120.8	89.

EXPERIMENTAL TRIALS OF OIL FUEL.

(Hohenstein Marine Water-Tube Boiler.)

No. of trial.	Total pounds feed water.	Pounds steam for burners.	Moisture (per cent.).	Total pounds oil burned.	Pounds feed per lb. oil.	Evaporation from and at 212°.	Cu. ft. air per lb. oil.
1	117,976	2,820	1.7	10,584	11.15	12.70	34.3
2	96,928	3,770	2.0	9,180	10.56	12.18	37.4
3	78,000	827	1.6	6,122	12.74	14.43	62.8
4	88,604	2,550	1.9	8,602	10.30	11.73	36.7
5	58,529	1,153	1.4	4,668	12.54	14.22	70.0
6	1,192,482	18,240	1.5	96,517	12.36	14.12	55.4
7	104,631	7,800	0.5	9,089	11.52	13.29	78.3
8	92,997	3,950	1.2	9,909	9.39	10.77	36.0
9	43,761	2,524	0.9	3,600	12.16	13.89	....
10	85,791	3,412	0.5	7,360	11.65	13.47	....
11	96,469	4,252	0.6	8,257	11.68	13.45	....
12	105,547	5,305	0.5	8,974	11.77	13.58	....
13	95,605	8,166	0.4	7,692	12.43	14.35	81.4
14	112,115	6,838	0.2	9,216	12.17	14.06	78.0

pounds feed water," and then to correct the difference for moisture, in order to obtain the weight of dry steam available from the boiler under test, for power purposes.

"Total pounds oil burned" includes only the oil used under the boiler in which the main test was carried out. The oil used in the auxiliary boiler that operated the burners is omitted, because in practice the steam used to run the burners would be drawn from the main boiler; and if the correction for the steam used in the burners is made as indicated above, it is not necessary to know how much fuel was burned under the auxiliary boiler.

The column headed "Cubic feet of air per pound of oil" gives the number of cubic feet of free air used for atomizing, as measured under the ordinary atmospheric conditions prevailing at the time of the test. The pressure under which the air (or steam) used for atomizing was actually delivered to the burners is given, in pounds per square inch, in the column headed "Pressure of atomizing medium."

In tests Nos. 1 to 8, inclusive, the air burner of the Oil City Boiler Works was used; this burner is shown in Figs. 2 and 3. In test No. 9 the Hayes steam burner, shown in Fig. 4, was used. The burner used in tests Nos. 10, 11, and 12 is shown in Fig. 5; and the F. M. Reed combined air and steam burner, shown in Fig. 6, was used for tests Nos. 13 and 14.

The differences in the evaporation from and at 212 degrees, as shown in the table, are due to a considerable extent to intentional changes made in the mode of carrying out the tests. For full details of this sort we must refer to the original *Report;* but it may be pointed out that of the first eight tests, Nos. 1, 2, 4, and 8, in which the evaporation is distinctly lower than in the remainder of the series with the same burner, were made under forced draft. No. 7 was made with natural draft, but with the blower working at its maximum capacity.

Major Pratt, the United States army officer in charge of the Carlisle Indian School, tells of an incident he saw at a western Indian agency. A squaw entered a trader's store, wrapped in a blanket, and pointing to a straw hat she asked, "How muchee?" "Fifty cents," said the merchant. "How muchee?" she asked again, pointing to another article. The price was quoted, and another query of "How muchee?" followed. Then she gazed blankly at the merchant and asked, mildly, "Do you not regard such prices as extortionate for articles of such palpably inferior quality? Do you not believe that a reduction in your charges would materially enhance your profits, as well as be ethically proper? I beg you to consider my suggestion." She was a graduate of the Carlisle school. — *Kansas City Journal.*

Professor Carl Darling Buck, of the University of Chicago, calls the linguistic situation in Chicago "an unparalleled babel of foreign tongues." "I say 'unparalleled babel,'" he continues, "with all due regard to the claims of Constantinople, Cairo, and other cities of the Orient, past and present. In Constantinople the number of languages may on occasions be as great as in New York or Chicago; but only a few of these languages are spoken by large bodies of the population, whereas in Chicago there are some fourteen languages besides English, each of which is spoken by 10,000 or more persons. Newspapers appear regularly in ten languages, and church services may be heard in about twenty. Chicago is the second largest Bohemian city in the world, the third Swedish, the third Norwegian, the fourth Polish, and the fifth German (New York being the fourth). In all, there are some forty foreign languages spoken by numbers ranging from half a dozen to half a million, and aggregating over 1,000,000."

The Locomotive.

HARTFORD, JANUARY 15, 1903.

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

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Obituary.

MR. JAMES WEST ARROTT.

It is with profound sorrow that we record the death of Mr. James W. Arrott, General Agent of the Hartford Steam Boiler Inspection and Insurance Company in its Western Pennsylvania Department. Mr. Arrott was born in Ireland, in 1835, and came to the United States when 21 years of age. In 1859 he went to Pittsburg, Pa., where he established the large insurance agency with which he has since been identified. He died of apoplexy on December 29th at his home at Osborne, near Pittsburg. Mr. Arrott was a man of large ability, and he was also kind-hearted, genial, and considerate to a fault. In 1895 he assisted in the organization of the Standard Manufacturing Company, and he was also a large owner of real estate, his holdings including the Arrott Power Company, and the beautiful 18-story Arrott building, completed for occupation about ten months ago. He was married, in 1861, to Miss Isabella Lee Waddell, of Philadelphia, who survives him. He also leaves four sons and two daughters. The following minute was adopted by the Pittsburg Board of Fire Underwriters, at a special meeting held on December 31st:

"In the order of Divine Providence, we are again summoned to pay tribute to the memory of one of our number who has been suddenly called from active business life to the life beyond. James West Arrott, who departed this life on Monday evening, December 29th, 1902, was one of the original members of this Board, an active, intelligent fire underwriter, who, by his energy and native ability, has not only achieved personal success, but has assisted in establishing correct forms and methods in our profession. A man of strong convictions and force of character, he at times urged his opinions with great persistence, but at the same time he was kind and considerate of the opinions of others. In the various interests in which he was engaged he gave the same tireless energy and thought which have established for him a prominent place and position in this community. Amid the cares of an active, busy life, Mr. Arrott did not forget his Christian duties. He was a devoted, loyal member of his church, and a liberal supporter of its interests. In his domestic life as a husband and father, he has shown a generous loving disposition that has endeared him in the home circle, and his memory will be a cherished inheritance. We therefore would place this tribute on record, and recommend that a copy be furnished to his family."

Mr. Porter's First Lessons In Mechanics.

Mr. Charles T. Porter is so well known as an accomplished mechanic that it seems hard to believe that there ever was a time when the "father of the high speed engine" was *not* a mechanic. However, we have his own account of how he took his first lesson, in the December issue of *Power*. He tells it as follows:

I was educated for the bar, and practiced law for six or seven years, first in Rochester, N. Y., and afterwards in New York City. My knowledge of mechanics may be illustrated by a story I once heard in England of a man who had been prosecuted for selling adulterated tobacco, and who got off by proving that there was no tobacco at all in the article that he sold; but this illustration hardly does the case justice. I had some mechanicai ideas, but they were exactly wrong. For example, I never could see any difficulty in perpetual motion. All one had to do was to pump up water, which by its fall would furnish power to run the pump. This, however, was no more absurd than two inventions that were brought out in England while I was there, and which were the only attempts to improve the steam engine made in England, so far as I could learn, during my six years' residence in that country. One of these was corrugating the faces of the piston so as to present more extended surfaces for the steam pressure to be exerted upon. The other was a device for utilizing that half of the force of the steam which had been wasted against the cylinder heads. Both of these were published with commendatory remarks in the *Mechanics' Magazine*. The last, if I recollect rightly, was the original bottom feature of the Wells balance engine.

My utter ignorance of everything mechanical at that time is capable of proof. I stepped right into one of those "springs to catch woodcock" which were being set in those days, and proved myself to be about as green a gosling, mechanically, as ever was plucked. I had a client by the name of Searle who was a "dead beat." He owed me about $100, which I could not collect. He finally called upon me and told me frankly that he could not pay me one red cent because he had no money; but he could put me in the way of making a fortune, and he was anxious in that way to discharge the great obligation which he felt himself under to me. A new invention had appeared, called the Gwynne & Sawyer static pressure engine, that was bound to revolutionize all applications of power. It was (he told me) attracting great attention in engineering circles, and there had been a hot discussion over its theoretical principles; but its advocates had successfully vanquished all their antagonists, and now the invention was established on a perfectly sound scientific basis. If I would give him a receipt in full for the money that he owed me, and would put another $100 into this enterprise, he was in a position to secure for me a number of rights to use the machine. He kindly offered to introduce me to Mr. Sawyer. Mr. Gwynne was, unfortunately, absent from home at the time. (I learned afterwards that he was in jail.) Mr. Sawyer received me most graciously. I think he had been told by Mr. Searle about how much taffy I might be expected to swallow, but he must have ventured far beyond his instructions. He told me that he was delighted to make my acquaintance. He had frequently heard of me through our mutual friend, Mr. Searle, and of my triumphs at the bar, and he had come to feel a great admiration for me, and was proud to show this great invention to a man so eminently capable of appreciating it. He told me that the invention was a practical method of utilizing that wonderful power known as centrifugal force. This force could be obtained in any amount. In fact, it was the force that kept the universe in motion. It had lain unutilized for so long a time because engineers had never been able to apply it practically. This difficulty had been completely overcome in this great invention, and this wonderful power was now to be made available for the world. He gave me quite an oration on the subject, saying, "We do not antagonize the forces of nature, we utilize them and apply them to beneficial purposes; consequently all nature coöperates with us," and more to the same effect. He was able to show me a working model of this great invention. He was very sorry that he could not put it in motion for me that day, as it happened to be a little out of order; but I would be able to see the principle of its operation very distinctly. Well, I saw the *principle*, with the result that Mr. Sawyer saw the *principal*, and with the further result that after that I never saw nor heard of either principal or interest. Our mutual friend Mr. Searle also disappeared.

This was my first lesson in mechanics, given to me by a master of his art. I am not sure, on the whole, but that in one way and another it has been worth the trifle that it cost me.

Boiler Explosions.

AUGUST, 1902.

(219.) — On or about August 1st a threshing machine boiler belonging to a man named Tittler exploded near Williamsburg, Iowa. Mr. Tittler was badly scalded.

(220.) — On August 2d a boiler exploded on the steam tug *Edward S. Dilly*, at Pearlington, Miss. Considerable damage was done, but nobody was injured.

(221.) — A boiler exploded, on August 3d, in the Philadelphia & Lehigh Valley Traction company's Souderton power house, near Morristown, Pa. Three men were injured. We have not learned further particulars.

(222.) — A boiler exploded, on August 4th, in C. M. Wenner's planing mill, at Brunswick, Md. The boiler house was demolished, but we have not learned of any personal injuries.

(223.) — A boiler explosion occurred, on August 4th, in the Sauquoit Silk Mill, at Scranton, Pa. Fireman Patrick Connerton was seriously scalded.

(224.) — On August 5th a slight boiler explosion occurred in the American Type Foundry company's plant, at Cincinnati, Ohio. We have not learned of any personal injuries, and the property loss was small.

(225.) — A small boiler exploded, on August 5th, in the rod mill at Rankin, near Pittsburg, Pa. Engineer James Dunbar was slightly scalded

(226.) — Richard Rafter was severely burned, on August 7th, by the explosion of a boiler at Elm Grove, W. Va

(227.) — A strange explosion occurred, on August ,th, at or near Newbern, Tenn. The explosion (so says our account) was "of a steam boiler used for running a magic lantern." This is the first time that we ever heard that magic lanterns were run by steam! The operator of the apparatus (lantern. or whatever it was) was named McKnight, and he was instantly killed. An assistant was also seriously injured, but will recover. It is not our practice to print all the horrible details of the boiler explosions that we record in these monthly lists, but lest it may be thought that this explosion was too trivial to be recorded in this place, we may quote the following words from the account at hand: "Mr. McKnight's whole left side was blown away, carrying his heart and left lung some distance from his body. It seems he was not accustomed to handling the machine, and overheated it until the steam reached a pressure of 200 pounds, when it should have been only 15."

(228.) — On August 8th a boiler exploded at Ben's Run, near Sisterville, W. Va. Fortunately nobody was injured. The boiler belonged to the South Penn Oil company, and was practically new.

(229.) — A blowoff pipe burst, on August 9th, on a boiler in the Brodie mill, at Mound City, near Cripple Creek, Colo. The fires were thrown out into the boiler room, and the plant took fire and was destroyed. The total cost of the property destroyed is estimated at $200,000.

(230.) — On August 9th a boiler exploded in Arthur Oram's laundry, at Adrian, Mich. James Oram (a son of the proprietor) was instantly killed, and Carl Hall and Benjamin Boughey were injured so badly that they died two days later. William Oram, Mary Mattiman, and Annie Boughey were also badly hurt. The building was wrecked, and the rear portion of the Gibson Hotel was also blown to pieces. A 600-pound fragment of the boiler was thrown over a high building, and fell 500 feet from the scene of the explosion.

(231.) — Two men were badly scalded, on August 10th, by the bursting of a boiler tube on Mr. George Weatherhead's steam launch *Canute*, on the Seekonk river, near Pawtucket, R. I. The scalded men were Joseph Robbins and A. M. Brassard.

(232.)—On August 12th a boiler exploded in Patterson Bros.' stone quarry, near Portage, Ohio. The boiler was completely shattered, but nobody was injured.

(233.) — A boiler exploded, on August 13th, in a sugar mill at Croswell, Mich. Several persons were injured, and at last accounts it was thought that two of the injured might not recover. We have not learned further particulars.

(234.) — On August 13th a boiler exploded on the tugboat *Jacob Kuper*, off Tompkinsville, N. Y. Louis Cose, Harry Johnson, and Henry Meyer were killed, and Christian Creig, William Purdy, William Hansen, and Charles Larsen were injured. The *Kuper*, which was one of the best known tugs in the harbor, was practically destroyed. The boat belonged to E. D. Kuper & Sons, and cost $15,000.

(235.) — A boiler exploded, on August 16th, in Sorenson's flouring mill, at Tower City, N. D. The roof was torn from the boiler house, but nobody was injured, as the accident occurred at the breakfast hour.

(236.) — On August 17th the boiler of one of the Chesapeake & Ohio railroad company's largest freight locomotives exploded near Covington, Va. Engineer Daniel Marable, fireman M. W. Hughes and brakeman E. H. Helms were seriously injured, and at last accounts it was said that Mr. Helms could not live. The boiler was torn loose from the frame of the locomotive, and after turning over and over several times, it landed some 200 feet from its original position.

(237.) — On or about August 18th a threshing machine boiler exploded at Crary, N. D. Fragments of the boiler were thrown in all directions, but nobody was injured, although at least a dozen men were standing all about the machine when the explosion occurred.

(238.) — The boiler of a locomotive used for hauling coal exploded, on August 18th, at the Knickerbocker colliery, Pennsylvania. Engineer Charles Knapp was thrown through the cab window, but was not seriously hurt.

(239.) — On August 19th a boiler exploded in A. Simpson's sawmill, at New Liberty, Ill. Robert Johnson, James Jeffords, sr., and a man named Horne were killed instantly, and Archibald Johnson and Roscoe Vickers were fatally injured. Guy Roberts, James Jeffords, Jr., Lester Johnson and eight other persons were also injured to a lesser extent. The mill was wrecked, and the boiler was thrown to a distance of a mile.

(240.) — Two huge pulp digesters exploded, on August 20th, in the Delaware Pulp Mills, at Wilmington, Del. John McCormick, William T. Burke, Granville Walters, James B. Stokes, Franklin T. Harris, George W. Wright, Joseph Laubacker, Joseph F. Henry, Joseph Nagle, Zachariah Colins, E. H. Mousley, Bernard Sweeney, William Scott, and Joel Hutton were buried in the ruins and killed, and Thomas Reeves, John Collins, James Jester, and John Durham were injured so severely that at last accounts it was doubtful if any of them could recover. The whole place was a scene of devastation and ruin, difficult to describe. The property loss is estimated at $35,000.

(241.) — The boiler of an agricultural engine exploded, on August 20th, on the Vandre farm, two miles northwest of Eckley, Ohio. Samuel King was killed, and a child named Marilet was injured. The engine was torn to pieces.

(242.) — On or about August 20th a boiler exploded in the Garfield creamery at Algona, Iowa. We have not learned further particulars.

(243.) — On August 23d the boiler of a big mogul locomotive drawing the first section of the Chicago & Alton meat train No. 86, exploded eleven miles east of Mexico, Mo. Brakeman H. C. Markwell was killed, and T. C. Shalenberger, J. J. McMahan, and H. L. Stephenson were injured so badly that at last accounts it was said that they could not recover. Engineer H. C. Page also suffered a compound fracture of the left thigh, and was burned about the face and legs. The boiler was thrown 200 yards, and nine cars of meat were ditched.

(244.) — On August 23d the boiler of Iron Mountain switch engine No. 894 exploded at the foot of Cherokee street, St. Louis, Mo. The locomotive was in charge of engineer Charles Doner. Nobody was injured.

(245.) — A boiler exploded, on August 26th, during the course of a big fire which destroyed the woolen mills at Prairie du Chien, Wis.

(246.) — The boiler of a traction engine exploded, on August 26th, on the John Wood farm, five miles northeast of Neponset, Ill. Engineer Hugh Sweet was fatally injured, and George Chase and Ralph Sweet were painfully injured.

(247.) — On August 26th a boiler owned by James Davis, and used for sawing wood, exploded at Hurley, Wis. Howard Paynter and Joseph Flandrini were severely injured, and the machinery was wrecked.

(248.) — The boiler of a threshing machine outfit exploded, on August 29th, near Davidsville, Somerset county, Pa. Joseph Johns was seriously injured. Mr. Johns is 80 years of age, and is a grandson of the founder of Johnstown, Pa.

(249.) — A boiler exploded, on August 30th, in Ambrose Cooley's canning house, at Webster, Harford county, Md. A Bohemian boy whose name we do not know was fatally injured, and Amos Cooley and Lesler Botts were also injured seriously. The boiler house was wrecked.

Concerning Cast Steel.

The merit of American methods and American industrial products is a subject concerning which we entertain opinions favorable to the verge of partisanship, but regard for the truth compels the admission that the comparison of American cast steel with that produced in Europe is an uncomfortable process. It is a matter of common knowledge in engineering circles that the buyer of cast steel made in this country has to take what he can get rather than what he actually wants. When a pattern of any degree of intricacy is offered to a steel founder, he throws up his hands in dismay; and if the customer is not too important in the industrial field, the founder intimates that he doesn't care for his — the customer's — business anyhow, if it runs that way. Angles must be filleted to an absurd radius, lugs of a size less than one capable of sustaining a ton or so may "come" on the casting or may not, air pockets or blow holes occur with disconcerting frequency and almost invariably in that section of the casting where they do the most harm. In short, the production of sound steel castings of small bulk and accurate contour appears to be accidental, if it ever occurs at all.

This is not true in the best European foundries. We have seen French steel castings, for example, that are amazingly true to pattern, thin-walled and sound, with cored recesses of a character that would doubtless be considered absolutely prohibitive in the United States. We do not know enough of the practical details of steel moulding to form any opinion as to the explanation of these facts; they exist, however, unfortunately beyond dispute, and their existence is without apparent justification. It is certainly true that the market here for fine steel castings is sufficiently large and attractive to warrant the most exhaustive experimentation and expensive plant equipment that one can conceive to be necessary for the production of such castings. It is true also that there is no lack of brains and energy in the American metallurgical industry. These two well-known facts are precisely the things that render it impossible to understand why foreign steel castings are so much superior to ours in the particulars mentioned.— *American Electrician.*

[This is by no means the first time that we have known of American steel castings being compared unfavorably with French castings, when the pattern is at all complicated. Will somebody please rise and explain? — *Editor* THE LOCOMOTIVE.]

The Locomotive

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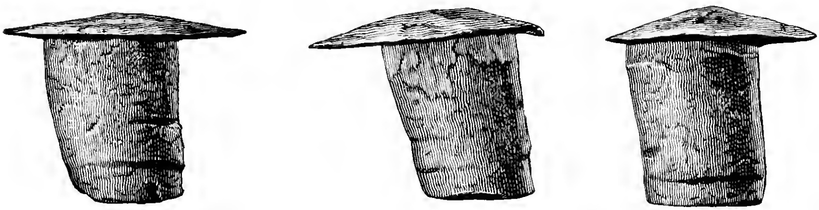
Concerning Rivet Heads.

It is not uncommon, even in these days of improved methods and presumably advanced ideas, to find boilers held together by rivets whose heads are far too thin and flat. Some examples of this, taken from actual specimens found by inspection, are presented in Figs. 1, 2, and 3. It is true that most of the rivets used in boiler work are subjected chiefly to shearing stress, but the endwise tensile stress that is always present in a good rivet, well driven, is by no means inconsiderable; and since it is this tensile stress that holds the plates together and prevents leakage, attention should be paid to the rivet-heads, upon whose strength and continued good condition the tightness of the joint depends. The thin, fin-like edges that such rivet heads too often present are liable to burn off, or at least to have their strength destroyed or greatly impaired by exposure to the hot furnace gases, and leakage and corrosion are the probable results. Moreover, the stresses in a boiler shell are not, in practice, nearly so simple as they are assumed to be, for the sake of convenience, in theory. We make certain assumptions concerning them, in our calculations,

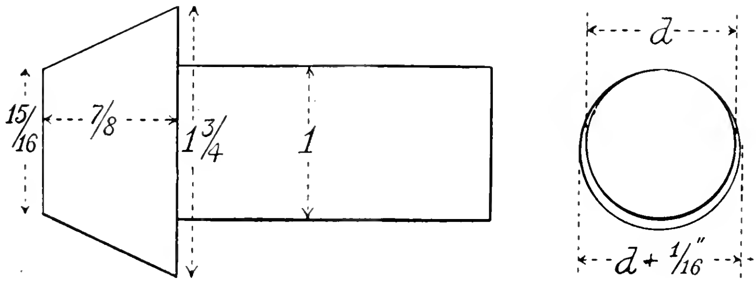


FIGS. 1, 2, AND 3. — SHOWING DEFECTIVE RIVET-HEADS.

and we then provide for a considerable margin of ignorance by allowing a factor of safety that our experience has shown to be sufficient. But in order for this mode of procedure to be justifiable, the construction of the boiler must be good in all respects; and so it is fair to demand that the heads of the rivets shall be satisfactory in shape and in the quantity of stock that they contain. This is particularly and undeniably true of rivets upon which the chief stress is to be a tension (as, for example, the rivets at the head-ends of the braces).

The objectionable flatness of the riveted ends of rivets is almost invariably due to the use of rivets that are far too short. The remedy, of course, is to use rivets that are long enough to contain the necessary stock for good heads: and we are of the opinion that the inadequacy of the heads of which we complain is not due to unwillingness, on the part of the builders, to use a proper amount of stock, so much as it is to a failure to appreciate the importance of careful attention to the matter.

The ideal rivet is one which has the same strength at both ends: and equal strength can be secured, most certainly, by making the two heads alike, both in shape and in size. There is no necessity of having them alike in shape, however, provided the equality of strength is secured in some other manner; and it is customary to consider them satisfactory when the two heads contain



FIGS. 4 AND 5.—SHOWING RIVET PROPORTIONS AND THE USUAL RELATION BETWEEN RIVET AND HOLE.

an equal amount of stock, and are also reasonable in shape, so as to give a proper bearing against the plates, as well as a satisfactory strength of body. In the common V-shaped riveted-end, the angle at the apex should be about 90°.

In driving a rivet, a certain amount of material is used in filling the hole; for the diameter of the hole is commonly $\frac{1}{16}$th of an inch greater than that of the rivet, as is indicated in Fig. 5. The length of shank to be allowed for this

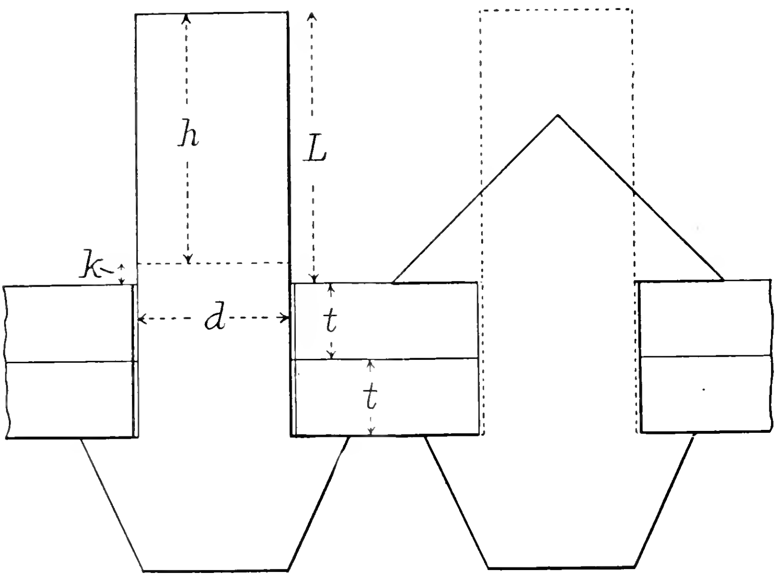


FIG. 6.—ILLUSTRATING THE PROJECTION OF THE RIVET THROUGH THE PLATES BEFORE DRIVING.

purpose (indicated by k in Fig. 6) will vary somewhat with the diameter of the rivet, and with the thickness of the plates through which the rivet is driven; but it is small in any case, and an allowance of ⅛th of an inch in the length of the shank will usually be quite sufficient to provide for the filling of the hole.

The main part of the allowance that must be made in the projection of the rivet-shank relates to the stock that is required for riveting up; and in order to have the same amount of stock in both heads of the rivet, we must plainly allow a length of shank that shall have a volume equal to the volume of the "cone head" that is on the rivet as it comes from the maker. The proportions of these cone heads vary a little, but in the general run of good rivets the dimensions are not widely different from those indicated in Fig. 4, which are taken from the catalogue of a rivet manufacturer. The unit of measurement is here supposed to be the diameter of the rivet; so that a rivet *half* an inch in diameter, for example, will have dimensions half as great as those indicated and similarly for other sizes. Accepting these dimensions, it is easy to calculate that such a head contains an amount of material equal to that contained in a section of the shank that is 1.63 times as long as the diameter of the rivet. (This length is indicated by h in Fig. 6.)

From another trade publication we take the following dimensions of a one-inch rivet, the dimensions of other sizes being proportional, as before, to those here given: Diameter of shank, 1 inch; greatest diameter of head, 1¾ inches; least diameter of head, 1 inch; height of head, $\frac{13}{16}$ths inch. With these dimensions, the volume of the head is easily shown to be equal to that of a section of the shank that is 1.58 times as long as the diameter of the rivet. Taking the mean of these two determinations, we may therefore conclude that in good general practice it will be sufficient to allow, for the head, a length of shank equal to 1.6 times the diameter of the rivet. This is the dimension designated by h in Fig. 6. The length of shank to be allowed for filling the hole (which we have already assumed to be ⅛th inch in all cases) is designated by k in the same figure. The *total* projection of the rivet beyond the plates to be joined is also denoted by L; and from what has been said it will be evident that L, which is the sum of h and k, is given by the simple rule:

$$L = 1.6\, d + \tfrac{1}{8},$$

the dimensions being in inches.

For the sake of convenience we have calculated the values of L for various diameters of rivets in actual use, and the results are presented in the accompanying table. The use of the table will be sufficiently evident from one or two examples.

TABLE OF THE PROPER PROJECTIONS OF RIVETS THROUGH THE PLATES TO BE JOINED.
(*i. e.*, Values of L, in Fig. 6.)

Rivet Diameter (Inches).	Projection of Rivet through Plate (Inches).	Rivet Diameter (Inches).	Projection of Rivet through Plate (Inches).	Rivet Diameter (Inches).	Projection of Rivet through Plate (Inches).
$\frac{7}{16}$	$\frac{13}{16}$	$\frac{11}{16}$	$1\frac{1}{4}$	$\frac{15}{16}$	$1\frac{5}{8}$
$\frac{1}{2}$	$\frac{15}{16}$	$\frac{3}{4}$	$1\frac{5}{16}$	1	$1\frac{3}{4}$
$\frac{9}{16}$	1	$\frac{13}{16}$	$1\frac{7}{16}$	$1\frac{1}{8}$	$1\frac{15}{16}$
$\frac{5}{8}$	$1\frac{1}{8}$	$\frac{7}{8}$	$1\frac{1}{2}$	$1\frac{1}{4}$	$2\frac{1}{8}$

Thus suppose that a double-riveted joint was to be made, to unite two plates, each ⅜ths inch thick; and suppose that ⅞ths inch rivets are to be used, driven in $\frac{15}{16}$ths inch holes. The combined thickness of the two plates is ¾ths inch, and the "projection beyond the plates" called for by the table in the case of a rivet of the specified size is 1½ inches. Hence the total length of the rivets used (measured, of course, under the head) should be 1½ + ¾ = 2¼ inches. Again, suppose that a triple-riveted butt strap joint is to be constructed, the rivets being $\frac{15}{16}$ths inch in diameter and the holes 1 inch, and let us suppose that the plates are to be ½ inch thick, and the covering straps $\frac{7}{16}$ths inch, each. Required, the length that the long rivets should have, in order that they may head up properly. In this case the rivets go through one thickness of the plate, and two thicknesses of the covering straps, making a total thickness of ½ + $\frac{7}{16}$ + $\frac{7}{16}$ = 1⅜ inches. By the table, the "projection beyond the plates" is seen to be (for a $\frac{15}{16}$ inch rivet) 1⅝ inches. Hence the total length of the rivets, under the head, should be 1⅜ + 1⅝ = 3 inches.

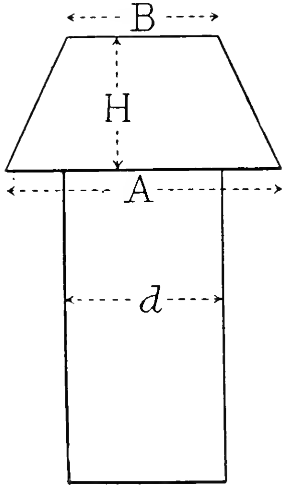


FIG. 7.—ILLUSTRATING A "CONE HEAD."

The formulæ relating to rivet lengths are simple, and are given below for the benefit of those who have to deal with rivet sizes that do not appear in the table. The dimensions of the original rivet being designated by letters, as shown in Figs. 6 and 7, and the diameter of the hole being denoted by D, the area of cross-section of the rivet is 0.7854 d^2, and that of the rivet hole is 0.7854 D^2. The difference of these, 0.7854 $(D^2 - d^2)$, is the sectional area of the space between the rivet and the plate. The volume of this space is found by multiplying the expression just given, by the combined thicknesses of the plates through which the rivet passes; and if we assume, for present purposes, that the rivet is to unite two plates, each of thickness t, as shown in Fig. 6, then the volume of that part of the rivet hole that is not initially filled by the rivet, is easily seen to be equal to $2 \times .7854\ (D^2 - d^2)\ t$. Let us now suppose that to fill this space we have to allow a length k on the shank of the rivet, as indicated in Fig. 6. The volume of metal in this length k is evidently 0.7854 $d^2\ k$, since 0.7854 d^2 is the sectional area of the rivet. Hence we have, as the equation for determining k,

$$2 \times .7854\ (D^2 - d^2)\ t = 0.7854\ d^2 k, \quad \text{or}$$

$$k = \frac{2(D^2 - d^2)\ t}{d^2}.$$

Now $(D^2 - d^2) = (D - d)\ (D + d)$; and if all dimensions are taken in inches, we may set $D - d = \frac{1}{16}$, for all diameters of rivets and all thicknesses of plates. The foregoing expression for k then reduces to

$$k = \frac{(D + d)\ t}{8d^2}.$$

No error of any practical importance will be introduced if we set $D = d$ in this formula; and by so doing we have the simple result

$$k = \frac{t}{4d},$$

where (it must be remembered) k, t, and d are all measured in *inches*. For the practical determination of k it will suffice to consider d as equal to $2t$ in all cases; and this makes $k = \frac{1}{8}$ inch, as stated in the early part of this article.

Passing now to the length of shank (h, in Fig. 6,) that must be allowed for the head, we observe, first, that since the rivet head shown in Fig. 7 is a frustum of a right cone, its volume is given by the formula

$$\text{Volume of head} = \frac{H}{3} \times .7854 \left\{ (A - B)^2 + 3AB \right\}$$

The volume of a length h of the rivet-shank is $0.7854\ d^2h$. Hence we have, upon equating these two expressions and dividing by 0.7854,

$$\frac{H}{3} \left\{ (A - B)^2 + 3AB \right\} = d^2h\,, \quad \text{or}$$

$$h = \frac{H \left\{ (A - B)^2 + 3AB \right\}}{3d^2}$$

If the proportions of the rivet head are as shown in Fig. 4, this formula gives $h = 1.63\ d$, as stated above. If we take for A, B, and H the second set of values given above, we find, similarly, $h = 1.58\ d$, as also stated in the earlier part of this article.

We have confined our remarks to the usual "cone-head" rivet, but the same general principles apply to heads of other shapes, and the allowance for heading up that is given in the present article will be equally satisfactory for any other form of rivet.

Boiler Explosions.

September, 1902.

(250.)—The boiler of a threshing-machine outfit exploded, on September 1st, on Parker's ranch, four miles south of Fort Collins, Colo. John Drager was instantly killed, and Arthur Drager, his 14-year-old son, was seriously injured. The total loss to property is estimated at $1,200.

(251.)—A flue failed, on September 4th, in a boiler in the Traders' Paper Mill at Lockport, N. Y. Nobody was injured, and no great damage was done.

(252.) — The boiler of a traction engine exploded, on September 5th, on William Grant's farm, at Buda, near Sterling, Ill. George Hofler, Frank Johns, and William Myers were killed, and Frederick Miller and Daniel White were seriously injured.

(253.) — A boiler exploded, on September 7th, in Benjamin Cate's rendering works, near Atlantic, Iowa. Half of the boiler was thrown 75 feet into the air, cutting off the top of an elm tree in its passage, and finally burying itself two feet in the ground, some 300 feet from its starting point. The building in which the boiler stood was considerably damaged by the explosion, the property loss being estimated at $2,000. Nobody was injured.

(254.) — On September 8th a tube failed in a boiler at the natatorium at Quincy, Ill. Nobody was near at the time, and the property loss was confined to the boiler.

(255.) — On September 8th the boiler of McDonald & Zimmer's threshing outfit exploded on George Penniman's farm, at Essexville, near Bay City, Mich. David Davidson was injured so badly that he died on the way to the hospital, and Mr. Penniman was painfully scalded.

(256.) — On September 9th the boiler of James McCanna's threshing outfit exploded at Cando, near Grand Forks, N. D. Nobody was injured, but the damage must have been curious and interesting, for our account says that the explosion "blew things seven ways for Sunday."

(257.)—A flue failed, on September 9th, in a boiler at the power plant of the Keokuk Electric Railway and Power company, at Keokuk, Iowa. Nobody was injured.

(258.) — On September 10th a boiler exploded in Niebarger & Hutchinson's sawmill, at Martinsburg, Knox County, Ohio. Nelson Hutchinson and Hart Spicer were instantly killed.

(259.) — A slight explosion about the boiler of the automobile body factory, at Lansing, Mich., on September 12th, caused the plant to shut down temporarily. We have not learned of any personal injuries.

(260.) — Major M. J. Dean was fatally injured, on September 12th, by the explosion of a boiler near Tyler, Tex. Two other men were also painfully but not seriously scalded.

(261.) — On September 13th a boiler exploded in the Cornucopia Lumber company's plant, at Cornucopia, near Ashland, Wis. Fortunately the mill was not running at the time, and but few workmen were about. Two men were slightly scalded.

(262.)—George Lutz was killed, and James J. Dooley and Walter Weber were injured, on September 14th, by the explosion of the boiler of a Pennsylvania railroad freight engine in the Bergen cut, Jersey City, N. J. The accident was due to the failure of the crown sheet. The locomotive was a Baldwin mogul, and had been in service only about three months.

(263.) — A boiler exploded, on September 15th, in a sawmill some seven miles east of Warroad, Minn. William Walker and William Smith were seriously injured, and at last accounts it was reported that the former could not live.

(264.) — William Bailey and Thomas B. Sitton were instantly killed, on September 15th, by the explosion of a boiler in Tremont Grant's sawmill, at Maxwell, five miles north of Greenfield, Ind. Tremont Grant, Roy Sitton, and Philander Cooper, were also painfully injured. The mill was totally demolished, and several buildings in the vicinity were damaged, by the explosion.

(265.)—A boiler exploded, on September 16th, in the F. Dickson elevator, at Whiteland, near Franklin, Ind. The boiler-room and machinery were completely destroyed, but the engineer had gone into the main mill a few minutes before the explosion, and nobody was injured.

(266.)—The boiler of a threshing-machine outfit, belonging to S. C. Hasseltine, exploded, on September 16th, near Hamilton, N. D. A. J. Hasseltine was severely scalded about the head and face.

(267.)—The Royal Blue Flyer, a fast express train on the Baltimore & Ohio Southwestern railroad, was wrecked, on September 18th, at Leesburg, near Chillicothe, Ohio, by running into an open switch at a speed of fifty miles an hour. To add to the disaster, the boiler of the locomotive exploded, and engineer Philip Roe and fireman Charles Studer were instantly killed.

(268.)—The boiler of a traction engine exploded, on September 19th, at Wales Center, four miles east of East Aurora, N. Y. Alfred Scott, John Baker, Michael Baker, William Higgins, and Perry Minton were badly injured. Fire resulted from the explosion, and the total property loss was about $10,000.

(269.)—A flue burst, on September 19th, in a water tube boiler at the Suburban Electric Light Company's plant, on Murray Street, Elizabeth, N. J. Chief engineer John W. Hewman, assistant engineer Benjamin Wilcox, and fireman George Colliard, and Joseph Gibson were burned and scalded.

(270.)—A boiler exploded, on September 20th, in Glasser's tannery, at Mendota, Va. The building was partially wrecked, but nobody was injured.

(271.)—A boiler, used in making sorghum molasses, exploded, on September 20th, on Heideman Bros.' farm, four miles southwest of Decatur, Ind. Nobody was injured, as the hands were all at breakfast at the time.

(272.)—On September 21st a boiler exploded in an oil pumping station at Tenth Street and Norwood Avenue, Marion, Ind. The boiler passed in a southeasterly direction, over an entire block, falling in Eleventh Street. It belonged to the Stubler-Siederman Oil Company. Nobody was injured.

(273.)—The boiler of a locomotive on the Southern Pacific Railroad exploded, on September 21st, between Ravenna and Acton, Cal. Fireman Harry R. Swan was instantly killed, and engineer William E. Love was injured so badly that he died two hours later.

(274.)—On September 22d a boiler exploded in the Denmark Colored Joint Stock Gin Company's plant, at Denmark, near Jackson, Tenn. The boiler was new, having just been delivered by the builders; and it is said that there were indications that gunpowder or some similar explosive was used to destroy it, by some person who desired to wind up the affairs of the Colored Joint Stock Company, and the Colored Joint Stock Company itself, in one operation. But we have so often heard this theory advanced, even when the explosion was certainly due to steam, that we must be pardoned for including this accident in our list of boiler explosions until further evidence is produced to show that it should be excluded.

(275.)—A boiler exploded, on September 22d, at Parkbeg, N. W. T. We have not learned further particulars.

(276.)—The boiler of locomotive No. 1101, on the Denver & Rio Grande Railroad, exploded, on September 23d, at Monument, Colo. Engineer George M. Andrews was instantly killed, and fireman Thomas Philbin was injured so badly that he lived less than an hour. The locomotive was damaged to the extent of about $2,000.

(277.)—On September 24th a boiler exploded in the flax fiber mill at Spring Valley, Minn., completely wrecking the boiler house. Engineer Jerome Stevens was buried in the wreckage, but escaped with a few bruises.

(278.)—On September 24th the boiler of Horace Wheeler's threshing outfit exploded, about twenty-five miles northwest of Sioux Falls, S. D. Engineer John McDonald was severely scalded. Frank Wheeler also received a slight scald.

(279.)—J. J. Sproule was severely scalded, on September 25th, by the explosion of a threshing machine boiler, at Orangeville, Can.

(280.)—On September 26th a boiler exploded in Edward Waggoner's sawmill, four miles from Roan Mountain, Carter county, Tenn. Nine men were injured, and at last accounts it was thought that two of these would not recover.

(281.)—An oil well boiler exploded, on September 29th, on the Yeager farm, at St. Joseph, Marshall county, W. Va. Theodore Eschelman was seriously but not fatally injured.

(282.)—On September 30th a boiler exploded in Jesse Kincheloe's sawmill, at Hays, Ky. Jesse Kincheloe, Carlton Kincheloe, Allen Schackelford, James Crumpton, and Jesse Crumpton were killed, and Kemp Hendricks was badly injured. The boiler was thrown about 70 yards, cutting off a number of maple trees in its course.

Inspectors' Reports.

JULY, 1902.

During this month our inspectors made 11,684 inspection trips, visited 19,397 boilers, inspected 11,180 both internally and externally, and subjected 1,052 to hydrostatic pressure. The whole number of defects reported reached 14,769, of which 1,129 were considered dangerous; 83 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,394	67
Cases of incrustation and scale,	3,895	72
Cases of internal grooving,	371	21
Cases of internal corrosion,	1,574	62
Cases of external corrosion,	1,028	50
Broken or loose braces and stays,	185	48
Settings defective,	441	37
Furnaces out of shape,	623	28
Fractured plates,	384	53
Burned plates,	495	36
Blistered plates,	170	4

Nature of Defects.	Whole Number.	Dangerous.
Cases of defective riveting,	388	99
Defective heads,	149	15
Serious leakage around tube ends,	1,704	231
Serious leakage at seams,	497	27
Defective water-gauges,	288	71
Defective blow-offs,	268	87
Cases of deficiency of water,	17	7
Safety-valves overloaded,	111	18
Safety-valves defective in construction,	68	17
Pressure-gauges defective,	660	38
Boilers without pressure-gauges,	35	35
Unclassified defects,	24	6
Total,	14,769	1,129

August, 1902.

During this month our inspectors made 11,201 inspection trips, visited 21,058 boilers, inspected 9,653 both internally and externally, and subjected 1,103 to hydrostatic pressure. The whole number of defects reported reached 12,942, of which 1,091 were considered dangerous; 80 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,320	68
Cases of incrustation and scale,	3,233	74
Cases of internal grooving,	207	19
Cases of internal corrosion,	1,206	49
Cases of external corrosion,	762	65
Broken or loose braces and stays,	155	36
Settings defective,	385	33
Furnaces out of shape,	492	16
Fractured plates,	238	46
Burned plates,	457	43
Blistered plates,	113	8
Cases of defective riveting,	399	25
Defective heads,	154	30
Serious leakage around tube ends,	1,909	289
Serious leakage at seams,	595	25
Defective water-gauges,	259	57
Defective blow-offs,	294	78
Cases of deficiency of water,	12	4
Safety-valves overloaded,	160	45
Safety-valves defective in construction,	71	23
Pressure-gauges defective,	491	34
Boilers without pressure-gauges,	20	20
Unclassified defects,	10	4
Total,	12,942	1,091

The Locomotive.

HARTFORD, FEBRUARY 15, 1903.

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

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The Onondaga Devilfish.

About the first part of last December a zoölogical "find" was made in Onondaga Lake, up in New York State. The "find" was nothing less than a couple of genuine squid (popularly known as devilfish), which are supposed to inhabit only the salt water of the ocean and its branches. The first specimen was caught by a citizen of Syracuse, N. Y., named Terry, while fishing for minnows with a net in shallow water. The second one was found by a restaurant keeper named Lang, near the same place. It is said that both of the creatures were alive when captured. Professor John D. Wilson, a teacher of science in Syracuse, took a very considerable interest in these specimens, and he states that they were found close to the spot where the first salt springs were discovered in the Syracuse region. It is quite possible that the deeper part of the lake in this vicinity is decidedly salt, and it has been suggested that if the whole matter is a hoax, the joker showed considerable acuteness in selecting Onondaga Lake, rather than some other lake in which we could not suppose any salty water to exist. A third specimen is reputed to have been found in the same neighborhood, but this "find" has not been so well substantiated. A bit of testimony, apparently corroborative of the existence of squid in Onondaga Lake, is given, in *Science*, by Mr. John M. Clarke. He quotes from a letter received from Mr. J. M. Scott, a teacher of sloyd in the Syracuse public schools, as follows: "Some twelve or thirteen years ago a number of boys, of whom I was one, were fishing just to the left of the outlet, and had a small scoop net for catching crabs and minnows. Another lad and myself went ashore, and in fooling around in the mud near the shore, looking for crabs, I saw something queer and got it in the net. We took it to an old man who claimed to be a sailor, and he told us it was a squid. Not knowing it to be of any value, we amused ourselves with it awhile, and left it in the water after having killed it. I have since thought it was a queer find."

One of the squid recently found was carefully examined by Professor A. E. Ortmann, of Princeton University, who is an expert in these matters. He reports that while the specimen had been roughly handled, and somewhat mutilated, before reaching him, he had no doubt whatever but that it is practically identical with the squid known to science as *Illex illecebrosus*, which occurs abundantly on the Atlantic shore, from Cape Cod to Newfoundland. He adds that if it is indeed a fact that the species lives in Onondaga Lake, the only explanation is that it has survived from a time when this Lake was connected with the St. Lawrence Gulf. He is loath to believe that the species actually does live in Onondaga Lake, however, and he makes the suggestion that as squid are used for bait in fishing, these specimens may have escaped from some fisherman's bait supply. For our own part, we confess that this explanation looks almost as improbable as the one it was designed to supplant; for while squid are used for ocean fishing, we think they would hardly be carried as far inland as Lake Onondaga, and furthermore, the experience of Mr. Scott would seem to negative the bait theory altogether.

Of course there is always the possibility that a thing of this kind is merely a hoax; and if it be thought that the evidence submitted in the present case is too circumstantial to be the work of a practical joker, we would merely say that within three years, and within fifty miles of Lake Onondaga, a remarkable story about a serpent being seen in Seneca Lake was offered to the public, accompanied by the most detailed information as to the creature itself, and a list of well known and responsible citizens of Geneva, who were said to be willing to certify to the "facts" as stated, but who, when approached, emphatically declined to do so. We printed this previous story in the issue of The Locomotive for September, 1900, where we took pleasure in acknowledging it to be a "masterpiece of circumstantial mendacity." We do not question the good faith of anybody in particular, but in the light of previous experience from this part of the country we should like to see some more squid produced from the open lake, before we dismiss the hoax hypothesis entirely.

The Pacific Cable.

The laying of an ocean cable is now so common an occurrence that it usually excites no particular interest; but surely the laying of a cable from the United States to the Hawaiian Islands, over an ocean bottom previously a stranger to such exploits, is an event of sufficient importance and significance to merit more than a perfunctory notice.

The Pacific cable now in operation was laid by the Commercial Pacific Cable Company, which is incorporated under the laws of the state of New York. The American shore end of it was laid on Sunday, December 14th, at Ocean Beach, near San Francisco, in the presence of thousands of spectators, among whom were President Clarence Mackay and other officers of the cable company, Governor Gage of California, and Mayor Schmitz of San Francisco. Governor Gage delivered an address, and his little daughter Lucille christened the splicing of the deep sea cable to the shore end. The cable steamer *Silvertown* then started on her way to Honolulu, paying out the cable as she went. She exchanged frequent messages with the American shore as she progressed, and after a gallant fight with the elements, she successfully landed the shore end of the cable at Honolulu on January 1st, the final through connection being made on that date at 8:43 p. m., Honolulu time. Previously to the final splicing of the deep sea length to the Honolulu shore end, the *Silvertown* had requested the operators at the American end to cease sending messages until a certain specified moment, in order that the splice might have time to harden, and all chances of electrical injury be avoided. The American operators waited with what patience they could command, but it is recorded that the suspense was such that they cut the time short by about ten minutes; and we have a suspicion that the experts on the *Silvertown* had made due allowance for a slight irregularity of this sort.

The *Electrical World* of January 10th gives a few of the first messages that were transmitted, which we print below:

HONOLULU, January 1, 1903.

THE PRESIDENT, Washington:

The people of the Territory of Hawaii send their greetings to you, and express their gratification at the inauguration of telegraph communication with the mainland. We all believe that the removal of the disadvantage of isolation will prove a strong factor in the upbuilding of a patriotic and progressive American Commonwealth in these islands.

HENRY E. COOPER,
Secretary of Hawaii.

The President's response was as follows:

White House, Washington, January 2, 1903.

HENRY E. COOPER, Secretary of Hawaii, Honolulu, Hawaii:

The President sends through you to Governor Dole and the people of Hawaii his hearty congratulations upon the opening of the cable. He believes that it will tend to knit the people of Hawaii more closely than ever to their fellow-citizens of the mainland, and will be for the great advantage of all our people.

GEORGE CORTELYOU,
Secretary to the President.

The following messages of congratulation were also sent to the officers of the cable company:

MR. CLARENCE H. MACKAY, President, New York:

We send this token of our high appreciation of the completion of the great enterprise undertaken by your company of laying a telegraphic cable from the coast of California to these islands. Mingled with our joy there is a feeling of deep regret that John W. Mackay did not live to see the completion of his project, and we assure you that his name will ever be cherished in fond remembrance by our people.

HENRY E. COOPER,
Secretary of Hawaii.

MR. GEO. G. WARD, Vice-President and General Manager, New York:

To your untiring efforts Hawaii is indebted for an early consummation of the enterprise that means untold advantages to all her interests, and we tender our hearty New Year greetings and trust that the final completion of the entire project will be to your full satisfaction.

HENRY E. COOPER,
Secretary of Hawaii.

The cable was opened for general business on Monday, January 5th. The "entire project" referred to in the message to Mr. Ward, is the extension of the line to Manila and Shanghai.

Vice-President Ward said: "It is a particular satisfaction to us to have the cable completed on the first day of the new year, because it fulfils our promise to Congress. Rapid progress is being made in the manufacture of the sections to be laid between Honolulu and Manila, and over 3,500 miles of this cable have already been manufactured, and I fully expect that messages will be exchanged with Manila by July 4th next. The laying of the remaining sections will commence from Manila the first week in May next."

Competition Among American Colleges.

Our American system of higher education is evangelistic in character. Our institutions (at least in the last generation) have never been satisfied with merely offering their facilities to the public, content to let those who wished such opportunities avail themselves of them. They have gone forth into the community in one form or another, and preached the gospel of a higher education; they have gone out into the highways and hedges and compelled guests to come to the feast which has been prepared for them. They have all engaged in this form of university extension work, and the result is seen in the ever-rising tide of university attendance. This campaign for higher education (we can really call it nothing else) takes on different forms in different parts of the country. The president of a small college not a thousand miles from Chicago told me of a missionary tour he made one summer which doubled the attendance at his college. He hired a large covered wagon and a strong team of horses for three months. He loaded in his college glee club and a few cooking utensils and started across a section of country from which, as far as he could learn, no candidates for any college had ever emerged. He would drive into a village, tether his horses, making arrangements for food and drink, and begin his campaign. The glee club would sing a series of all-compelling college songs on the space in front of the wagon, or on the village green. After a suitable crowd had gathered, the president would deliver an address on the desirability of a higher education. This would be followed up by a meeting in the church or churches, by an address before the town schools, and by such other similar public meetings as suggested themselves. Before he was through with his three days' campaign, the whole town was as excited on the subject of colleges and universities and higher education as it was in the habit of becoming only over politics and religion.

This may be a somewhat crude form of preaching the gospel of higher culture, though it was certainly effective. It is the salvation army plan of getting into the educational depths. The greater institutions have pursued more subtle methods, often with even greater effect. The building up of great alumni associations with one of their chief objects the increase of attendance at alma mater; the publication of alumni magazines and semi-scientific periodicals of various kinds: the sending out of news letters to the press, the organization of university extension work in all its various forms; the trips of the college associations like glee clubs, football elevens, and base-ball nines; intercollegiate debates; the annual tours of university presidents through the country; the offering of scholarships and fellowships; — these, and other similar devices, all contribute to the same end of popularizing the university, and of accomplishing by different methods, and methods more consonant with our American life, the same end of bringing large numbers of persons in contact with higher education, as the compulsory methods of European countries do for them.

Some critically inclined persons have called this evangelistic work by the cruel term of "advertising," have denounced it as unworthy of the institutions and the educational policy of a great country, and have referred in scathing terms to the strenuous competition of our universities and colleges for students. Such a conception fails to grasp the vital elements in the situation. The whole movement has undoubtedly assumed the form of a strenuous competition. It would, of course, be easy for such a strife to degenerate, and to assume a ruinous and destructive form; but the actual fact is the contrary. Our institutions have competed with one another in improving their facilities, striving to see which one could offer the best libraries; the best laboratories; the most learned and skillful teachers; the best opportunities for physical culture; the best chance for an all-around, well-developed manhood and womanhood. And the story of advance along this line is marvelous. They have competed with one another in raising their standards of admission and their requirements for graduation, until many of our able educators think that this progress has already gone too far, and that we are making unreasonable requirements for admission to college, for graduation from college, for admission to graduate work, and for the higher degrees. — From the *Inaugural Address* of President EDMUND J. JAMES, of Northwestern University.

Sleepy Grass.

Professor Vernon Bailey tells, in *Science*, of an experience that he had with the so-called "sleepy grass" that grows in and near the Pecos Valley, New Mexico.

We had made camp one evening (he says) in a beautiful park, bordered with spruces and firs, and covered with tall grass that, with its green base leaves, and ripe heads loaded with heavy rye-like grain, offered a tempting feast to our hungry animals. The moment saddles and harness were off, the horses were eagerly feeding. A few minutes later a passing ranchman stopped his team and called over to us, "Look out there! Your horses are getting sleepy grass," and added, "If they get a good feed of that grass you will not get out of here for a week." We were not prepared to spend a week in that locality, but I was anxious to test the grass, so we let the horses feed for half an hour and then brought them up for their oats and picketed them on some short grass on a side hill well out of reach of the sleepy grass.

The following morning just after sunrise the cook called my attention to the attitude of one of the team horses, saying that there was "sure something the matter with old Joe." The horse was standing on the side hill, asleep, his feet braced wide apart, his head high in the air, both ears and the under lip dropped, a most ridiculous picture of profound slumber. The other horses apparently had not eaten as much of the grass as old Joe, for they were merely dozing in the morning sun, and showed signs of life in an occasional shake of the head or switch of the tail. At breakfast time the others woke up to a keen interest in their oats, but old Joe, after being dragged to camp much against his will, preferred to sleep rather than eat, and after pulling back on his rope all the way down to the spring, refused to drink or even to lower his head to the water. My little saddle mare showed the least signs of the general stupor, so, dropping behind with her, I woke the others up pretty thoroughly and brought them into camp on a lope. Later, when in the harness, the team traveled along steadily with some urging, but when we reached Cloudcroft and left the horses in front of the store while getting supplies, their heads dropped, and for an hour they slept soundly. Even my nervy little mare did not move from her tracks, but stood with drooping ears, paying no attention to the unusual surroundings and stir of a town. On starting again the saddle horses responded to the spurs with worried switches of the tail, quite different from their usual manner, while the team paid no greater attention to the whip. For the rest of the day our progress was slow, notwithstanding which fact (as the driver pointed out) the team, and especially old Joe, were sweating profusely. Our saddle horses would sigh with relief when allowed to stop for a moment, and we had many a good laugh at the flapping ears of my companion's horse — a large-eared, raw-boned cayuse, which seemed to have lost all control of its usually erect ears.

That night we camped in another park-like valley where sleepy grass was abundant, but took care to picket the horses out of reach of it. They were hungry, and all began to feed eagerly, but old Joe soon stopped, braced his feet, and relaxed into forgetful slumber. The next morning when we went to bring them in for their grain all were fast asleep. The stupor lasted about three days, and was too evident and unusual to be attributed to weariness or natural indisposition. We were making easy trips, and the horses were in good condition. After it wore off they showed their usual spirit and energy, as well as appetite. The only after-effect was a gaunt appearance, apparently resulting from lack of energy to get their usual amount of grass. Old Joe had even refused his grain for about half the time.

It should be remembered that our horses had but a small amount of the grass. The ranchman told us that other travelers coming into the country had been obliged to camp for a week while their horses slept off the effect of a good feed of it; and while its effects usually lasted for a week or ten days, it did no more serious damage than to leave the animals thin from fasting. Stories were told of horses being lost in the mountains and found several days later, fast asleep in the bushes near the camp.

I have offered no real proof that this particular species of grass is what affected our horses. They undoubtedly ate a dozen other species of grass, as well as some other plants, every day while we were in the mountains. But after our experience I am inclined to give credit to the uniform statements of the ranchmen in regard to it. They all agree on the species, on its effects, and to the fact that after one good dose of sleepy grass horses will never touch it again. This latter statement has ample proof. Horses and cattle are ranging in many of the valleys where it grows in abundance, untouched and full of ripe seed, while the other grasses are cropped close all around it. I did not see horses or cattle touch it except in the case of our own animals and the team of another traveler from the valley, all of which ate it eagerly. They ate both the base leaves and the heads that were full of ripe seeds. I shelled out and ate a handful of the seeds, but without noticeable effect. The ranch men generally agree that it is the leaves which produce the sleepiness. I did not hear that cattle were affected by it, but they certainly avoid it, for many were grazing near where it stood untouched.

While this experience was new to me, I find that sleepy grass has long been known to botanists as such, or technically as *Stipa vaseyi*. Something has been known of its effects on horses, but apparently its chemical properties have not yet been determined.

According to the *Popular Science Monthly*, it is probable that the Nobel prizes for this year will be awarded as follows: In chemistry, to Professor Emil Fischer, of Berlin; in physics, to Professor S. A. Arrhenius, of Stockholm; in medicine, to Professor Niels F. Finsen, of Copenhagen, and to Major Ronald Ross, of Liverpool. The value of these prizes, it will be remembered, is about $40,000 each.

The Locomotive

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Re-Enforcing Blow-Off Pipes.

The blow-off pipe appears to be one of the simplest things about a boiler, and it might naturally be assumed that of all the accessories and fittings it would be the least liable to get out of order. This is not the case, however, and the blow-off needs its full share of attention, in design, construction, and general care. We have discussed many phases of the blow-off question in previous issues of The Locomotive, but there is more to be said, and in the present article we desire to call attention to the subject of re-enforcing the opening through which the pipe enters the boiler. A piece of boiler plate, somewhat thicker than the shell of the boiler itself, should be riveted securely to the shell at this point, and

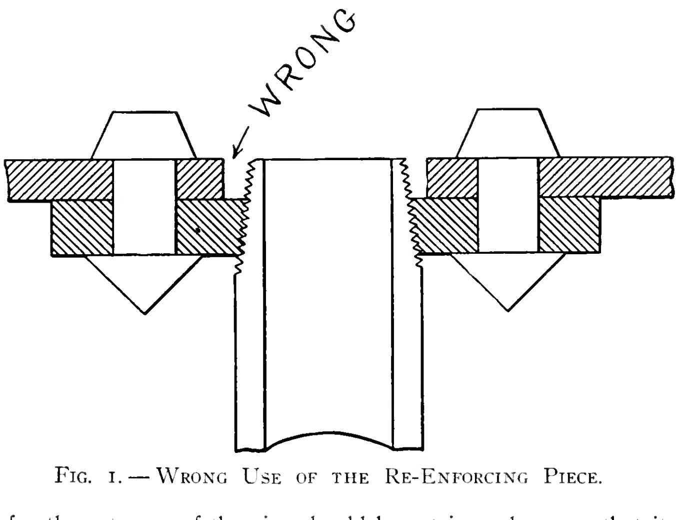

Fig. 1. — Wrong Use of the Re-Enforcing Piece.

the hole for the entrance of the pipe should be cut in such a way that it can be properly threaded, both in the re-enforcing piece *and in the shell.* The importance of the italicized words is often overlooked by boiler constructors, and we frequently find that the opening in the shell is punched large enough to admit the end of the blow-off pipe and leave considerable free space around it, as is indicated in Fig. 1. The re-enforcing plate is then threaded, and the blow-off pipe screwed into that alone. When a job is done in this manner, it is impossible to detect the error from the outside of the boiler, although it is readily discovered by examining the inner end of the blow-off through the handhole in the back head, except when the hole in the shell is made small enough to fit the end of the blow-off closely, without engaging its threads.

We have repeatedly seen blow-off pipes put in in the manner indicated in Fig. 1, with not more than three threads holding in the re-enforcing piece. The object of the re-enforcing piece is not particularly to strengthen the small hole that is made in the shell, but to provide a greater thickness of metal for the thread, so that when the pipe is screwed into position it may have a suitable holding power. The correct mode of construction is shown in Fig. 2. In this case the hole is threaded both in the re-enforcing plate and in the shell, and when the blow-off pipe is screwed into position, a good, strong joint is formed, which should be entirely safe under all ordinary conditions of operation.

Many serious accidents have resulted from the adoption of the faulty construction shown in Fig. 1. It is not much more work to make the connection as shown in Fig. 2, and no job that is done as shown in Fig. 1 ought to be accepted.

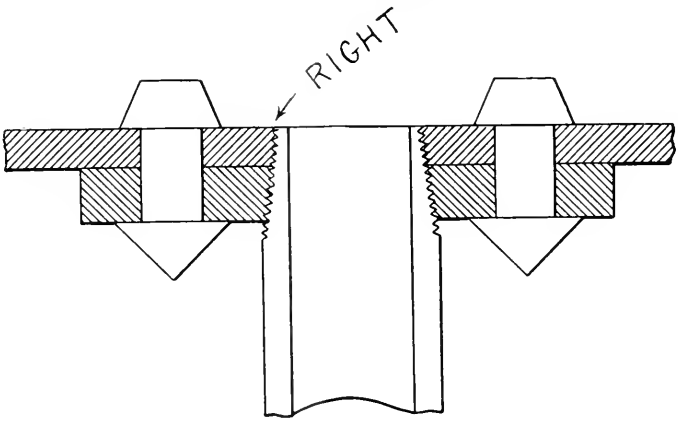

FIG. 2 — CORRECT USE OF RE-ENFORCING PIECE.

Inspectors' Report.

SEPTEMBER, 1902.

During this month our inspectors made 10,884 inspection trips, visited 21,245 boilers, inspected 8,846 both internally and externally, and subjected 1,005 to hydrostatic pressure. The whole number of defects reported reached 11,966, of which 1,056 were considered dangerous; 91 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,139	47
Cases of incrustation and scale,	3,150	92
Cases of internal grooving,	171	19
Cases of internal corrosion,	1,009	48
Cases of external corrosion,	710	69
Broken or loose braces and stays,	227	44
Settings defective,	348	39
Furnaces out of shape,	438	16
Fractured plates,	275	54

Nature of Defects.	Whole Number.	Dangerous.
Burned plates,	363	41
Blistered plates,	128	7
Cases of defective riveting,	439	33
Defective heads,	106	32
Serious leakage around tube ends,	1,844	181
Serious leakage at seams,	352	22
Defective water-gauges,	300	59
Defective blow-offs,	239	85
Cases of deficiency of water,	16	8
Safety-valves overloaded,	122	61
Safety-valves defective in construction,	114	39
Pressure-gauges defective,	436	26
Boilers without pressure-gauges,	30	30
Unclassified defects,	10	4
Total,	11,966	1,056

Boiler Explosions.

October, 1902.

(283.) — On October 2d a boiler exploded in the Lewis mill, at Roosevelt, seven miles east of Warroad, Minn. William Walker was killed, and William Smith was severely injured. The building and machinery were totally wrecked.

(284.) — A small upright boiler, in use in a fertilizer factory near Troy, Ala., exploded on October 2d. T. W. Powell was seriously injured, but no great damage was done.

(285.) — A boiler exploded on October 2d, in the No. 3 Mill of the Greentown Tile Works, Greentown, Ohio. William Carl and George Schlithley were scalded so badly that they died within a short time.

(286.) — A boiler exploded on October 2d, in the United Barium Company's plant, on Buffalo Avenue, Niagara Falls, N. Y. Albert J. Fyfe was instantly killed. The account that we received indicates that the boiler was of the sectional type, and that the accident consisted in the blowing out of the manhole plate, while Fyfe was in the act of tightening some of the bolts. We have frequently called attention to the danger of tightening bolts, or of doing other work of this sort about any kind of a boiler or steampipe, while pressure is on; but the lesson appears to be a hard one to learn, and many men, like the unfortunate Mr. Fyfe, have been victims of this folly.

(287.) — On October 4th a boiler exploded at an oil pumping station at West Marion, Ind. The boiler was thrown through the air to a distance of about one hundred yards, landing on the tracks of the Belt railroad. Nobody was injured.

(288.) — A boiler exploded, on October 4th, in the power house of the Electric Light Co., at Dublin, Ga. We have not learned of any personal injuries.

(289.) — A boiler exploded, on October 6th, in a sawmill at Warwick, near Danville, Va. An unknown man, who worked about the place, was scalded to death.

(290.) — On October 6th the boiler of freight engine No. 298, of the Short Line railroad, exploded at Bard, five miles east of New Martinsville, W. Va. Engineer William Ronan, Fireman Henry Knight, Conductor Owens, and Brakeman Chas. Capel were seriously injured. The locomotive was badly wrecked, and the track was torn up for thirty yards.

(291.) — A boiler exploded, in the Jones Laundry Company's establishment, at Creston, Iowa, on October 7th. Fortunately nobody was seriously injured, although the building was badly damaged. The boiler passed at least one hundred feet into the air, and came down through the roof of Merchants' block, several hundred feet from its starting place.

(292.) — On October 7th the boiler of locomotive No. 255, on the Lehigh Valley railroad, exploded at Freeville Junction, near Auburn, N. Y. Nobody was injured. The explosion consisted in the blowing off of the steam dome.

(293.) — On October 7th a boiler exploded in W. R. Bryan's sawmill, at Salters Depot, Williamsburg county, S. C. Nobody was injured. (See No. 298, below.)

(294.) — A boiler exploded, on October 7th, in George Short's grist mill at Yatesville, seven miles from Louisa, near Ashland, Ky. Adelbert Muncy was injured so badly that it is doubtful if he recovers. Several other persons, including the proprietor and his son, were severely scalded and otherwise injured. The boiler and a part of the other machinery were thrown through the roof of the mill.

(295.) — On October 8th a boiler exploded in Day & Hammersley's flouring mill, at Aberfoyle, near Guelph, Ont. The building was damaged to the extent of about $1,000, but nobody was injured.

(296.) — The boiler of a threshing outfit exploded, on October 9th, on James Morgan's farm, four miles southeast of Waukesha, Wis. Frederick Stigler was badly injured, and several others were injured slightly by flying débris.

(297.) — On October 9th a boiler exploded in the Lewisburg Coal and Coke Company's mines, at Mary Lee, Ala. Nobody was killed, but two men were injured. We have seen no estimate of the property loss.

(298.) — A boiler exploded, on October 10th, in James Bryan's mill at Trio, near Kingstree, S. C. Isaac Brockinton and Henry Dece were instantly killed, and Levine Sevinton was severely injured. The building was completely wrecked. This is the second boiler explosion in Williamsburg county within a week; the previous one being No. 293, above.

(299.) — On October 10th the boiler of the towboat *Lydia Van Sant* exploded near Davenport, Iowa. Nobody was injured, though the boat was considerably damaged.

(300.) — On October 11th a slight boiler explosion occurred in Powell and Cooper's sawmill, three and one-half miles south of Arcadia, Ohio. The mill was wrecked, but nobody was injured.

(301.) — On October 11th a boiler explosion occurred at Pillager, near Brainerd, Minn. Engineer Ellison was seriously injured.

(302.) — A boiler exploded, on October 12th, on a small launch owned by John Cummings, of Ithaca, N. Y. The launch was new, and had already been taken on a trial trip on Lake Cayuga. Later in the day, when about to start on a pleasure excursion, the boiler of the launch exploded, severely injuring John and William Cummings, and Scott Cross.

(303.) — A heating boiler exploded, on October 13th, in the Matthews building, at Milwaukee, Wis., causing a panic among the pupils of McDonald's business college, and other occupants of the building. Nobody was injured, and the property loss was confined chiefly to the boiler room.

(304.) — On October 14th a boiler exploded at the power station of the Connecticut Railway and Lighting Company, New Britain, Conn. Chas. W. Williams and Michael Scanlon were fearfully scalded, so that they died on the following day. The boiler was of the sectional type, and the accident consisted in the pulling out of the main steam pipe from a flange, where it was secured to the boiler. The boiler was allowed to carry 135 lbs. of steam, and there is no evidence that this pressure was exceeded.

(305.) — The boiler of a traction engine, owned by Mr. John Davis, exploded, on October 15th, near Galena, Ill. Mr. Davis was hurled more than a hundred feet, and injured so that he died a few hours later.

(306.) — On the 18th of October, a boiler used in sinking an oil well exploded on the John Marshall place, near Galveston, Texas. Professor George Quigley, John Larsen, A. E. Bush, and Mrs. John Marshall were seriously injured.

(307.) — A boiler exploded, on October 19th, on the tugboat *Frederick Nellis,* near Mound City, Ark. William Phillips and Mrs. Josie Hill were killed, William Gillem was fatally injured, and Thomas Manning, Frank Hill, and Captain Thomas Ledger were painfully scalded. The upper deck of the boat was wrecked.

(308.) — On October 21st the boiler of locomotive No. 1521, on the Coast division of the Southern Pacific Railroad, exploded at Surf, Santa Barbara county, Cal. The explosion consisted in the failure of the crown sheet. Fireman Richardson was badly injured, and may die. Two other members of the crew were also burned and scalded.

(309.) — Casper Krantz, a boiler worker on the Pennsylvania Railroad, was working under a locomotive at Fort Wayne, Ind., on October 22d, when an explosion occurred, scalding him so severely that he cannot recover.

(310.) — On October 24th a boiler exploded in the slaughter house of Dennison, Karg & Schlee, at Findlay, Ohio. The building was partially wrecked, but nobody was injured.

(311.) — The boiler of a threshing outfit exploded, on October 24th, at Cottonwood, Minn., fatally injuring Theodore Dahl and Carl Holt. Mason Tompkins and Nelson Colgren were also badly injured, though it was thought, at last accounts, that they would recover.

(312.) — A boiler exploded, on October 24th, in Franklin & Rhodes' shingle mill, five miles east of Warren, Ark. Two workmen were fatally injured, and two others were injured less severely. The mill was completely wrecked.

(313.) — The boiler of a mogul locomotive exploded, on October 25th, on the Chicago & Alton railroad, at Mount Washington, near Independence, Mo.

Fireman H. M. Rhodes was instantly killed, and Engineer John Connelly was injured so badly that he died within a short time.

(314.) — On October 27th the boiler of a locomotive exploded at Oklahoma City, Okla. Fireman Managhan was badly hurt. It is said that fragments of the locomotive were blown to a distance of a mile.

(315.) — A boiler exploded, on October 27th, in the Bingham cotton ginnery, at Talladega, Ala. The boiler house, which was a heavy, concrete structure, was wrecked, and the neighboring plant of the Talladega Oil Mills was also damaged. Seven persons were seriously injured, including Mrs. James Limbaugh and her little son, who were passing the ginnery at the time of the explosion.

(316.) — On October 28th a heating boiler in the Taylor Inn, at Lodi, Ohio, exploded, but without doing any great damage, so far as we have learned.

(317.) — A heating boiler exploded, on October 29th, in the Park Hotel, at Oberlin, Ohio. Nobody was injured, and the damage was slight.

(318.) — The boiler of a logging locomotive exploded, on October 31st, near Swainsboro, Ga. Engineer Green Underwood and two other men were killed, and four persons were also injured so badly that at last accounts it was thought that they would die. The locomotive was torn to pieces.

(319.) — On October 31st a flue failed in a boiler at Kelley's mill, at Ironton, Ohio. Three men were slightly injured. Some of the boiler stacks were thrown down, and the boiler house was partially wrecked.

Steel Frames and Corrosion.

In the minds of a great many people the impression is firmly implanted that the steel frame in modern architecture is a temporary and makeshift expedient; that it will continue in use until a "skyscraper" collapses in a pile of rubbish and a cloud of dust, and that one such calamity, resulting from the unsuspected corrosion of the metal, will end the life of the present type of business building by compelling a return to the materials in use before the advent of architectural shapes in rolled steel. That there is absolutely nothing on which to base such a prognosis of change in architectural methods does not unsettle the popular conviction that the forces are at work which will compel it.

Until a few weeks ago there stood on part of the site of the Times Building, to be erected on the block bounded by Broadway, Forty-second Street, Seventh Avenue, and Forty-third Street, a building of the steel-frame construction. It was popularly known as the Pabst Building, and was a conspicuous feature of Upper Broadway. So far as we are aware, it was the first of the steel-frame structures of the distinctly modern type to be demolished. It did not stand long enough to afford a basis for safe generalizations, but considering the fact that it was poorly built of generally inferior materials, and that in its construction many of the precautions deemed essential in good practice were neglected, the vicissitudes of its four years of life were probably as great as need have been experienced in twenty-five had the architect been insistent upon a rigid observance of specifications and the builders more careful in guarding against the beginnings of corrosion in the members of the frame exposed to the weather. Generally speaking, the building was of fireproof construction, framed with Z-bar columns, with the walls supported at each story. The basement floor and sidewalk beams and girders were supported on cast-iron columns resting directly on the rock. All the steel columns were supported on cast-iron bases, resting on rock, with the exception of the north wall columns, which were supported on grillage beams resting on rock. According to the specifications the steel-work was to be thoroughly cleaned of scale, rust, and dirt before leaving the shop, and given a coat of boiled linseed oil worked into all joints and open spaces. All pins, pin-holes, and machined surfaces were to be coated with white lead and tallow, and in riveted work the contact surfaces were to be painted before joining. Pieces not accessible after erection were to receive two coats of paint before erection. After erection all steelwork was to have one good coat of linseed oil paint. Grillage beams were to be coated with asphalt before setting in place. There is reason to believe that these specifications were not strictly followed. The steel-work was run up in winter, work was delayed by severe weather and heavy snow, and part of the time the masons pushed the framers so hard that painting was generally neglected or done in a perfunctory way. Construction was begun in October, 1898, and was finished in one year. Demolition began in November, 1902, and the steel frame was taken apart a month later.

So far as may be judged from the most careful and critical study of the structural members as they were taken apart, no other corrosion of consequence existed than had begun before the building was covered in. The only places where it had developed in measurable quantity was behind the splice plates of the column connections in the fifth story. A few column splices in the other stories indicated a slight tendency to rust, but not enough to cause any uneasiness. That in the fifth story was probably due to negligence on the part of the builder. Photographs taken coincidently with those of the rusted members above mentioned of new steelwork delivered at buildings in the same neighborhood and not yet erected showed that they were in no better condition than the average of those taken out of the Pabst Building. This fact points to the desirability of a vigilant enforcement of Section 129 of the Building Code, which requires that "all structural metal work shall be cleaned of all scale, dirt, and rust, and thoroughly coated with one coat of paint. When surfaces in riveted work come in contact, they shall be painted before assembling. After erection all work shall be painted at least one additional coat." Such deterioration as was found in the frame of the Pabst Building was unquestionably due to the neglect of or perfunctory compliance with these requirements. That nothing was discovered which afforded a basis for a gloomy prognosis touching the useful life of steel-frame buildings shows that the apprehensions entertained of the transient character of such buildings are without substantial foundation. Paint honestly applied to clean surfaces will effectually protect columns, beams, and girders of upper stories, and concrete will as effectually safeguard those of the lower tiers, where greater dampness is encountered. Steel frames have stood the tests of fire and wind, and are standing that of corrosion much better than any one interested had reason to expect. — *New York Times.*

A PROTRACTED dry spell in the New England states was followed by two or three light showers that were of little or no benefit to the parched crops. Some wag thereupon sent the following telegram to the Weather Bureau, marked "Collect":

"U. S. Weather Bureau, Washington, D. C. — Samples received, and found satisfactory. Send us some three inch goods. Rush.

NEW ENGLAND."

The Locomotive.

HARTFORD, MARCH 15, 1903.

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

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Obituary.

Channing Snow Belden.

It is with profound regret that we record the death of Mr. Channing Snow Belden, which occurred on February 21st, at his home in Hartford, Connecticut. Mr. Belden was forty-eight years old. He was born at Whately, Massachusetts, and entered the employ of the Hartford Steam Boiler Inspection and Insurance Company on November 11, 1872. At the time of his death he was chief clerk in the home office of the company, and his minute knowledge of the business, in all its details and from its earliest days, made him an invaluable man in every way. His most marked characteristic was his unwavering loyalty and love for the company in whose service his life was spent, and he was noted for his sympathetic nature, and for his readiness to help all who stood in need of assistance. He filled a large place in the hearts of his associates, and his memory will long be cherished with the kindliest sentiments of respect and affection.

Richard William Hart Jarvis.

On January 21st Mr. Richard W. H. Jarvis, a highly esteemed citizen of Hartford, Connecticut, and a member of the board of directors of the Hartford Steam Boiler Inspection and Insurance Company, died at the residence of his sister, Mrs. Elizabeth Colt of this city. Mr. Jarvis was born at Portland, Connecticut, on November 30, 1829, and was graduated at Trinity College in 1848. He immediately entered the Yale law school, graduating therefrom in 1850. In 1860 he came to Hartford, and became connected with the Colt Patent Fire Arms Company. Upon the death of Colonel Colt, in 1862, Mr. Jarvis was taken into the active management of the company, and on November 15, 1865, he became its president, in which office he continued until July 2, 1901. He gave up the active management of the company in 1888, however, on account of a protracted illness, and thereafter was merely its nominal head, the active duties being performed by General William B. Franklin and Mr. John H. Hall. Mr. Jarvis had a wide reputation for sound judgment and acute perceptive qualities as a business man. He was a man of even temperament and pleasant social attainments, despite his invalidism, and was highly respected and esteemed by all who knew him.

At a meeting held on February 10, 1903, the directors of the Hartford Steam Boiler Inspection and Insurance Company formulated the following expression of its regard for him, and directed that it be entered upon the records of the company:

"Richard W. H. Jarvis, who has been recently removed from our board by death, was elected a member in October, 1868. During all these years he has attended our meetings with marked regularity. He manifested a deep interest in the company's progress, even in the early days when its success to some seemed problematical. His counsels were always wise and conservative. His genial, courteous bearing endeared him to all his associates, and this board desires to record its deep sense of the great loss and sorrow occasioned by his removal."

On Accurate Thermometry.

It is a simple matter to determine a temperature to the nearest degree or so, by the aid of an ordinary mercury thermometer. We have merely to verify, first, that the instrument reads 32° Fahr. when it is left for a sufficient time in freezing water, and that it reads 212° Fahr. after being left for a similar time in the steam rising from water that is in full ebullition under a pressure of one atmosphere; and after this we need do nothing but expose the thermometer to the temperature that is to be determined, and read what it says, when we are sure that it has attained that temperature.

This is all that is required when we wish merely to know the temperature to the nearest degree. If we wish to know it to the nearest tenth of a degree, the problem is much more complicated. First of all, we have to verify the readings at the freezing and boiling points as before, but with a higher degree of precision. Then we have to investigate the caliber of the thermometric tube very carefully, so that we may be in position to take account of any irregularities that it may show. If the tube were perfectly cylindrical (inside, of course) and true, the graduation marks should be spaced at uniform intervals. But if the tube is larger at some places than at others, the graduation marks should be closer together at the large places, in order that an equal expansion of the volume of the mercury may make an equal showing upon the scale, in all parts of the tube. The examination of the tube in this way, for the purpose of ascertaining the variations in calibre, is called "calibration." No thermometric tube is ideally perfect, and in actual practice it often happens that a thermometric tube is irregular enough in bore to give rise to errors in the readings of considerably more than a tenth of a degree. (Of course we are speaking of thermometers that are intended for accurate work; the thermometers that are used about the household, and which have no pretensions to accuracy, may be in error from this cause by much larger amounts.) When the caliber of the thermometric tube has been investigated with suitable care by the methods that are given in books on experimental physics, the next step is to calculate a table of corrections, so that proper allowance can be made for the irregularities that are found, and the readings of the instrument reduced to the values that they would have if the tube were perfectly uniform in caliber. The chief remaining source of error will then be the instability of the zero point, to which full reference will presently be made.

We have assumed, in the preceding paragraph, that the temperature is to be determined to the nearest tenth of a degree. It will be readily understood that when the problem is to determine it to the nearest hundredth of a degree all the work that has been spoken of above must be attended to with correspondingly greater care, and numerous other sources of error must also be attended to. And when it is proposed to determine the temperature of a body to the thousandth of a degree, it is no exaggeration to say that the resources of the laboratory are taxed to their utmost.

In executing these refined measurements, careful attention must be paid to the pressure upon the bulb of the thermometer, because a slight increase of pressure will compress the bulb to a sensible extent, and cause the mercury to rise in the stem, so as to give a reading that is too high. Several other sources of error must also be considered, and allowance must be made for them.

The most important of these, without doubt, is the "variation of the zero." It is found that when a thermometer is submerged in freezing water, the point to which the mercury descends is not always the same, but that it depends to a certain extent upon the temperatures to which the instrument has been previously exposed, within a short time. Rowland ("Physical Papers," page 349) tells of having made certain experiments on this point, in 1879, with a thermometer that he used in connection with his determination of the mechanical equivalent of heat. The thermometer was graduated on the Centigrade scale, and was therefore supposed to read 100° at the boiling point, and 0° when immersed in freezing water. The thermometer with which he experimented had lain in its case for four months at a temperature of from 20° C. to 25° C. He first submerged it in freezing water, and noted the point to which the mercury sank. This point he called "zero" in the subsequent experiments. He next heated the instrument to 30° C. for a few minutes, and upon placing it again in freezing water, he found that the mercury fell to — 0.016° C., or 0.016° lower than it did when first taken from its case. It was next heated to 40.5° for a few minutes, and upon being returned to the ice-water it fell to — 0.033° C. These experiments were continued, at intervals of about 10°, up to the boiling point (100° C.), and the results that were obtained are given in the accompanying table.

Temperature to which thermometer was exposed.	Reading subsequently obtained in freezing water.
22.5° C.	0.000° C.
30.0	— 0.016
40.5	— 0.033
51.0	— 0.039
60.0	— 0.105
70.0	— 0.115
81.0	— 0.170
90.0	— 0.231
100.0	— 0.313
100.0	— 0.347

The last reading in the table was obtained after a prolonged exposure to the temperature 100° C. This table illustrates quite clearly what is meant by the "depression of the zero" of a thermometer, — a phenomenon that has been known for many years, but whose laws are not yet thoroughly understood, except for certain kinds of glass, and over the temperature interval comprised between the freezing and boiling points.

The first systematic researches upon the relation between the temperature to which a thermometer has been exposed, and the position of the zero point as observed immediately before or after the exposure, were made by M. Pernet, and published in 1875. Numerous other researches have since been made, notably by M. Guillaume of the International Bureau of Weights and Measures, and for certain kinds of glass the phenomenon may now be said to be fairly well understood, for the temperature interval comprised between the freezing and boiling points. Accurate thermometers should therefore be made of one or other of these glasses that have been studied; for the variation of the zero point will obviously give rise to an error of serious magnitude in glasses that have not been studied sufficiently to enable the observer to make due allowance for it, or to eliminate it by his method of experiment.

The glasses that have been most thoroughly studied are the French "verre dur" ("hard glass"), and the two Jena glasses that are known respectively as "16III" and "59III." The phenomena as observed in the case of "verre dur" are thus described by Guillaume: "When a verre dur thermometer is quickly exposed to a temperature of 100° C., after having reposed for a considerable time at the ordinary temperature of the laboratory, its zero point falls with such rapidity that after an exposure of one minute at 100° C. the displacement is practically complete. If the thermometer is then placed in ice-water its zero ascends, for the first few moments, at the rate of about 0.001° C. per minute; but this rate diminishes rapidly. When a thermometer is maintained at a constant temperature, its zero point rises little by little, and the change can be traced plainly for several years. For thermometers of verre dur, the gradual rise at constant temperature amounts to about 0.001° C. per month when the thermometer is two years old; and at the end of four or five years the motion is found to have diminished to about 0.002° C. per annum."

As has already been indicated, the details of the zero-point variation are quite different in different kinds of glass; and the great importance of the three kinds of glass mentioned above is chiefly due to the facts that their zeros are depressed very rapidly indeed when the temperature of the thermometer rises, and that they return again with extreme slowness to their normal positions. With thermometers made of these kinds of glass, the ideal way of determining a temperature is as follows: The thermometer is exposed to the temperature to be measured, and its zero-point falls to a certain (presumably unknown) position. After the instrument has been read, it is introduced, as quickly as is consistent with its safety, into a mixture of ice and water. The mercury sinks at once, and soon attains a stable position, which, on account of the slowness of the change of zero with falling temperature, is taken to be the zero corresponding to the higher temperature to which the instrument has been previously exposed. In accordance with this plan, the temperature to be measured is found by subtracting the subsequent reading in ice-water from the reading obtained at the temperature to be determined.

The method outlined above, for eliminating the effect of variations in the zero-point of a thermometer, is known as the "method of movable zeros," and it is now adopted (we believe) at all the centers of accurate thermometry except Kew, for temperatures between the freezing and the boiling points. Very consistent and presumably accurate results can be obtained by its use at these temperatures; but for temperatures much above the boiling point (those approximating to 350° or 400° Fahr., for example) it does not appear to be possible, by any method, to ensure an equally close agreement among different thermometers constructed of verre dur. At 400° Fahr. the systematic differences among several thermometers exposed side by side may amount to as much as 0.05 or 0.06 C., in spite of every precaution that can be taken. This indicates that the phenomena of the zero point are not yet properly understood at such high temperatures. It is also true that temperature determinations made with the mercury thermometer in regions much below the freezing point cannot be assumed to have anything like the weight that similar observations have, when made between the freezing point and the boiling point. For suppose that a thermometer has been exposed to a temperature of —15° C., with the object of determining this temperature with precision. If the thermometer had been previously kept for some time at the temperature of the laboratory, then upon being cooled to —15° C. its zero-point will probably not change to any great extent for some time, on account of the slowness of the change of zero with falling temperature. But when the thermometer is afterwards plunged in freezing water, its zero will rise quite rapidly (although to a probably small and uncertain extent), in accordance with the general principle that the change in question is rapid on a rising temperature; but the zero-point as thus observed is not necessarily the zero-point corresponding to the temperature, —15° C., that was to be measured. It would appear to be more logical to observe the zero-point first, when determining a temperature below the freezing point; but even in this case an ideal result will probably not be obtained, because the zero-point as given by this proceeding is the one which normally corresponds, not to the temperature that is to be determined, but to the temperature of the laboratory, at which the thermometer had been previously resting.

These difficulties, at temperatures below the freezing point, have been recognized at the International Bureau, but not until after the main comparisons there carried out between gas and mercury thermometers were completed. Thus the principal series of comparisons of this sort was published in the sixth volume of the *Travaux et Memoires*, in 1888; and we do not find that the Bureau conceded the importance of the source of uncertainty here indicated, until 1894.

It is unfortunate that more has not been written on the subject of precise thermometry in English. Few of the books on heat and allied subjects contain anything of importance on this matter of the variation of the zero-point of a thermometer, although a full knowledge of it is essential to the execution of thermometric determinations that will be comparable with those carried out at the International Bureau of Weights and Measures. The English or American experimenter who would be informed on these matters must perforce consult Guillaume's *Thermométrie de Précision.*

On the Use of Beaumont Oil as Fuel.

A little more than a year ago the first discovery of oil was made at Spindle Top, near Beaumont, Texas. It was the writer's privilege, in the interest of a client, to visit these oil fields in January, one year after the first discovery of oil. Riding out from Beaumont through the flat rice lands of southeastern Texas, one pictures a beautiful mound rising above the plain and surmounted by derricks, but this picture of the imagination is doomed to disappointment. Spindle Top is, perhaps, 10 or 12 feet high, as the surveys show it, but the rise is so gradual that the ground appears level. The derricks are there, standing as thick as they can be crowded and looking like a forest of pines in the distance.

At that time there were about 150 wells, all grouped within a space not exceeding 235 acres in extent. These wells vary in output from 10,000 barrels to the largest, which flows approximately 80,000 barrels per day of 24 hours. The only limit to the flow of oil appears to be the size of pipes, as the largest wells flow with the same pressure as the smaller ones. The total output of these wells would reach the enormous quantity of over 7,000,000 barrels per day should they all be allowed to gush at the same time and should the pressure remain undiminished for 24 hours. This output of oil almost exceeds the limits of the imagination, and is more than a year's output of such well-known older districts as the Indiana oil fields.

Even with this immense output available the consumption of Beaumont oil has hardly begun. A well-known shipper in Houston, having very complete data regarding the shipment and use of oil, stated that but 3 per cent. of the steam boilers of Texas has been equipped with fuel oil burning apparatus during the first year. The average daily shipments are estimated at 16,000 barrels. I believe that this exceeds, rather than falls short, of the actual shipment.

The price at the wells has dropped until, at the present time, it is from 9 to 10 cents per barrel f. o. b. cars. The price at other points depends entirely upon the freight rate and the expense of delivery from the railroad to the user's plant. The price quoted me in St. Louis last week by one large shipper of oil is $1.14 per barrel f. o. b. St. Louis, of which price $1.05 is paid for freight. It is found that, at the present prices for oil, few of the oil companies desire to make long-time contracts, and the prospect is that prices will go higher rather than lower in the future, notwithstanding the inexhaustible supply.

The importance of this oil discovery can be appreciated when it is recalled that the Texas coal fields are limited in extent and the quality is poor. Fort Worth coal varies in quality from that having 9,500 heat units per pound to the best, having 11,800 units per pound, and the lignite from the mines in the eastern part of the state is of much poorer quality. The next best source of supply is from the Arkansas fields. This coal contains about 11,400 B. T. U., and costs in the neighborhood of $2.30 per ton delivered at consumer's plant at northern Texas points. The best steam user's coal reaching northern Texas markets is the McAllister coal from Indian Territory. It contains about 13,500 B. T. U. per pound. Its cost, delivered, varies from $2.50 per ton for pea and slack mixed to $3.40 per ton for run-of-mine coal.

The use of crude petroleum as a fuel is in many respects ideal. It does away with all dust and dirt about the building from the handling of coal and ashes. In the case of a first-class office building in the heart of a city this is an important consideration. When properly burned it is a smokeless fuel, thus complying with the requirements of large modern cities, and possessing a desirable feature to all users of steam who take a pride in the cleanliness of their city. I say that when properly burned it is smokeless, as it is possible to make an oil-burning plant as smoky as when using the poorest of soft coal. It is by the proper regulation of the atomizer, producing a complete atomizing of the oil, and also by the proper supply of air, producing complete combustion, that the burning of oil is found to be absolutely smokeless. A further advantage in the use of this fuel is its accurate regulation to the requirements for steam, thus insuring a uniform steam pressure. There is also a great saving in large plants in the item of labor, although in smaller plants this saving is not effective, as it is not practicable to operate boilers without someone in attendance. It is a clean fuel, making it possible for the boiler room to be kept as clean as any well-cared-for engine room. Where oil is used, it is quite common to see the boiler fronts, walls, etc., neatly whitewashed, presenting a very attractive appearance. It is also much easier to keep boilers clean where the oil is used as fuel, as the practically complete combustion of the fuel leaves little soot to be deposited upon the boiler tubes. It is my belief, also, that by the use of oil the fire risk is lessened, although insurance companies have not yet arrived at the point where they look at the use of oil in this light. Oil spilled upon the boiler room floor by accident will not burn when a lighted match or burning coal is thrown upon its surface. There is no odor in the boiler room from the burning of fuel oil, although it is a common impression that such is the case. With the use of oil there is no necessity for opening and closing the fire doors of the boiler, and the boiler is not thus subjected to the strains of receiving cold air on highly heated surfaces. The accurate regulation of air to the requirements of the burner, as well as the accurate regulation of oil to the requirements for steam, make it possible to secure better economy in the use of fuel than is possible by any method of firing coal except the most expensive of automatic stokers. It is also possible to get up steam quicker when using oil than when using coal, and the boiler also responds quicker to changes in load.

The disadvantages in the use of fuel oil are few. Some types of burners make considerable noise, which would be objectionable in some locations. The space required for storage tank is a serious objection to the use of oil in many places, as it will be found impossible to find room for the tank without having it occupy a valuable space. There is also an odor from the storage tank when filling from the car or other source of supply. There is also considerable uncertainty regarding the delivery of oil at present, as shipping arrangements are not as well systematized as in the case of the supply of coal. There is also the disadvantage that the atomizers use some steam, the amount varying from 3 to as high as 13 per cent. in some cases. The use of compressed air instead of steam for the operation of the atomizers is to be recommended in all cases where a source of compressed air is available.

With all of these advantages in the use of oil, and with so few disadvantages, and, added to this, with the price of oil as low as 9 to 10 cents per barrel of 42 gallons at the wells, and with coal at the high prices mentioned above, it is not surprising that steam users throughout the state of Texas are at present investigating the merits of this new fuel or are equipping their plants for its use.

The first question presented to the prospective user of oil is, How will it affect the insurance? The underwriters have made a study of the use of oil as fuel, and have hedged its use about with certain essential restrictions. They require that the tank for storage of oil supply shall be of boiler iron, of No. 18 galvanized iron or steel; shall have ventilation at top, and shall be located not less than 50 feet from the building if wholly underground or 100 feet if wholly or in part above ground. In the latter case the tank should be inclosed in a substantial brick or stone wall or earth embankment of sufficient capacity to hold contents of tank in the event the oil is released from any cause, and in every case the tank shall be so placed that the highest point in said oil supply shall be lower than the furnace where such oil is to be burned or converted for burning.

"The conveying of oil to furnace shall be by artificial pressure or suction either by pump, vacuum, or other means that will accomplish the purpose. This expressly prohibits the feeding of oil by gravity and pressure or by other means from the storage supply higher than the furnace; provided, however, that oil may be fed to burners under a maximum pressure of 8 pounds to the square inch from an iron standpipe having a maximum capacity of 5 gallons, located at storage tank and supplied from storage tank by pump while the oil is being conveyed to furnace. Standpipe shall have an overflow pipe (with capacity equal to discharge pump) leading back to storage tank and shut-off cock where supply pipe leaves standpipe for furnace."

Many different types of apparatus for the burning of crude petroleum are on the market, all complying with the underwriters' requirements as above outlined.

These equipments vary from the simplest, consisting of a No. 18 galvanized iron oil-storage tank, with ventilators, standpipe, pump, and burner. The latter is sometimes home-made, although generally one of the well-established types of burners on the market is used. These burners are introduced into the furnace doors, generally interfering as little as possible with the boiler front. The grate bars of a common furnace are covered with fire brick and a broken network of fire brick laid up, or sometimes only a rough pile of fire brick, upon which the flame of the oil is allowed to impinge.

From this cheapest possible outfit to the best is a long step. The best equipment consists of a steel oil-storage tank, with flanged outlets and ventilating pipe at the top, equipped with an indicator showing the amount of oil in the tank. This tank is also furnished with a pipe for heating the oil with steam to keep it in a liquid condition in cold weather. The pumping outfit consists of a duplicate set of duplex pumps, mounted upon a table and surmountd by a small filtering tank, which also contains a coil of pipe for heating the oil. This pumping equipment is properly valved and dripped, provided with thermometer, gauge glass, and pump governor.

The burner is of special design, receiving the oil through a central tube through which steam at 50 pounds pressure is taken, atomizing the oil. This burner is set in a special tuyere block for the admission and regulation of the free air necessary for complete combustion.

The changes in the boiler setting comprise a special study in each particular case. These changes generally consist of the istallation of a fire brick lining over the grate bars and a special checkered baffle wall of fire brick, and behind this, near the rear of the boiler, another wall intended to retard the velocity of the heated gases, and the whole designed with the idea of diffusing the heat of the flames and preventing its localization to the injury of any part.

It is interesting to observe, in this connection, that the plant of the World's Columbian Exposition was equipped with the highest class of fuel oil burners, this being one of the largest plants that have used oil fuel in this country. That plant contained approximately 25,000 horse power of boilers. The engineers in charge of that plant found that the best results were obtained when the oil was heated to a temperature just below its distilling point before being delivered to the oil atomizer. They found this preliminary heating of the oil insured a speedy vaporization at the burner, with a resultant flame soft and diffusing, and not sharply impinging upon boiler surfaces. They also discovered the advantages of using low-pressure steam to vaporize the oil in the burner. — Extract from a paper by Henry M. Humphrey, read before the Engineers' Club of St. Louis on April 2, 1903, and published in the *Journal* of the Association of Engineering Societies, for March, 1903.

The element radium (if it is an element) promises to be one of the most important substances ever discovered, even although it is exceedingly rare, and occurs only in very small quantities. It is known to continuously emit radiations capable of affecting photographic plates, and this alone would be a sufficiently remarkable attribute. It now appears, however, that radium has a far more wonderful quality; for when it is surrounded by objects of an absolutely uniform temperature, the metal itself is found to have a temperature higher than its surroundings by from 1.5° to 2.0° Fahr. This property is absolutely unprecedented, and its cause is not yet known.

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The Stiffening of Boiler Heads by Angle Iron.

The subject of bracing boiler heads has been thoroughly discussed in previous issues of The Locomotive, notably in the issue for September, 1893. We have always taken the position that boiler heads should be thoroughly braced, under all circumstances; for while the unbraced head without doubt has some strength in itself, the allowance to be made on this account is not very great, and it is, moreover, uncertain in amount, especially upon surfaces of the form of the segment of a circle, for which no entirely satisfactory formulæ have yet been given. The only safe way, therefore, is to entirely neglect such strength

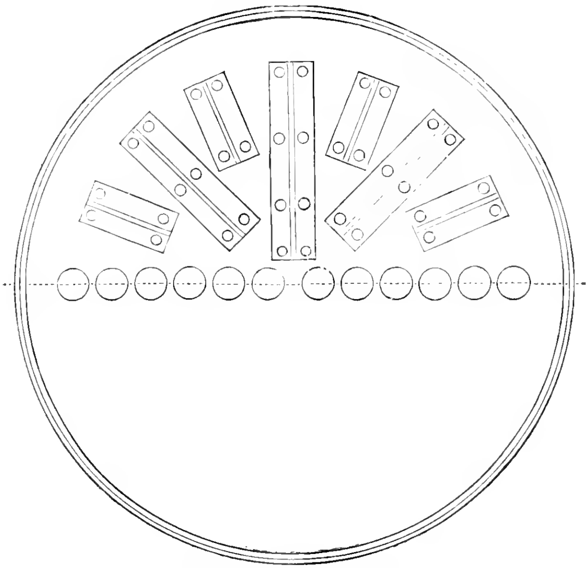

Fig. 1. — Showing Radial Stiffening Irons.

as the unbraced head may have, and to put in a sufficient number of braces to take care of the whole load that is thrown upon the head. The strength of the head itself then comes in on the right side, by increasing the factor of safety of the structure.

It sometimes happens, however, that a boiler is found to be braced to an extent that calculation indicates to be almost sufficient, and yet not quite; and in these cases the question naturally arises, whether or not the boiler can be safely passed for the pressure that its owner desires to carry upon it. We do not deem it advisable to lay down a hard and fast rule for such cases, for a good deal depends upon the general evidence that exists as to the quality of the material in the boiler, and the care that has been exercised in its construction; and this must be left to the judgment of the inspector who has the opportunity of examining the boiler personally. It has always been recognized that a boiler that is built of materials whose quality is thoroughly known, and the workmanship upon which is also known to be beyond reproach, can be safely run at a somewhat higher pressure than it would be wise to carry on a similarly designed boiler about whose materials and construction less is known. It is here that the judgment of the inspector comes in.

Turning to the mechanical question of the actual strength that angle (or tee) iron communicates to a boiler head to which it is riveted, we may say that a full mathematical discussion of this problem has never been given. It contains

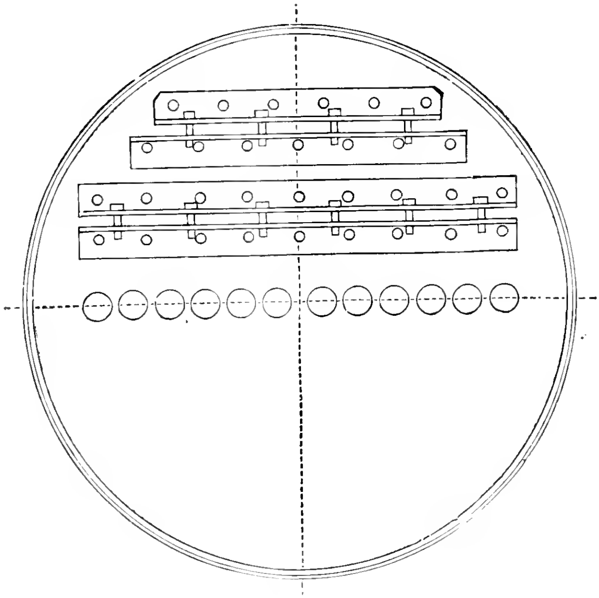

FIG. 2. — SHOWING HORIZONTAL STIFFENING IRONS.

numerous difficulties that appear to be almost insuperable when the problem is faced in all its rigor, resembling, in this particular, the vexed question of the collapsing pressure of flues. The only mode of treating it that we know of, that can be justified at all, is to base the computation upon the assumption that the angle irons, or tee irons, act like beams, each one supporting the load that falls upon that part of the head to which it is secured, and transferring that load to those parts of the head against which the ends of the angle irons rest. In the case of locomotive crown sheets, this calculation is comparatively simple, and a discussion of it will be found in THE LOCOMOTIVE for September, 1897. The rules given in that article, however, apply only to beams that are rectangular in cross section; and in the case of angle irons and tee irons the same rules are to be followed in spirit, although in their practical application they are much more complicated, on account of the altered form of cross section. We shall not give a general discussion of the strength of beams of irregular cross sections, because the rules to be applied in such cases will be found in all the engineering pocket-books. We may point out, however, that the deflection of a beam of given cross section increases as the cube of the length of the beam, under a given load; so that if one beam is five feet long and another, similar to it, is ten feet long, then under the same given load the deflection of the longer one will be eight times as great as that of the shorter one. The practical deduction that we wish to point out, from this fact, is that when a boiler head is stiffened by radial irons, as indicated in Fig. 1, it is better supported than when it is stiffened by horizontal angle irons, as in Fig. 2. For the radial bars are shorter, and hence possess greater stiffness. The weakest point in a head such as is shown in either of these cuts is along the upper row of tubes; for while the tube ends have a sufficient holding power to stay that part of the head into which they are expanded, it must be remembered that a good part of the stress that comes on an unbraced segment is thrown upon the ends of the upper rows of tubes, and may easily be great enough to cause these tubes to draw through the head. We may point out, also, that the four short radial bars shown in Fig. 1 are of no value in stiffening the head, because they contain only two pairs of rivets, one pair at each end. These short bars are put in merely for the attachment of braces. The longer radial bars support the head where they are riveted to it, except at the end rivets.

In conclusion we wish to say, again, that we do not approve of relying upon angle-irons or tee-irons for supporting boiler heads, to the exclusion of braces; and that our only present purpose is to draw attention to the fact that radial bars, riveted to the heads at numerous points, stiffen them better than the comparatively longer horizontal bars. When the number of braces is undoubtedly ample, either arrangement of the bars may be adopted; but the radial disposition is preferable when there is some slight doubt about the adequacy of the bracing.

Inspectors' Report.

October, 1902.

During this month our inspectors made 13,451 inspection trips, visited 25,918 boilers, inspected 9,090 both internally and externally, and subjected 1,115 to hydrostatic pressure. The whole number of defects reported reached 12,245, of which 1,115 were considered dangerous; 66 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,153	53
Cases of incrustation and scale,	3,225	77
Cases of internal grooving,	153	16
Cases of internal corrosion,	918	29
Cases of external corrosion.	646	52
Broken or loose braces and stays,	288	71
Settings defective,	369	34
Furnaces out of shape,	350	25
Fractured plates,	368	52
Burned plates,	343	40
Blistered plates,	120	5
Cases of defective riveting,	498	16

Nature of Defects.	Whole Number.	Dangerous.
Defective heads,	71	10
Serious leakage around tube ends,	1,959	328
Serious leakage at seams,	532	51
Defective water-gauges,	282	47
Defective blow-offs,	288	75
Cases of deficiency of water,	28	11
Safety-valves overloaded,	126	39
Safety-valves defective in construction,	73	28
Pressure-gauges defective,	400	28
Boilers without pressure-gauges,	26	26
Unclassified defects,	29	2
Total,	12,245	1,115

Water-Tube Boilers in the U. S. Navy.

The special board, composed of Commanders Perry, Bailey, and Canaga, appointed by Secretary Moody to examine the boilers of the *Maine* [which are of the Niclausse type (see THE LOCOMOTIVE for November, 1902)], have made a preliminary report in which it is stated that a considerable number of tubes distributed throughout three of the boilers have been found to be so damaged as to make it clear that the water was forced out of them by the heat of the fires, the tubes being bent out of position from ½ inch to 6 inches. In some cases the tubes were bent downward, while in other cases they buckled upward. Certain tubes are also found to have burst, which is attributed to burning out. The board, having been instructed to estimate the cost of repairs to the boilers, state that from $10,000 to $15,000 would be required to put the battery in shape for another trial, including the expense of renewing the damaged tubes, providing new gauges and glasses and installing a device to be operated from the deck, by which individual boilers may be cut out in case of further damage during the trial.

The importance of these conclusions, which will not be officially announced until the final report of the special board referred to has been received, can hardly be overestimated, as they will carry great weight, not only with our own naval authorities, but with the admiralties of the world. The immediate effect in the United States navy will probably be to put a stop to the installation of this type of boiler, and will cause great care to be taken in the management and inspection of those of our war ships in which the boiler has been installed, including the *Colorado*, *Pennsylvania*, *Virginia*, *Georgia*, and *Nevada*, the last mentioned being a monitor.

While it will no doubt be very disappointing to the American people as well as to the naval service to learn that no less than six of our war ships are fitted with boilers which are unsuited to sea service, yet there is some consolation in the fact that our comparative naval strength is not reduced by this discovery. The Niclausse boiler is a French invention, and has been installed in a large portion of the war ships recently contracted for by the French government, the admiralty authorities following the rule of using French devices and material of domestic manufacture wherever possible. Germany has also built a number of vessels in which the Niclausse boiler has been used, and in a much larger number has installed a Durr boiler, of the same general type, employing the Field "tube within a tube." England has installed the Niclausse boiler in two gunboats, and has given contracts for its installation in two battleships and several armored cruisers. The Russian government has also used this boiler in a considerable number of war ships, but has decided not to employ it hereafter.

The officials of the Bureau of Steam Engineering freely concede that the Niclausse boiler possesses certain distinct advantages in that an installation of high power can be made within a very limited space, and also because of the economy of fuel consumption, which has proven very attractive to naval authorities anxious to extend the steaming radius of all the vessels of the navy. The great disadvantage in the Niclausse type, however, in the opinion of the officials of the Bureau of Steam Engineering, is the fact that it is so constructed that there is a strong tendency when the boilers are forced for the water to leave the ends of the tubes, which are then apt to burn out. This tendency is greatly accentuated when the vessel rolls or pitches, which, of course, is a decided disadvantage from a naval standpoint. Not only is the bursting of tubes as reported attributed to this weakness of the boiler, but also the bending, which is believed to be due to the heating of the tubes out of which the water has been driven.

The *Maine's* battery contains no less than 12,000 tubes, and it is pointed out that should even a fraction of 1 per cent. of these tubes scattered throughout the boilers become damaged the entire ship would be disabled. It has been found that "foaming" in the boilers, as well as the forcing of the fires and the pitching of the vessel, is apt to clear the ends of the tubes of water, permitting them to burn out or bend.

Naval officers now emphasize the fact that for the past twenty years Admiral Melville has strenuously resisted all efforts to cut down boiler and engine weights, and it is pointed out that experience has confirmed his opinion, and will convince naval authorities in all countries that weights should be economized only in auxiliaries and luxuries above the protective deck rather than in the important and constantly working machinery beneath that structure. Naval engineers declare that, because the boilers are not in sight of the casual visitor, the constructors are disposed to cut them down as much as possible, while adding to the useful but not absolutely necessary auxiliaries and the wholly unnecessary furnishings of the ship above the protective deck.

In this connection Admiral Melville calls attention to an extract from a report made a few months ago by the Edwards Board upon the "problem of the water tube boiler," in which was emphasized the vast importance, which, in the Admiral's opinion, is now greatly underestimated, of an efficient boiler, an importance which he thinks is second to no other feature of construction or equipment. This extract is as follows:

"The present problem of the modern battleship is not that of the gun and its mount, but the boiler and its installation. The gun is mounted in the most favorable position for care, operation, and inspection, and practically everything on board ship is subordinated to its efficient working. Since a large factor of safety is given to every part of the weapon that is subjected to shock, the gun can only be impaired by incompetence, neglect, or by chemical action of the explosive. Before it is placed in a turret or redoubt it is fully tested, but it is never put on board ship if there is a suspicion that it has been subject to undue strain.

"The boiler, on the other hand, is placed beneath the protective deck just above the bilges and near the bunkers. It is installed in compartments that are avoided rather than sought by other than engineer officers. While a careful test is made of the structure before being placed in the vessel, it must necessarily be subjected, even before installation, to conditions that often impair its strength.

In its construction many of the plates are subjected to the severest kind of flanging, and its efficient inspection is much more difficult that that of the gun. As there has been a progressive demand for increased steam pressure, the factors of safety used in designing a marine boiler are progressively becoming smaller. The conditions under which the boiler is operated necessarily cause some of the parts to be subjected to rapid corrosion, and only incessant care and attention can prevent the disablement or rupture of the structure.

"The experience of the United States navy with the boilers of the torpedo boats and torpedo boat destroyers ought to afford some startling evidence as to the manner in which incompetent or untrained men can impair or destroy the efficiency of these steam generators. The agitation in Great Britain over the navy boiler question ought also to convince naval administrators that the boiler problem is the naval problem of the hour. In view of the British experience with the Belleville boiler, it is not surprising that the general public of that empire regard the boiler commission, now in session, as the most important board appointed by the Admiralty during the past ten years. The membership of this board comprises distinguished experts within and without the naval service. This board has been in session nearly two years investigating the question as to which type of marine boiler is most suitable for use in the navy as the one of approved design. The Admiralty regard the solution of this problem as of vital importance to the efficiency of the British fleet, for it has been discovered, after installing over a million and a quarter of horse-power of boilers of particular design, that a doubt has risen as to whether or not this particular form of boiler should have been settled upon as the approved type for the naval service. A series of evaporative and endurance tests have been made, and the more carefully the question is investigated the more important does it appear in relation to the operation of a modern navy.

"The British boiler commission will have a very important influence upon naval construction, since it will cause thoughtful experts to give more attention to the design, construction, installation, and operation of the boiler. One must have experience in the operation of a modern marine boiler to appreciate the intelligence, skill, and care that must be devoted to keeping it in a state of efficiency. The boilers are the lungs of a vessel, although this fact is not generally understood. It was not many years ago when a naval officer of high rank spoke of the boilers as 'the steam tanks in the bottom of the ship,' it being probably his impression that these tanks could be tapped like a gasometer, and it was the fault of the fireman if the boiler output was not sufficient at all times.

"While the war ship may be nothing more than a gun platform, it requires considerable power to move a platform of 14,500 tons at a high speed in a heavy sea. This platform is not only expected to be manœuvered rapidly, but to steam uninterruptedly for a distance one-fourth the way around the world. The battleship that cannot make the enemy's coast the first line of defense is limited in the field of its usefulness, and when operating at such distance the value of the boiler factor comes only second to the value of the factor of the gun.

"With a deep appreciation of the necessity of soon settling upon an approved type of marine boiler for the battleships and armored cruisers of the United States navy, the bureau has invited competition among designers. It believes, however, that if possible a boiler of American design should be adopted, and that this marine boiler should be a development of one in general use on shore. By seeking design that is familiar to thousands of firemen on shore, an important military advantage would be secured, since in time of emergency there could thus be recruited for the naval service water tenders and firemen who had operated almost similar steam generators, and who would therefore require but little training to familiarize themselves with the duty on board ship. While the navy can and ought to do some efficient work in training firemen, it would be very advantageous to the service if the enlisted force in the stoke holes could have considerable preliminary training with boilers of nearly like design to the one in most extensive use as the approved type for the navy.

"There are now being built for the battleships in course of construction water-tube boilers of three distinct types. Practically four-sevenths of this boiler power will be of the Babcock & Wilcox design, two-sevenths of the Niclausse, and one-seventh of the Thorneycroft. These types include the best of representative groups of water-tube boilers, and a sufficient installation of each kind will be secured to test the efficiency and endurance of the several designs."

The suggestion having been made that the boilers installed on the *Maine* enabled her to be built for $30,000 or $40,000 less than it would have cost to equip her with boilers of another patern, it is urged by engineer officers that this consideration should not govern the department for a moment. The cost of a battery of boilers of the average type for the *Maine* is perhaps $300,000. The highest type now constructed would cost perhaps 15 per cent. more than this figure, while the cheapest cannot be built at a saving of more than 10 or 15 per cent. Under the circumstances, therefore, it is urged that it is very poor economy to attempt to cut down the cost of boilers of battleships which are likely to see most of their service at great distances from home ports. — *The Iron Age.*

America's Shortcomings.

It is a good thing, once in a while, when we think we are getting along famously, and have the world firmly by the tail as a preliminary to snapping its head off, to see what somebody else "on the outside" thinks about us. From this point of view the following article will be of interest. It is reprinted from *Cassier's Magazine*, and was written by Mr. George N. Barnes, who is secretary of the British Amalgamated Society of Engineers, and visited this country something less than a year ago to inspect American machine shops and other analogous engineering establishments.

"In venturing a few lines in response to your invitation," he says, "I will deal with the subject only in general terms. Let me say also that I am going to assume the role of 'candid friend,' feeling assured, as I do, that the American must be getting puffed up into an undue conceit of himself, — that is, if he has read recent magazine articles, — and that he will be all the better for having his attention directed to a few spots on America and Americanism which he may otherwise be disposed to ignore.

"First, however, I desire to express admiration for the splendid system of education in America, and for the no less admirable American patent laws. I believe that these two together, — the first by contributing to mental alertness on the part of directors of industry, and the second by the encouragement given thereby to inventiveness, — have done more than all other causes to develop American industrialism. There is public provision of free education, not only in the elementary schools, but in the secondary and continuation schools as well; and by that means the technical schools are always supplied with an ample number of young men, properly prepared to go right ahead. This compares very favorably with the English system, — or want of system, — which gives no free tuition after the pupil reaches the age of fourteen, and which thus leaves the ground unprepared for technical instruction.

"Again, in regard to the patent laws, I find that the American government gives a patent for $35, which in England would cost $500; and they also sift the applications so as to give reasonable guarantee of novelty with the patent grant, whereas our people at the British patent office practically give patents for fees, and regard inventors as sources of profit.

"America, then, I freely admit, is ahead of us in these respects as much as in vastness of area, magnificence of natural manifestations, or stores of raw material. It is when one considers America in its social aspects, — in the character of its government or in the low standard which passes current in regard to quality of workmanship, — that America sinks in one's estimation. Its laws have led to the creation of monopolists who seem to be all-powerful, and who oppose any change in the direction of real freedom; its towns are uneven and slovenly, disfigured by sky-scrapers, gridiron railways, and other contraptions of the 'boodler' and company promoter; and its workshops turn out a lot of shoddy work at the expense of constant draughts upon the workers' health, efficiency, and permanent well-being. It is upon this last point only that I shall offer a few observations.

"The American industrial system, on the whole, is directed to the greatest possible production of goods, and it is advocated and defended generally from that point of view. In regard to this two things may be said, — first, that it tends to produce a man of stunted growth and narrow view; and, second, that it tends to produce goods of inferior finish, because the workers' attention is too much directed to quantity, and too little to quality. Americans are drilled and specialized to a far greater extent than obtains in England, and, as a result, America has, so far, been largely dependent upon other countries for the supply of mechanics. Everywhere I went in America I found persons of foreign extraction in positions as foremen and chief mechanics, and just as often I found the native-born American tending automatic tools or divided into gangs of specialists under the control of gang bosses whom we should here call 'sweaters.' They have but few holidays, they work harder and longer per day, and their days are fewer as a result. The American worker is, as a rule, a person of grubbing proclivities and dyspeptic complexion, who seems to have got beyond the point of taking his pleasures sadly, by dispensing with them altogether.

"As to the production of goods, the ill effects, qualitatively, are no less marked. I saw work being turned out as finished which would not pass muster in England, but which is considered good enough for the American standard. The iron used is softer than that used here, and therefore less durable; less of it is used for any given purpose; and the workmanship put into it is far less painstaking than that of the British workman. For proof of this the British traveler in America has but to keep his eyes open. He may note, for instance, the American locomotive, which he will find far different from that to which he has been accustomed. Instead of the trim, clean, and nicely painted engines of the Midland or other of the English main roads, he will find a great, lumbering monster, with leaky joints and asthmatic wheeziness, rough, black paint, and dirt-begrimed. Going into another field, if he compare the newspapers, he will find corresponding unfavorable features, — a few lines inverted in every other column, or words misspelt, and the reading matter of only a very commonplace character.

"Observe, however, that I do not speak here of design, in which, especially where machine tools are concerned, the Americans are greatly in advance, and have, in fact, shown our people the way. I speak of workmanship. But, if our supposed traveler be interested in structural work, he will find the same unfavorable comparisons between our substantial, and in some cases artistic, bridges, and the flimsy-looking girders of unvarying pattern which span American rivers; or between our glazed brick, clean and water-tight tunnels, such as at Blackwell, and the dirty, dingy, and leaky holes, such as those found in Chicago. Again, it is said for America that there is equality in the workshop and in social relations. This is not true. There is, certainly, a sort of free-and-easy, familiar conversational style between bosses and workmen; but it is merely superficial, and denotes no real social equality. As a matter of fact, the general attitude of the American workman towards his employer is more embittered than is that of the workmen of England. To be convinced of this one has but to read the newspaper accounts of such disputes as the recent one in the Pennsylvania coal fields. The American industrial upheavals are characterized by violent scenes and lawless acts, in striking contrast with the quiet orderliness and regard for law which mark the settlement of industrial disputes in England. The fact is that there is less fellow feeling in America than here, either amongst the working people as a class, or between the American people as a whole. Nor could it be otherwise. The Americans are not a homogeneous people. They are recruited, year by year, from nearly every country in the world, and, as a result, there are large numbers of people in American stamped with the seal of racial, as well as economic, inferiority.

"The only sentiment which I noted as pervading all with whom I came in contact was, that the Americans are a chosen people; that they do better things and have bigger things than any other people. I was shown at least half a dozen buildings which were said to be the 'biggest on earth.' These idiosyncrasies of the American people are sometimes said to denote vitality; they are regarded by American apologists as evidence that the Americans are really 'awake.' To me they simply indicated a neurotic and unhealthy condition. There is such a thing as being too wide-awake, and therein lies, to my mind. America's danger.

"America is undoubtedly a great country, — in the making, — but I think that Americans would do well for themselves if they were to decide to live a little slower. Otherwise they may find, when perhaps too late, that in the effort to 'lick creation' they may themselves get prematurely used up in the process."

New York City. — New York's greatness is shown by the fact that the port of New York transacts a vast proportion of the foreign commerce of the United States; that of letters alone the New York post-office handles 897,778,820 annually, and that of the total clearances of the United States, 67 per cent. pass through the New York clearing house, the amount being $79,420,000,000. The police force of the borough of Manhattan is 4,546. The chief of the fire department writes that the fastest time ever made in getting ready to respond to a fire call was 1⅝ seconds, at an exhibition in Madison Square Garden. The average time is from 2½ to 4 seconds. The Croton and Bronx River systems of water supply have cost about $95,000,000. The length of the aqueducts is 70 miles, and of the distributing mains 886 miles. The capacity of the storage reservoirs is 44,700,000,000 gallons; the average daily supply is 275,000,000 gallons, a per capita rate of 134 gallons. The figures are for Manhattan and the Bronx, but apply mainly to the former. — *Pearson's Magazine.*

The Locomotive.

HARTFORD, APRIL 15, 1903.

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

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Obituary.

William Buel Franklin.

General William Buel Franklin, vice-president of the Hartford Steam Boiler Inspection and Insurance Company, died on March 8, 1903, at his home in Hartford, Connecticut. He was born at York, Pennsylvania, on February 27, 1823, and was therefore eighty years of age at the time of his death. His father, Walter S. Franklin, was clerk of the House of Representatives in Congress; his great-grandfather was a soldier of the Revolution, and his great-grandmother, Mary Rhoads, was the daughter of Samuel Rhoads, a member of the first Continental Congress. His mother was the daughter of Dr. William Buel of Litchfield, a descendant of Peter Buel of Windsor, Conn.; and it has been well and truly said that "all the heritable virtues of such stock met in this descendant."

General Franklin was a veteran both of the Mexican war and of the Civil war, serving in each with extraordinary distinction, and participating in many active campaigns. Upon his retirement from the army, in 1866, he made his home in Hartford, and was chosen vice-president and general manager of the Colt's Patent Fire Arms Manufacturing Company, a position which he held until April, 1888. In 1886 he became president of the board of visitors of the United States Military Academy, and he was elected president of the commission which built the Capitol, in 1872, his record as an officer of engineers in the Mexican war peculiarly fitting him for the position. He was the consulting engineer of the commission from 1873 to 1877, and superintendent from 1877 to 1880. He was a member of the board of water commissioners of the city of Hartford from 1863 to 1878, and was chairman of the committee of judges on engineering and architecture at the Centennial Exposition at Philadelphia in 1876.

General Franklin was one of the presidential electors from Connecticut, who nominated Samuel J. Tilden as the democratic candidate for president, and from 1877 to 1879 was adjutant-general on the staff of Governor Hubbard. In July, 1880, he was chosen president of the board of managers of the National Home for Disabled Volunteer Soldiers, a position to which he gave the greater part of his time until about three years ago. In June, 1888, he was appointed commissioner-general from the United States to the International Exposition at Paris, and in the following year received the decoration as a grand officer of the French Legion of Honor, being the only American citizen at that time who held that distinction. He was for several terms commander of the New York Commandery of the Legion of Honor of the United States, in which he always retained his membership. He was a member of the Society of the Cincinnati, the Sons of the American Revolution, the Army and Navy Club of Connecticut, and of Robert

O. Tyler Post, No. 50, G. A. R., of which he was a charter member. The general was formerly a director in the Colt's Patent Fire Arms Manufacturing Company, and was, until about a year ago, when he resigned, a director of the Panama Railroad Company. He was also a director of the National Fire Insurance Company, and until comparatively recently attended the meetings of the board; and he was vice-president of the Hartford Steam Boiler Inspection and Insurance Company, and a director in the Connecticut Mutual Life Insurance Company.

General Franklin was an Episcopalian in faith, and a democrat in politics. He became a member of the Church of the Good Shepherd when he came to Hartford to live, and had frequently served in the positions of senior warden and vestryman. He was married on July 7, 1852, to Miss Annie L. Clark of Washington, D. C. She died at Hartford on July 17, 1900.'

Colonel Jacob L. Greene, president of the Connecticut Mutual Life Insurance Company, of which General Franklin (as already noted) was a director, gives the following appreciative estimate of General Franklin's character: "There are men whose influence upon their times and whose impress on men's memories come from the unusual development and activity of certain specific but limited abilities, or from special traits of character. An unusually energetic exhibition of even a moderate amount of these may make their possessor strikingly prominent under favorable circumstances, the more so perhaps for their onesidedness. There are those, again, whose mark is made, not by a few strong points of either mind or character standing out from the background of an otherwise commonplace personality, but by mental powers of unusual breadth and force and traits of character of unusual value, and yet all so full rounded and balanced, so harmonious in blending and in exercise, so free from defect in structure and from noise in action, that not until by long opportunity men have measured them and their work with other standards of being and doing, do their strength and beauty stand revealed in full and impressive majesty.

"General Franklin was distinctly of this type. Physically, intellectually, and spiritually, he was built upon a magnificent model. As a scholar of the first order in his chosen lines of study, and sympathetic with all intellectual life and effort, as a man of action, clear in insight and in thought, broad and strong in his grasp, certain in judgment, definite, direct, prompt and vigorous in action, peculiarly diligent in attention to duties of whatever magnitude, pure and high-minded, with an integrity that never left his vision at fault and a courage that never hesitated, wise, prudent, and strong, simple, kindly, of perfect but unconscious dignity, he presented a rare balance of great gifts. He graduated from West Point at the head of a class remarkable for its membership of men who made themselves famous later on. Among those intimate with his professional capacity and attainments there was never a question that these were of the highest grade. He was one of the few men deemed entirely competent to the highest military command, while his character as a man rendered complete the trust reposed in him. All his qualities marked him for a great commander. Added to those already mentioned, he had — what so few possess — coupled with a perfect sense of responsibility, that confidence which is not born of conceit nor of any undue consciousness of power, and often goes with the humblest spirit: the confidence that, having done all possible to prepare for the issue, one can trust his courage and integrity to spend might to the uttermost and life itself, and to face defeat unflinching, in its final hazard: the calm intelligence that knows when the hour of supreme trial has fully come, and the courage that rises to its entire responsibility and to take and, if need be, suffer all consequences. Less happy in his assignments to duty than many lesser men, his was often the hard honor of saving their wreckages instead of leading them to the victories they knew not how to win. Jealousy, intrigue, and complaint were each alike impossible to him. His great soul was patient and steadfast. His patriotism was untouched by any personal considerations. And so he took the duties which the ambitions of others and the diverse influences of the troubled times left for his employment, and went his straightforward way, true man, true knight, and true lover of his nation. Few men of his time could have contributed more from a military point of view to its inner history of influences, measures, and actions. It must be always a matter of profound regret that he has not left such knowledge behind him.

"So quietly and unostentatiously was all his work done that only upon a full and detailed survey can the great magnitude of it all, and the great importance of its many parts and the invariable high standard of its excellence, be appreciated. But those who knew the strength and uprightness of his mind and character, the kindliness of his heart, his noble simplicity and personal dignity, his ready devotion to every patriotic interest and duty, the loyalty of his nature and the purity and unaffected piety of his life, know that one of the bravest of gentlemen, one of the purest of patriots, one of the most cherished of friends, and one of the knightliest of men, has answered to his name."

The following minute was adopted by the directors of the Hartford Steam Boiler Inspection and Insurance Company, and entered upon its records as a testimonial of the esteem in which General Franklin was held by his associates on the board: "It is with profound sorrow that we record the death of our associate and vice-president, General William Buel Franklin, who died on the morning of the 8th instant. He was elected a member of the board of directors of this Company in October, 1869, and was elected vice-president in October, 1872. He was a member of the finance committee since 1894. No member of the board was more punctual in attendance on its meetings than General Franklin. He always manifested a deep interest in the Company's affairs, and his wide knowledge and experience in the fields of civil and mechanical engineering rendered his advice invaluable. Loyalty to what he regarded as right and just, and loyalty to his friends, were marked characteristics of the man. We shall miss his stately figure at the meetings of this board, but the remembrance of his dignified, courtly bearing, of his inflexible devotion to duty, and of his kindly fellowship, will ever remain with us."

The Corrosion of Boilers by Magnesium Chloride.

In a recent issue of London *Engineering*, we find a review of a paper by H. Ost, which was originally published in the *Chemiker Zeitung*, and which relates to the corrosive action of chloride of magnesium upon boilers. As Herr Ost advances some original views on this subject, we reproduce *Engineering's* review, with certain changes which will render it somewhat more intelligible to the general reader.

"It has been assumed that magnesium chloride attacks the iron of boilers because it splits off hydrochloric acid. Ost contradicts this, and his experiments appear to be fairly conclusive. The question is interesting to the engineer, because magnesium salts occur in many boiler waters, and in large quantities in sea water. A. Wagner conducted (in 1875) some experiments on the action of various salts contained in the feed-water for boilers, and working at ordinary atmospheric pressure, he observed that the iron rusted in the presence of the chlorides of the alkalies and alkaline earths, when the air had access. When air was excluded, only magnesium chloride attacked the iron. The corrosion was not well understood, then, and was conveniently ascribed to some catalytic action. The chloride of magnesium was later thought to be decomposed in boiling water, but not unless it be present as hydrate, $MgCl_2 . 6H_2O$, and the temperature be above 223° Fahr.

"Ost has only experimented in closed vessels, so as not to be troubled by ordinary oxidation. Water in which some magnesium chloride was dissolved, when distilled from glass vessels, was always found to be neutral and free from chlorine. The distillate also remained neutral when copper or tinned copper boilers were used for the distillation, at a pressure of several atmospheres; but some decomposition took place in these cases, for a certain amount of tin or copper was dissolved by the water. Ost then had a small experimental boiler specially constructed in Krupp's works, at Essen. It is a horizontal cylinder with hollow bottom, pressed out of a block of Siemens-Martin steel, and closed in front by a flange and a steel plate, packed with lead. The capacity of the boiler is nearly three quarts, and it was generally charged with 2 quarts of water, and the heating by gas burners continued until one quart of the water had evaporated. The temperature was 360° Fahr., corresponding to a pressure of about 10 atmospheres. After each experiment, the inside of the boiler was found to be coated with a black, adhesive crust of the iron oxide, Fe_3O_4, a mixture of oxide and protoxide. This oxidation he ascribes to a decomposition of water into hydrogen and oxygen, which takes place whenever the hot feed-water comes in contact with the bare iron. Ost does not refer to electrolysis; some might possibly occur. The water was charged with 10 per cent. solutions of various salts. The generation of hydrogen was most energetic, as much as 7.5 cubic inches of hydrogen being found in a total quantity of 8.8 cubic inches of gas collected in the presence of calcium chloride, potassium chloride, and potassium sulphate. No iron was dissolved in these cases, however, except when magnesium chloride or magnesium sulphate were present; but the chloride of magnesium dissolved as much as 2.08 grains of iron per quart of the 10 per cent. solution. Now, we do not understand how magnesium sulphate could split up so as to be acid, and no free acid was observed in the case of magnesium chloride either, although the steam pressure was high. In Ost's opinion, the attack of the iron is primarily due to the decomposition of water; the oxygen oxidizes the iron, and the magnesium salt reacts with the protoxide of iron so formed, with the result that some of the iron is dissolved, while magnesium hydrate is precipitated. This reaction takes place according to the formula:

$$MgCl_2 + Fe(OH)_2 = Fe\ Cl_2 + Mg(OH)_2.$$

The sulphate of magnesium would react similarly. In neither case is the reaction complete, however; that is to say, the reaction does not proceed until all the magnesium salt has been transformed, but only until a certain quantity of magnesium hydrate has been formed. It then ceases until the magnesium hydrate is removed, or until the equilibrium is disturbed in some other manner.

"In support of this view, Ost treated iron with hot solutions of magnesium salts in glass vessels on a water bath, where the temperature could not rise above the boiling point. Similar experiments were conducted with various irons and steels obtained from the Krupp works, including nickel steel, and also with flower-wire, and the finely-divided iron employed in pharmacy. These all generated hydrogen, the finely-divided iron most (as was to be expected), and the nickel steel and weld iron least. The more sulphur the iron contains, the more easily it will be attacked; silicon, phosphorus, manganese, and also carbon, seem to protect the iron to a certain extent; but this point appears to require further investigation. The behavior of the iron also changes with the steam pressure.

"Thus magnesium salts, and especially magnesium chloride, are injurious to boilers, though probably for different reasons than are generally assumed. There is a remedy, however. At higher pressures, magnesium chloride and calcium carbonate interact, forming calcium chloride (which does not attack the iron), magnesia (which falls out as mud), and carbonic acid (which escapes with the steam). The escape of carbonic acid gas begins at low steam pressures; and though the reaction is never complete, it would appear from Ost's experiments in his boiler that a little carbonate of lime suffices to prevent the corrosion of the iron by the magnesium salt; he estimates that we need only a quarter as much carbonate as we have magnesium chloride. The precipitated magnesia does not swell the bulk of the scale in such cases, because an equivalent amount of the calcium salt is dissolved. Some of the rivers, whose contamination with magnesium chloride induced Ost to investigate the subject, contain a sufficient amount of carbonates and bicarbonates to render the water harmless as feed-water from this point of view, though we have to fear the formation of rust owing to the decomposition of water by the iron. In sea water we have no natural carbonates as a remedy, and the detrimental action of the magnesium salts that are always present is therefore unchecked."

Earthquakes.

Professor John Milne, the well-known specialist upon earthquakes, and seismological phenomena in general, recently delivered an interesting lecture before the Royal Geographical Society of Great Britain, upon "Seismological Observations and Earth-Physics." He pointed out the distinction which exists between macroseisms, or large earthquakes, and microseisms, or small earthquakes. The former he described as world-shaking disturbances, which occur only occasionally; while of the latter some thirty thousand are recorded annually, each of which disturbs from ten up to several hundred square miles of the earth's surface. All earthquakes belong either to the upper or the lower class. When a world-shaking earthquake takes place, and its origin is sub-oceanic, evidence is occasionally obtained that this has been accompanied by the bodily displacement of very large masses of material. For example, sea waves may be created which will cause an ocean like the Pacific to pulsate for many hours. The dimension of the mass which was moved — and which, inasmuch as the displacement was beneath the surface of the ocean, must have been moved suddenly to create an effect of this description — is not known. The observations made by cable engineers, which have shown that in the vicinity of the origin of such earthquakes depths have been greatly increased over a considerable area, enable rough approximations to be made respecting the mass of material moved. When the effect has extended to shore lines, it is possible to measure definite currents of elevation or depression. With large earthquakes which have originated on land surfaces, the accompanying displacements are visible, and their magnitudes are, to a certain extent, measurable.

Nearly all active volcanoes occur along the ridges of rock folds which are in proximity to oceanic waters. By the percolation of water to the foundations of these folds, and its subsequent contact with highly heated rocks, extraordinary pressures are developed, the sudden relief of which results in a volcanic outburst. If we accept a theory of this description, it is easy to imagine a stage when volcanic strain due to an increasing internal pressure was in a critical condition, and therefore likely to be destroyed by any movement in the rock fold where it existed. A good illustration of this relationship between sudden movements in rock folds and displays of volcanic activity was presented by the eruptions in the West Indies and the large earthquakes which have occurred there or in adjacent countries. From the recent geological history of the region it is shown that the Antilles once connected North and South America, while the Isthmus of Panama was submerged, the present Caribbean Sea being therefore a gulf of the Pacific. In Lower or Middle Miocene times, according to Dr. J. W. Gregory, Antillia itself was submerged, and abyssal oozes were deposited, which are now elevated in the Barbadoes to a height of 1,095 feet above sea level. In fact, the elevations and depressions of this region had been so great and performed with such rapidity that they had frequently been referred to by the opponents to the theory of the permanence of oceanic basins and continental masses. The most recent movements in the Antilles, as indicated by raised sea beaches, etc., have been upward. The inference to be drawn from the geological history of this region is that the Antillan ridge is one of unusual instability, and that is probably the reason that it is so responsive, volcanically, to adjustments in the neighboring geological folds.

It is in connection with such regions that seismograms are so valuable, since from these records of earth vibration obtained in epipocal areas, measures of earthquake energy expressed in mechanical units have been obtained. One result of this is that engineers and builders in earthquake-shaken countries now build to withstand known forces. In Japan it has been repeatedly shown that bridges and buildings constructed according to European practice are unable to withstand the severe shakings which so frequently occur in that country, and, therefore, as opportunity presents itself, the old types of structure are being replaced by forms which experience has proved to be less readily disturbed. The importance of seismology is so far recognized by the Japanese government, that at its university are a professor and assistant professor of this subject, whose duties in part consist in giving to students of engineering and architecture a course of instruction bearing on their future profession. The government also supports a bureau controlling about one thousand stations, and in addition to this it grants an annual subsidy to a committee, consisting largely of practical men, whose duty consists in making investigations which would lead to the mitigation of earthquake effects. This body investigates the destruction which occurs from time to time in Japan, and when a disaster takes place in Manila, India, or some distant country, a commission is dispatched to report on that which fell and that which remained intact. By this means Japan has become a repository for almost all that is known about applied seismology, and this systematic study has already been the means of saving life and property. Seismograms of unfelt earthquakes not only explain certain irregularities in magnetograms, but they also throw light on abnormal movements in the records from electrometers and barometers. Apparent changes in the rates of timepieces have frequently been traced to earth movements, the occurrence of which would not be suspected without the aid of seismograms. It has often happened that cables have been destroyed by submarine earthquakes, and to know the causes of such interruptions is of great importance, especially to communities who have by such occurrences been suddenly isolated from the outer world. The breaking of cables in certain instances has been regarded as an operation of war, with the result that military and naval preparations have been made, expenses of various descriptions incurred, and naturally much alarm caused, all of which would have been avoided by the inspection of a seismogram. These records enable us to locate submarine sites where it would be rash to lay a cable. Lastly, they enable us to confirm, correct, extend, and occasionally to disprove messages that have been received by cable, describing seismic catastrophes in distant countries. — *Scientific American Supplement.*

The Locomotive

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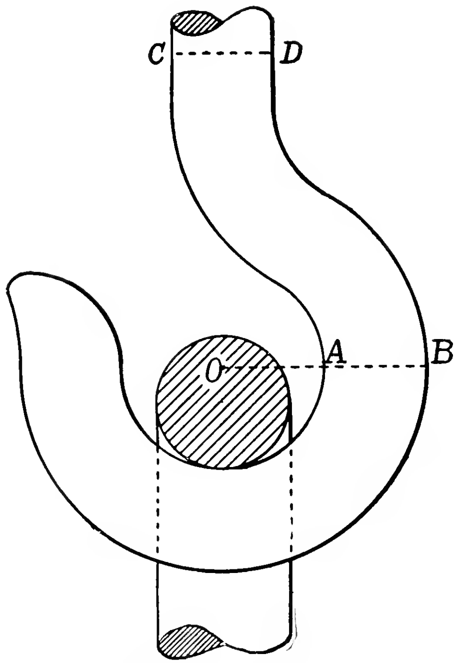
Concerning Hooks.

In the issue of The Locomotive for January, 1899, we discussed, at some length, the strength of the hooks that are often used for supporting boilers. We also gave the working loads that such hooks can bear, according to the accepted method of calculating the strengths of such appliances, without the material of which they are composed being anywhere strained beyond its elastic limit. The results that were obtained do not agree satisfactorily with the loads that such hooks are known to support, continuously and without distress, in regular practice,— a fact which we also pointed out at the time, although actual data for comparing the computed strengths with those calculated by theory were not then at hand. Mr. John L. Bacon has since made some experiments on this subject, which are to be presented at the Saratoga meeting of the American Society of Mechanical Engineers. He has compared the common form of hook with that proposed by Mr. Towne and described in our previous issue, and his general conclusion is that Mr. Towne's form does not possess any marked superiority over the more usual one. Some of the hooks were made of 5/8 inch stock, and others of 1 1/4 inch stock. The material was mild steel, having a tensile strength of 62,150 pounds per square inch. The two large hooks were cut from the same bar, and all the smaller ones were also cut from a single bar, upon which the tensile test was likewise made. In some cases the material was not specially treated. In others it was case-hardened or "carbonized" by heating with granulated raw bone, the small hooks being heated for eight hours and the large one for nine hours. The thickness of the carbonized coating so obtained was about 1/16 of an inch. Some of the hooks were annealed by a separate operation, after the carbonization, and others were



Common Form of Hook.

hardened in the usual way. These particulars are briefly indicated in the accompanying table, under the heading "Kind of Hook."

All of the hooks tested gave way about the section indicated by *AB* in the illustration, the Towne hooks yielding first by compression at *B*. We do not regard the increase of strength due to the hardening as of any great practical value, because, as has been often pointed out by authorities on this subject, a hook ought always to bend noticeably before it breaks, so that the workmen may have warning of its weakness. Hooks Nos. 3 and 6, it will be seen, broke under a load only 200 pounds greater than that at which the first yield was observed. This is too small a margin for good practice.

MR. BACON'S EXPERIMENTS.

No.	Kind of Hook.	Size Stock, Inches.	Yield began (lbs.).	Maximum Load. (Lbs.).	
				Bent.	Broke.
1	Plain, untreated, ...	⅝	2,500	3,000	....
2	Plain, untreated, ...	"	2,400	3,300	....
3	Plain, carbonized and hardened, . .	"	4,000	....	4,200
4	Plain, carbonized and annealed, . .	"	2,750	....	2,900
5	Plain, carbonized and annealed, . .	"	2,600	3,200	....
6	Plain. (This was the preceding hook, reformed and hardened.)	"	5,000	....	5,200
7	Towne hook, carbonized and hardened,	"	....	....	3,000
8	Towne hook, carbonized, ...	"	2,800	....	3,200
9	Towne hook, untreated, ...	"	3,000	3,500	....
10	Plain, carbonized and annealed, . .	1¼	9,000	....	13,500
11	Towne hook, untreated, ...	"	6,000	13,000	....

In the tables given in THE LOCOMOTIVE for January, 1899, it was assumed that the material of the hook is nowhere strained by more than 15,000 pounds per square inch. This corresponds to a factor of safety of 4.14, for a material, such as that used by Mr. Bacon, which has a tensile strength of 62,150 pounds per square inch. The average ultimate load sustained by hooks Nos. 7, 8, and 9, in the table, was 3,233 pounds, and this, with a factor of safety of 4.14, would indicate that a Towne hook, made of ⅝ inch stock, can support a load of $3{,}233 \div 4.14 = 781$ pounds, without being strained, at its weakest point, by more than 15,000 pounds per square inch. The load as calculated for this size and design of hook, and given in the table in our previous issue, is 590 pounds. The agreement is as close, perhaps, as could be expected. The safe load for a Towne hook made of 1¼ inch stock, and subject to the same condition as to maximum admissible stress, is given in our previous table as 2,420 pounds. Hook No. 11, in the present table, began to yield under a load of 6,000 pounds, though it withstood far more than this when it had straightened somewhat. The calculated value of the safe working load may here also be taken as reasonably satisfactory, so that the present experiments are in a sense confirmatory of the results obtained for Towne hooks by calculation, and printed in our previous issue.

The same can hardly be said of Mr. Bacon's experiments on hooks of the common form, for here we find that the experimental strength exceeds the strength as calculated from the principles ordinarily applied to such problems, by amounts that indicate that the theory of the common hook requires extensive revision.

Why be Good?

The announcement to the effect that the inmates of a county jail are to be provided with facilities for physical culture brings the reader again to that paradox of modern civilization by which a young man of exemplary character gets fewer advantages and opportunities than the young man who perseveres in a disregard for law.

Take two boys in an urban tenement district as illustrations. One boy is good. He attends school regularly. He is in a room in which there are twice as many boys as there ought to be, and in which the courses of instruction may have practically nothing to do with the industrial life to which he is destined. After a few years of perfunctory study he reaches his industrial majority — 14 — and he begins to work. He has learned no trade. His "general culture" is not exactly efflorescent. His chances of becoming anything better than an unskilled employee are slight.

How much better would it have been for him if he had been bad! First, he would have been sent to a school for truants. There he would have got much better food than at home, and, in general, much better physical conditions. Also, he would have had instruction much more adapted to his wants, because he would have been given a large amount of manual training.

After he was released from the school for truants, if he only had sense enough to keep on being bad, he would escape going to work, and he would be sentenced to a school of delinquents where his education would be continued. More games! More discipline! More manual training! All supervised by experts in the sciences of pedagogy and criminology.

Having become too old for the school for delinquents, our boy now proceeds to a reformatory. The good boy, whom we took leave of some time ago, is expiating his piety in a printing establishment in which he is trying to develop his faculties by means of shoving several thousand pamphlets a day through the throat of a stapler. Our bad boy, shrewdly sticking to his reformatory, gets lots of physical exercise, plenty of reading in the library, and a final fitting for his trade in the elaborately fitted reformatory tool shop. He steps out into the world at the age of twenty a trained American workman, uninjured by excessive toil as a boy, and prepared to use his skill in some trade in which skill means large wages.

Viciousness brings its own reward. — *Chicago Tribune.*

[We are sorry for the good boy, who fares so badly; but we shouldn't wonder if the state is better off, on the whole, for making a good citizen of the one who started on the wrong track. The other one would turn out to be a good citizen, anyhow, because he was born that way.]

Inspectors' Reports.

NOVEMBER, 1902.

During this month our inspectors made 12,152 inspection trips, visited 23,657 boilers, inspected 8,649 both internally and externally, and subjected 1,051 to hydrostatic pressure. The whole number of defects reported reached 11,823, of which 1,610 were considered dangerous; 88 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,144	73
Cases of incrustation and scale,	2,956	113

Nature of Defects.	Whole Number.	Dangerous.
Cases of internal grooving,	162	19
Cases of internal corrosion,	788	46
Cases of external corrosion,	522	44
Broken or loose braces and stays,	202	105
Settings defective,	398	23
Furnaces out of shape,	419	21
Fractured plates,	424	86
Burned plates,	559	51
Blistered plates,	103	12
Cases of defective riveting,	391	136
Defective heads,	91	13
Serious leakage around tube ends,	2,044	573
Serious leakage at seams,	420	27
Defective water-gauges,	268	76
Defective blow-offs,	282	84
Cases of deficiency of water,	20	3
Safety-valves overloaded,	92	29
Safety-valves defective in construction,	61	30
Pressure-gauges defective,	434	26
Boilers without pressure-gauges,	3	3
Unclassified defects,	40	17
Total,	11,823	1,610

DECEMBER, 1902.

During this month our inspectors made 12,667 inspection trips, visited 23,342 boilers, inspected 8,187 both internally and externally, and subjected 971 to hydrostatic pressure. The whole number of defects reported reached 11,219, of which 1,108 were considered dangerous; 104 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,113	54
Cases of incrustation and scale,	3,212	85
Cases of internal grooving,	200	49
Cases of internal corrosion,	794	73
Cases of external corrosion,	549	68
Broken and loose braces and stays,	166	21
Settings defective,	317	22
Furnaces out of shape,	360	15
Fractured plates,	328	55
Burned plates,	385	44
Blistered plates,	118	7
Cases of defective riveting,	385	113
Defective heads,	106	24
Serious leakage around tube ends,	1,447	207
Serious leakage at seams,	483	24
Defective water-gauges,	354	53
Defective blow-offs,	221	76
Cases of deficiency of water,	27	14
Safety-valves overloaded,	93	36
Safety-valves defective in construction,	78	17

Nature of Defects.	Whole Number.	Dangerous.
Pressure-gauges defective,	407	27
Boilers without pressure-gauges,	24	24
Unclassified defects,	52	0
Total,	11,219	1,108

Summary of Inspectors' Reports for the Year 1902.

During the year 1902 our inspectors made 142,006 visits of inspection, examined 264,708 boilers, inspected 105,675 boilers both internally and externally, subjected 11,726 to hydrostatic pressure, and found 1,004 unsafe for further use. The whole number of defects reported was 145,489, of which 13,032 were considered dangerous. The usual classification by defects is given below, and a summary by months is presented on page 71.

Summary, by Defects, for the Year 1902.

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	14,070	625
Cases of incrustation and scale,	38,487	1,007
Cases of internal grooving,	2,458	267
Cases of internal corrosion,	11,715	633
Cases of external corrosion,	8,131	645
Defective braces and stays,	2,546	703
Settings defective,	4,750	416
Furnaces out of shape,	5,355	259
Fractured plates,	3,951	633
Burned plates,	5,012	539
Blistered plates,	1,458	71
Defective rivets,	4,321	647
Defective heads,	1,176	220
Leakage around tubes,	21,563	3,019
Leakage at seams,	5,882	315
Water-gauges defective,	3,382	687
Blow-offs defective,	2,974	880
Cases of deficiency of water,	216	91
Safety-valves overloaded,	1,213	375
Safety-valves defective,	931	319
Pressure-gauges defective,	5,377	388
Boilers without pressure-gauges,	229	229
Unclassified defects,	292	64
Total,	145,489	13,032

Comparison of Inspectors' Work during the Years 1901 and 1902.

	1901.	1902.
Visits of inspection made,	134,027	142,006
Whole number of boilers inspected,	254,927	264,708
Complete internal inspections,	99,885	105,675
Boilers tested by hydrostatic pressure,	11,507	11,726
Total number of defects discovered,	187,847	145,489
" " of dangerous defects,	12,614	13,032
" " of boilers condemned,	950	1,004

We append also a summary of the work of the inspectors of this company from 1870 to 1902 inclusive. The years 1876 and 1878 are omitted, because the data that we have at hand for those years are not complete. The figures, so far

SUMMARY OF INSPECTORS' WORK SINCE 1870.

Year.	Visits of inspection made.	Whole number of boilers inspected.	Complete internal inspections.	Boilers tested by hydrostatic pressure.	Total number of defects discovered.	Total number of dangerous defects discovered.	Boilers condemned.
1870	5,439	10,569	2,585	882	4,686	485	45
1871	6,826	13,476	3,889	1,484	6,253	954	60
1872	10,447	21,066	6,533	2,102	11,176	2,260	155
1873	12,824	24,998	8,511	2,175	11,998	2,892	178
1874	14,368	29,200	9,451	2,078	14,256	3,486	163
1875	22,612	44,763	14,181	3,149	24,040	6,149	216
1877	....	32,975	11,629	2,367	15,964	3,690	133
1879	17,179	36,169	13,045	2,540	16,238	3,816	246
1880	20,939	41,166	16,010	3,490	21,033	5,444	377
1881	22,412	47,245	17,590	4,286	21,110	5,801	363
1882	25,742	55,679	21,428	4,564	33,690	6,867	478
1883	29,324	60,142	24,403	4,275	40,953	7,472	545
1884	34,048	66,695	24,855	4,180	44,900	7,449	493
1885	37,018	71,334	26,637	4,809	47,230	7,325	449
1886	39,777	77,275	30,868	5,252	71,983	9,960	509
1887	46,761	89,994	36,166	5,741	99,642	11,522	622
1888	51,483	102,314	40,240	6,536	91,567	8,967	426
1889	56,752	110,394	44,563	7,187	105,187	8,420	478
1890	61,750	118,098	49,983	7,207	115,821	9,387	402
1891	71,227	137,741	57,312	7,859	127,609	10,858	526
1892	74,830	148,603	59,883	7,585	120,659	11,705	681
1893	81,904	163,328	66,698	7,861	122,893	12,390	597
1894	94,982	191,932	79,000	7,686	135,021	13,753	595
1895	98,349	199,096	76,744	8,373	144,857	14,556	799
1896	102,911	205,957	78,118	8,187	143,217	12,988	663
1897	105,062	206,657	76,770	7,870	131,192	11,775	588
1898	106,128	208,990	78,349	8,713	130,743	11,727	603
1899	112,464	221,706	85,804	9,371	157,804	12,800	779
1900	122,811	234,805	92,526	10,191	177,113	12,862	782
1901	134,027	254,927	99,885	11,507	187,847	12,614	950
1902	142,006	264,708	105,675	11,726	145,489	13,032	1,004

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 by Months, for 1902.

Month.	Visits of inspection.	Number of boilers examined.	No. inspected internally and externally.	No. tested hydrostatically.	No. condemned.	Number of defects found.	Number of dangerous defects found.
January, .	12,716	24,457	7,367	919	85	11,210	927
February, .	10,194	19,425	6,198	619	65	9,293	806
March, . .	12,169	22,344	8,355	925	76	12,607	1,054
April, . .	11,684	21,654	8,665	953	83	11,538	919
May, . .	11,764	21,751	9,604	981	90	12,390	907
June, . .	11,440	20,460	9,881	1,032	93	13,487	1,310
July, . .	11,684	19,397	11,180	1,052	83	14,769	1,129
August, .	11,201	21,058	9,653	1,103	80	12,942	1,091
September,	10,884	21,245	8,846	1,005	91	11,966	1,056
October, .	13,451	25,918	9,090	1,115	66	12,245	1,115
November,	12,152	23,657	8,649	1,051	88	11,823	1,610
December,	12,667	23,342	8,187	971	104	11,219	1,108
Totals, .	142,006	264,708	105,675	11,726	1,004	145,489	13,032

The following table is also of interest. It shows that our inspectors have made over a million and three quarters of visits of inspection, and that they have made more than three million and a half inspections, of which more than a million and a third were complete internal inspections. The hydrostatic test has been applied in over a hundred and eighty thousand cases. Of defects, over two and a half millions have been discovered and pointed out to the owners of the boilers; and more than a quarter of a million of these defects were, in our opinion, dangerous. More than fifteen 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 Hartford Company Began Business, to January 1, 1903.

Visits of inspection made,	1,815,465
Whole number of boilers inspected,	3,568,838
Complete internal inspections,	1,381,657
Boilers tested by hydrostatic pressure,	185,819
Total number of defects discovered,	2,559,592
" " of dangerous defects,	270,856
" " of boilers condemned,	15,169

The Locomotive.

HARTFORD, MAY 15, 1903.

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

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The First American Locomotives in England.

As long ago as the year 1840 the first American locomotives for an English railway arrived in England from Philadelphia. There were four, built by Norris & Company for the Birmingham & Gloucester Railway, now a part of the extensive Midland system. They were ordered at the instigation of Captain Moorsom for working the Lickey incline between Blackwell and Bromsgrove, which is nearly two miles long, upon a gradient of 1 in 37. These four engines were alike in dimensions, and had cylinders 10½ inches in diameter, with a stroke of 18 inches. The driving wheels were 4 feet in diameter, and the total weight of the engine, in working order, was about 9½ tons. They bore the respective names "England," "Philadelphia," "Columbia," and "Atlantic," and were certainly very successful engines, considering the heavy loads that they were put to. Their usual work consisted of a load of 33 tons drawn up the Lickey incline at a speed of 12 or 15 miles per hour, and the maximum work was drawing up a load of 53¼ tons at a speed of 8½ miles per hour. Shortly after these locomotives had proved their good capabilities eight more were ordered from the same builders, Messrs. Norris & Company. It is interesting to note that all of the engines worked satisfactorily excepting one, which unfortunately blew up soon after being put in service. Two men were killed by the explosion, and were buried in Bromsgrove churchyard, where their tombstones may still be seen, with a carving of the exploded locomotive on each. The inscription on one of the stones is as follows:

"Sacred to the memory of Thomas Scaife, late an engineer on the Birmingham and Gloucester Railway, who lost his life at Bromsgrove station by the explosion of an engine boiler, on Tuesday the 10th day of November, 1840. He was 28 years of age, highly esteemed by his fellow workmen for his many amiable qualities, and his death will be long lamented by those who had the pleasure of his acquaintance.

My engine now is cold and still,
No water does my boiler fill;
My coke affords its flame no more,
My days of usefulness are o'er;
My wheels deny their noted speed,
No more my guiding hand they heed;
My whistle, too, has lost its power [tone?],
Its shrill and thrilling sounds are gone;
My valves are now thrown open wide,
My flanges all refuse to guide;

My clacks, also, though once so strong,
Refuse to aid the busy throng;
No more I feel each urgent breath,
My steam is now condensed in death;
Life's railway's o'er, each station passed,
In death I'm stopped, and rest at last;
Farewell, dear friends, and cease to weep,
In Christ I'm safe, in Him I sleep."

The other stone bears the inscription:

"Sacred to the memory of Joseph Rutherford, late engineer to the Birmingham and Gloucester Railway Company, who died November 11, 1840, aged 32 years.

Oh, reader, stay, and cast an eye
Upon this grave wherein I lie;
For cruel death has challenged me,
And soon also will call on thee;
Repent in time, make no delay,
For Christ will call you all away;
My time was spent like dew in sun,
Beyond all cure my glass is run."

A long interval of over forty years followed the importation of the Norris engines, and no other American locomotive made its appearance on an English railway until 1882, when the Eames Vacuum Brake Company carried over the 5,000th locomotive built by the Baldwin Locomotive Works.—*Railway Machinery.*

The Newly-Discovered Mysteries of Physics.

Students of physics are prepared now, better than ever before, to appreciate the force of Hamlet's remark, that there are more things in heaven and earth than are dreamed of in our philosophies. The discovery of the mysterious element radium, and its unique properties, has opened up a new vista, and suggested possibilities that were never contemplated before by any physicist, even in his most imaginative moments. It has been found that radium sends out heat continuously without any sensible loss of substance or sensible diminution in the rate at which the heat is emitted, even when the experiments extend over months. It appears to us that some of the speculations that have been advanced in connection with this phenomenon are without adequate experimental or theoretical basis; but this point can hardly be settled yet, until we have a more accurate knowledge of the precise phenomena that the element manifests. Nobody has yet seriously maintained that the continuous emanation of heat from radium implies the possibility of perpetual motion, but Sir William Crookes and others have advanced the hypothesis that it is to be explained on the assumption that the second law of thermodynamics (which states that heat will not pass from regions where the temperature is low to regions where it is higher) is violated in some manner, the heat radiated from the radium being obtained somehow from the surrounding air, even though the air is at a lower temperature. Another hypothesis, which is in great present favor, although it appears to be quite improbable from many points of view, is that radium and the other substances that have similar properties are perpetually giving off a rain of ultra-atomic particles, whose kinetic energy is responsible both for the chemical effects that those bodies produce and for the apparent perpetual loss of heat. According to this view radium is a magazine of energy which must ultimately become exhausted, but which is capable of delivering kinetic energy for vast periods and in vast amounts before the resulting loss of matter from the radium itself can be detected by the chemist's balance. The following editorial from the *New York Sun* presents this view of the case very fairly.

"Perhaps no scientific discovery of recent times has awakened such general interest as that of spontaneous radiation. When Becquerel showed that the substance uranium is capable of evolving energy continuously without a supply of any kind, the fundamental law of the conservation of energy seemed seriously shaken. *Ex nihilo nihil fit* had become an accepted dictum of science, alike for matter and for energy; and to bring either of these into existence from nothing, seemed of necessity to involve the exercise of creative power. Meanwhile investigations went on. New substances were discovered, hitherto unknown to chemistry, possessing this new property of emitting energy uninterruptedly and without any assignable cause to an extent a million times greater than uranium could do. Radium was found to emit excessively minute corpuscles with such immense velocity that the energy of a single grain of them represents about two hundred million foot tons! Actual measurements have shown that this new radio-element sends out every twenty-four hours thirty times as much energy in the form of heat as an equal weight of oxygen and hydrogen evolve when they combine to form water; an amount greater than is produced in any other chemical reaction. The energy of the changes accompanying radio-activity, therefore, must be enormous. Rutherford tells us that it is at least twenty thousand times, and it may be a million times, as great as that of the most intense molecular changes known; such, for example, as that set free by modern explosives.

"But since the carriers of this energy are moving particles, it was natural to inquire whether this emission of energy must not necessarily result in a corresponding loss of matter. So Becquerel calculated what this loss would be; and he finds that a single square inch of radio-active surface will radiate into space only a single gram of matter in ten million years. To detect the infinitesimal trace of matter thus emitted during the time of an ordinary experiment would seem entirely hopeless. And yet so wonderfully has the delicacy of modern instruments of research been increased that, as we are told, 'if 1,000 grams of thorium produced the thousandth part of a gram of emanation in a million years, the amount from one gram in one second could still be, as it actually is, easily detected by the electrometer.' This instrument, therefore, will detect in one minute an amount of matter which must accumulate for two million years before it becomes sufficient to be recognized by the chemical balance. [It should be remarked, however, that this statement assumes that the radiation *really is* material in its nature. — ED. LOCOMOTIVE.]

"Inasmuch as the term radio-activity represents simply the property which certain bodies possess of emitting rays, it is evident that the three radio-active elements, uranium, thorium, and radium, are so called because they emit their energy in this form. These rays are supposed to consist of material particles projected with a high velocity. We are told that practically all the energy of a radio-active substance is emitted by two sorts of rays, one of which consists of negatively electrified particles, each having a mass of only one-thousandth of that of the atom of hydrogen and moving with nearly the speed of light; the other, which is by far the more important, since it constitutes about 99 per cent. of the total radiation, consists of positively charged particles, whose mass is approximately that of the entire hydrogen atom, and whose speed is less than one-tenth of the above value. It is the former sort of particles to which Thomson has given the name 'corpuscles,' which he considers to be electrons or masses of electricity.

"Since radio-activity is a specific property of the chemical element itself which exhibits it, and since during the process this element is continually losing particles of its substance, the changing system involved must necessarily be the atom. In any radio-active changes, therefore, it must be the chemical atom which undergoes disintegration. The system which remains after the expulsion of these heavily charged particles from it must be lighter than before, and must possess different physical and chemical properties from the original substance. But rays may be again expelled from the new body, and so a second new system may result, and so on. Rutherford has shown us, for example, that the emission of rays from thorium is the accompaniment of a continuous change of this element into new kinds of matter. The first product of this radio-active change he calls 'thorium X.' It has well-defined chemical properties of its own, quite unlike those of thorium. The expulsion of rays from 'thorium X' accompanies the production of a gaseous element, the so-called 'thorium emanation.' This is a radio-active gas capable of liquefaction at 180° Fahr. below zero, remarkably inert chemically, and resembling the monatomic gases argon and helium. Another loss of particles takes place with the production of a third new substance, the so-called 'excited activity,' capable of being volatilized at a fixed high temperature, and of being deposited again on cooling and of being dissolved by certain solvents. Investigation has indicated the existence of at least two still further similar changes.

"What a revolutionary result have we now reached! The thorium atom, universally believed, since its discovery by Berzelius three-quarters of a century ago, to be a single and indivisible particle of matter, now appears as the progenitor of five new substances, even more elemental than itself, evolved by successive and spontaneous changes within its substance. 'Radio-activity,' says Soddy, 'has introduced us to new kinds of change, so that now it is no longer possible to consider the atom as the unit. But the moment the atom also is regarded as composed of parts, each perhaps with a definite motion of its own inside the system, it is easy to see at least a possible mechanism by which an element could undergo slow spontaneous changes.'

"But the phenomena of radio-activity become even more wonderful when we consider the atom as a storehouse of energy. We have seen that while, on the one hand, the amount of matter which is involved in radio-active change is wellnigh infinitesimal, the energy concerned, on the other, is colossal. 'On the one hand we have a change so slow that milliards of years are necessary for its consummation; on the other, a change of energy so great that it is possible to detect it at any instant over the whole period, by experiment.' Until Becquerel's discovery, what did we know of the internal energy of an atom? Before the discovery of radio-activity, the idea of intratomic energy was wholly unknown to science. Its development now demonstrates the existence in the universe of an amount of energy which has never even been dreamed of. The conversion of atomic potential energy into kinetic energy upon the surface of the sun, for example, would furnish him a supply of radiating power far in excess of that which the accepted theory of meteors could supply. As it has been said, what controls these gigantic forces is still a mystery. The knowledge of their existence, however, must alter our attitude toward inanimate matter and make us regard the planet on which we live rather as a storehouse stuffed with explosives, inconceivably more powerful than any we know of, and possibly only awaiting a suitable detonator to cause the earth to revert to chaos."

Boiler Explosions.

NOVEMBER, 1902.

(320.) — On November 1st a boiler exploded on a farm at Caledonia, near London, Ont., badly injuring Otis Johnson.

(321.) — The boiler of locomotive No. 1724 of the Baltimore & Ohio Railroad exploded, on November 2d, between Halethrope and St. Denis, some seven miles west of Baltimore, Md. Engineer E. W. Biggs, fireman O. W. Hunt, and head brakeman C. O. Stalling were killed. The explosion consisted in the failure of the crown-sheet. The boiler of the locomotive was blown clear of the running gear, and the wheels did not leave the track. The locomotive was making its second trip after coming from the shop, and was believed to be in first-class condition.

(322.) — The boiler of a freight engine exploded, on November 5th, at Mentor, Ky. Fireman Frank Thornton of Covington was fatally scalded, so that he died shortly afterwards.

(323.) — On November 5th a boiler exploded in the United Oil Company's pumping plant at Florence, Col. D. W. Gass, a pumper, was fatally injured, and the boiler house was demolished.

(324.) — On November 6th a boiler exploded in the Delaware Steam Laundry at Delaware, Ohio. Miss Ida Tracey, who was in an adjoining room, was struck by flying debris and seriously injured. We have seen no estimate of the property loss.

(325.) — On November 6th a boiler exploded on the tug-boat *Fred Nellis*, at Mound City, Ark. William Phillips and Mrs. Josephine Hill were killed, and Willie Gillem was fatally injured. Three other persons were also injured to a lesser extent.

(326.) — A small boiler explosion occurred, on November 7th, in the press-room of the *Arkansas Democrat*, at Little Rock, Ark. Nobody was injured, and the property damage was small.

(327.) — A boiler exploded, on November 9th, in the Queensborough pumping station, at North Beach, N. Y. Engineer William Digby and fireman James Nelson were killed, and the pumping station was totally destroyed, everything about the building being swept level with the ground. The boiler was thrown to a distance of about 200 feet, cutting off numerous trees in its passage as readily as if they were toothpicks. The property damage is estimated at $25,000.

(328.) — On November 10th a boiler exploded in F. N. Hawkins' sawmill, three miles from Dover, N. C. Henry Tucker was very seriously and perhaps fatally injured, and Mr. Hawkins and George Gray were also injured to a lesser extent.

(329.) — The boiler of a threshing machine belonging to Alexander Seaton exploded, on November 11th, on the farm of P. Sprenkle, some three miles north of Cowles, Neb. The thresher was totally demolished, and Harry Conway, Peter Howe, Charles Sprenkle, and Kanan Sprenkle were seriously injured.

(330.) — The boiler of a cotton gin belonging to N. A. Davis exploded, on November 12th, near Pittsburg, Texas. The boiler house was completely destroyed, but the employees were all at dinner, and there are no personal injuries to record.

(331.) — On November 12th a traction engine boiler, belonging to Louis Clapp, exploded about two miles south of Marysville, near Jeffersonville, Ky. Several men were near the machine at the time, but nobody was injured.

(332.) — A boiler exploded, on November 13th, in the Eagle flouring mill, at New Ulm, Minn. Fireman George Ebenhoh was injured so badly that he cannot recover. The roof and rear wall of the boiler house were blown away.

(333.) — On November 13th a large boiler, used in connection with a puddling furnace, exploded in the West Works of the American Iron and Steel Manufacturing Company, at Lebanon, Pa. Jacob Bricker, Walter Turner, and James Hissinger were instantly killed, and Wallace Oakes, James Nein, John Hable, Frank Murray, Simeon Pottinger, John Hershey, and one other man, died within a day or two from the injuries that they received. At least thirty others are reported to have been injured to a lesser extent. A large portion of the boiler was thrown high into the air, passing over the offices of the company and finally burying itself in the south bank of Quittapahilla creek, several hundred yards away. Nine of the puddling furnaces were wrecked, and the total property loss was about $35,000.

(334.) — A boiler belonging to Green & Contard, and used in drilling an oil well, exploded, on November 14th, about a mile and a half south of Cannonsburg, Ohio. The boiler was destroyed, and it is reported that a tool dresser was painfully injured; but we have not learned full particulars.

(335.) — On November 18th a boiler exploded in Thomas Tadlock's cotton gin, at Marshville, near Monroe, N. C. Alexander Tadlock was thrown to a considerable distance and instantly killed, and Ellis Tadlock was also fatally injured. Another man, whose name we have not learned, received lesser injuries.

(336.) — On November 19th a boiler exploded in the plant of the Snohomish Electric Light and Power Company, at Snohomish, Wash. Richard Padden was killed, and Adam Anderson and John Mulleken were seriously injured. The damage to the buildings was considerable, and the pump of the city water works was wrecked.

(337.) — The boiler of a locomotive exploded, on November 21st, at Centretown, a small station near Jefferson City, Mo. Engineer Ruby was injured very seriously, and fireman Anderson received lesser injuries. The explosion consisted in the failure of the crown sheet.

(338.) — The boiler of a ten-wheeled "battleship" locomotive exploded, on November 22d, on the Kansas & Arkansas division of the Missouri Pacific Railroad, near Osawatomie, Kan. Engineer John Lund was killed almost instantly.

(339.) — A small hot-water boiler exploded, on November 22d, in the Neighborhood House, a Jewish social settlement in St. Paul, Minn., in which sewing and other arts are taught to children. The heater was thrown up through two floors, and considerable loss of life would undoubtedly have resulted if the day had not been Saturday, and the children therefore absent. Only two persons were in the building at the time, and both of these escaped injury. The building itself was damaged to the extent of about $1,000.

(340.) — On November 23d a boiler exploded in the County Home at Uniontown, Pa. John Fox had his left hip broken, and Hugh Friel was painfully scalded.

(341.) — The boiler of locomotive No. 656 of the Pittsburg, Virginia & Charleston Railroad exploded, on November 23d, at Thompson, near McKeesport, Pa. John Markowitch, a track walker, was killed, and Charles Lindle, William Lawrence, James Meyers, F. P. Stang, Michael Markowitch (a brother of the man killed), C. C. Killer, and F. J. Hunter were seriously injured. The locomotive was destroyed.

(342.) — On November 24th the boiler of freight engine No. 2113 of the Pittsburg division of the Pennsylvania Railroad exploded, at Mineral Point, thirty-two miles west of Altoona, Pa. Daniel J. Pringle and Scott Seese were killed, and Samuel L. Davis, Alfred Snyder, and Harry Miller were seriously injured.

(343.) — The boiler of a gristmill exploded, on November 24th, at Clearmont, Warren County, Tenn., some ten miles west of McMinnville. William Lowe and George W. Haley, Jr., were instantly killed, and John Haley was fatally scalded.

(344.) — On November 24th a portable boiler, used in railroad construction, exploded, on Charles Strohm's farm, in Lyons, N. Y. Nobody was injured, although some twenty men were standing about at the time. One of the accounts that we have received says that "the boiler had been in service a long time, and probably needed trading off."

(345.) — An agricultural boiler exploded, on November 25th, on the Coleman estate, near Lebanon, Pa. Nobody was injured, but the barn in which the boiler stood was burned, together with its contents, and the property loss is estimated at $15,000.

(346.) — A boiler exploded, on November 25th, in Frank Manus' slaughter house, at New Albany, Ind. George Heckel was struck by flying debris and painfully injured. The slaughter house and several adjoining buildings were slightly damaged, the total property loss being about $1,000.

(347.) — A small heating boiler exploded, on November 28th, in the basement of Rothert & Co's furniture store, Richmond, Va. J. H. Ficke and F. P. Peck were painfully scalded, but neither is considered to be injured seriously. The property loss was small.

(348.) — The boiler of locomotive No. 1305 of the Union Pacific Railroad exploded, on November 28th, between Cheyenne Wells and Denver, Col. We have not learned further particulars.

(349.) — A boiler exploded, on November 28th, in Rogers' sawmill, near Lizella, a station on the Macon & Birmingham Railroad, twenty-one miles from Macon, Ga. Paul Rogers (owner of the mill), J. A. Taylor, Henry Johnson, and Arthur Johnson were instantly killed, and the mill was utterly destroyed.

(350.) — On November 29th a boiler exploded on Spindle Top, near Beaumont, Tex. Henry Austen was seriously injured. We have not learned further particulars.

(351.) — A hot-water boiler exploded, on November 29th, in Ruestow Bros.' greenhouse, in the town of Greece, near Rochester, N. Y. The roof and sides of the greenhouse, which was a structure over 200 feet in length, were completely shattered, and the establishment was almost entirely destroyed. Nobody was injured, as the explosion occurred in the night.

(352.) — A boiler exploded, on November 29th, in D. A. Guider's sawmill, two miles north of McGuffey, Hardin County, Ohio. D. A. Guider, Albert Armentrout, and Oscar Decker were instantly killed. The mill was entirely wrecked, and pieces of the boiler were found over a mile away from the site of the explosion.

(353.) — On November 29th a boiler exploded in Swift & Co.'s refrigerating plant, at Chicago, Ill., with terrible consequences. A. P. Berg, Hugh Arnold, William Parks, Thomas Cubit, B. C. J. Henry, James Owen, Samuel Tate, Emil Rachner, John Stanizyk, A. M. Bushnell, Moses Berryman, John Walsh, T. Holmes, E. Wright, and C. Webb (fifteen in all) were killed, and J. Chandler, R. Venable, J. Frank, P. Snooks, E. H. Ellis, E. Suttennich, J. Sailer, R. Schultz, F. Tomak, G. Teshner, J. D. Cooper, Everett Minich, N. F. Oliver, F. James, F. C. Francis, Emil Olsen, W. Dewitt, Nicholas De Boer, John Augustine, John D. Ogden, J. J. Burke, H. Pillash, William T. Wells, James McArdle, M. T. Ash, and a Miss Cullum (twenty-six in all) were injured. The building in which the boiler stood was wrecked, little remaining of it but a heap of tangled iron and wood, and the property loss amounted to something over $15,000. The explosion was apparently due to "cutting in" the exploded boiler (that is, connecting it with the other boilers in the battery after it had been out of service for a time) before the pressure within it had been raised to that prevailing in the remaining boilers. The shock caused by the sudden increase of pressure due to the steam that entered it from its neighbors proved too great for its strength, and the explosion was the result.

By the death of Professor Josiah Willard Gibbs, which occurred on April 28th, Yale University loses one of its most distinguished professors, and the world at large loses one of its greatest men of science. He was born on February 11, 1839, and was graduated from Yale in the class of 1858. For the next five years he pursued special studies at Yale, and in 1863 he became a tutor there. In August, 1866, he went to Europe, where he studied physics and mathematics in Berlin, Heidelberg, and Paris, returning to this country in June, 1869. In July, 1871, he was elected Professor of Mathematical Physics in Yale University, a position which he filled with distinction up to the time of his death. Professor Gibbs was a wonderfully kind-hearted man, with a genial and sunny disposition which endeared him to all who knew him. The subjects with which he dealt were exceedingly difficult, but he treated them with an extraordinary power and originality, and his lectures were profoundly stimulating and suggestive. His writings were not voluminous, but everything that came from his pen was pregnant with new ideas and broad generalizations. Ostwald, one of the greatest authorities upon physical chemistry, has justly said that certain papers written by Professor Gibbs more than a quarter of a century ago contain, explicitly or implicitly, a large part of the discoveries since made in physical chemistry; and he adds that untouched treasures "in the greatest variety and of the greatest importance" still lie within them. Professor Gibbs never attempted to apply his intellect to commercial ends; but as a discoverer of new principles in science he has had few equals in this country, and perhaps none.

The Locomotive

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The Construction of Seamless Boiler Shells.

At the recent Dusseldorf Exhibition, in the pavilion of the Rheinische Metallwaaren und Maschinen Fabrik, the products of the Ehrhardt hydraulic pressing process were exhibited. These works were established in 1889 by Mr. Ehrhardt, and now, with their supplemental works, employ more than 6,000 hands. The process is briefly described by Mr. G. Lentz of Dusseldorf, in the May issue of the *American Engineer*, to which paper we are indebted for the material from which the present article was prepared.

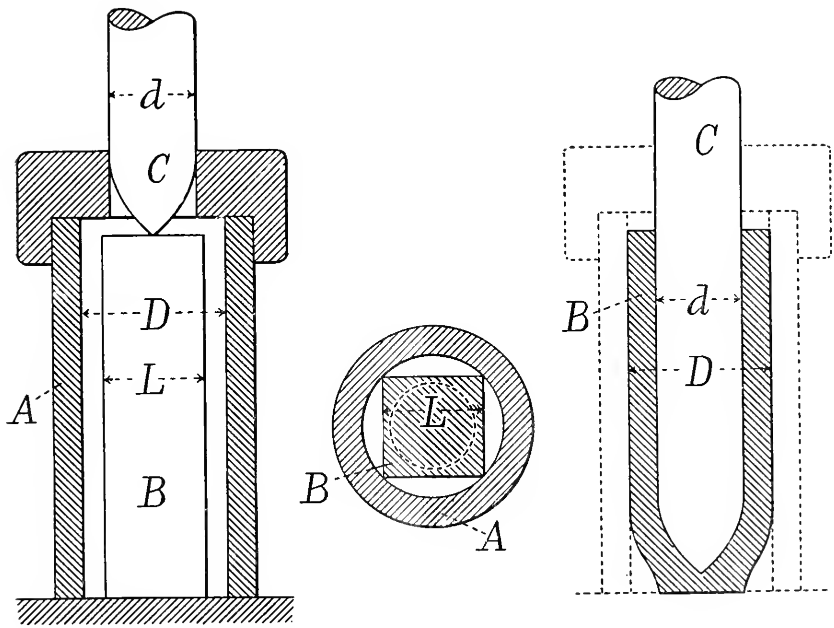

FIG. 1. FIG. 2. FIG. 3.

THE EHRHARDT METHOD OF PERFORATING STEEL BILLETS.

The manufacture of a seamless boiler shell by the Ehrhardt process involves two distinct operations: — the manufacture of a thick-walled cylinder from a solid billet of steel, and the subsequent enlargement of this cylinder (by the action of a set of rolls) until it assumes the dimensions of the shell desired. We shall consider these two parts of the process separately, beginning with the perforation of the solid block.

To produce a hollow cylinder by this method a square piece of red-hot steel, *B* in Fig. 1, is placed within a hollow cylindrical matrix, *A*, and a mandrel, *C*, is forced down through it, so as to swell it out against the sides of the matrix. As the piece *B* is free to expand laterally, this operation is quite feasible, and the mandrel can be forced down without difficulty, by means of a hydraulic press. A comparison of Figs. 1 and 3, in which corresponding parts are similarly lettered, will make the nature of the operation clear.

Certain of the distinctive features of the Ehrhardt process for perforating solid blocks of metal are further illustrated in Fig. 2. The various dimensions of the apparatus and of the work are adapted to one another, for example, in such a way that the block to be perforated will be held firmly in position during the introduction of the mandrel, and so that at the end of the operation it will have been forced out snugly against the walls of the matrix *A*, without being subjected to any material modification in its length. One thing that is essential to the realization of these ends is to choose the sizes of the matrix and of the block to be worked so that when the block is first put in position, its diameter, measured diagonally, is just equal to the internal diameter of the matrix. This

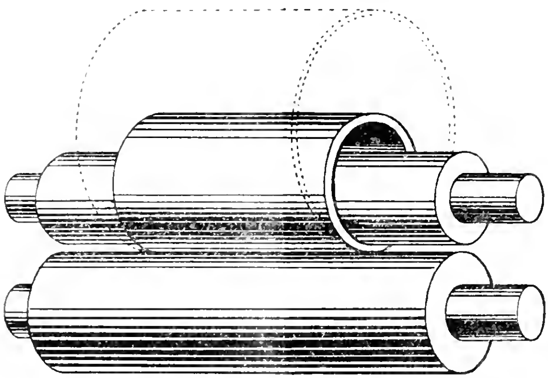

FIG. 4. — ROLLING OUT THE PERFORATED BLANK.

implies that the diameter of *B*, as measured along the side of the piece, and denoted by *L* in Figs. 1 and 2, shall always be 0.707 of the internal diameter, *D*, of the matrix. This does not necessitate the use of odd sizes of stock for the block *B*, because the matrix, *A*, can easily be made so as to accommodate a billet of any proposed size. For example, if *D* is made equal to 5.657 inches, the matrix *A* will be adapted to billets 4 inches square (since $5.657 \times 0.707 = 4.000$).

A second essential to the realization of the conditions mentioned above is to choose the size of the mandrel *C* so that when it has been forced down into the position shown in Fig. 3, the billet will have been just brought out into good contact with the interior surface of the matrix *A*. In Fig. 2 the mandrel is indicated by the dotted circle, and it is plain that the geometrical condition that must be fulfilled in order that the billet *B* may be just forced out against *A* by the mandrel is that the area of the dotted circle shall be precisely equal to the united areas of the four unshaded segments. In order that this may be the case it is easily shown to be necessary and sufficient to make the diameter of the mandrel, *d*, equal to 0.603 times the internal diameter, *D*, of the matrix. Of course the matrix and the mandrel need not necessarily be circular in cross-section, and, in fact, various other shapes are given to them in certain cases, when products of other forms are desired. The circular shape, however, is far more common in actual work.

The hollow cylinder which is formed by this process will necessarily have a thickness equal to 0.197 of its external diameter; and when it is desired to produce tubes of less thickness the hollow billets that are obtained as described above are drawn out in the usual manner. It is said that the German Admiralty Office uses these tubes exclusively in marine boilers and for other purposes in which strength and uniformity of material are essential. It is plain that tubes of poor quality can be made by this process, however, provided certain precautions are not taken; but we do not propose to discuss this aspect of the Ehrhardt process at the present time, our immediate object being merely to illustrate its general principles.

Heavy billets, after being perforated as described above, are rolled out into boiler-barrels, in the Ehrhardt shops, as indicated in Fig. 4. Mr. Ehrhardt uses

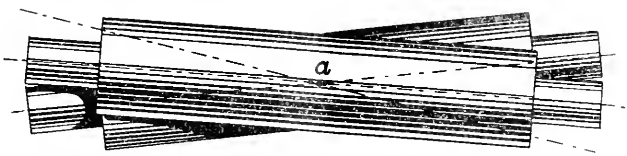

Fig. 5. — Illustrating the Swiveling of the Rolls.

a rolling mill with two rollers, of which the top roller takes the hollow billet, and the bottom one swivels in rolling. The hollow billet is made of such a diameter that it easily goes over the top roller, the bottom of the original blank being cut off so that a cylinder of the finished length remains. The bottom roller is arranged to swivel right and left, about the center point, denoted by *a* in Fig. 5; and it is pressed upward by a uniform hydraulic pressure. When the lower roller is in the inclined position it bears upon the work only in the middle; but as it swings back into the parallel position, the pressure spreads gradually away from the middle, until it is exerted against the whole length of the work. This action, when intelligently regulated, tends to counteract the inevitable bending of the rolls, and cause the cylinder to be of equal thickness in all its parts. Shells for marine boilers, having a diameter as great as sixteen feet, are said to be rolled up in this manner at the Ehrhardt works.

Inspectors' Report.

January, 1903.

During this month our inspectors made 13,836 inspection trips, visited 26,895 boilers, inspected 8,342 both internally and externally, and subjected 846 to hydrostatic pressure. The whole number of defects reported reached 11,900, of which 1,232 were considered dangerous; 75 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,177	83
Cases of incrustation and scale,	3,259	117
Cases of internal grooving,	230	8
Cases of internal corrosion,	836	44

Nature of Defects.	Whole Number.	Dangerous.
Cases of external corrosion,	578	51
Broken or loose braces and stays,	175	44
Settings defective,	342	23
Furnaces out of shape,	510	12
Fractured plates,	400	93
Burned plates,	476	59
Blistered plates,	107	3
Cases of defective riveting,	480	49
Defective heads,	73	17
Serious leakage around tube ends,	1,433	334
Serious leakage at seams,	665	50
Defective water-gauges,	225	44
Defective blow-offs,	284	63
Cases of deficiency of water,	23	10
Safety-valves overloaded,	118	55
Safety-valves defective in construction,	81	24
Pressure-gauges defective,	386	34
Boilers without pressure-gauges,	13	13
Unclassified defects,	29	2
Total,	11,900	1,232

Boiler Explosions.

DECEMBER, 1902.

(354.) — On December 1st a slight boiler explosion occurred in the Regal Textile Company's factory, at Utica, N. Y. Nobody was injured, and the damage to property was small.

(355.) — On December 2d a boiler exploded in Mr. J. Lowe's sawmill, in Cannon county, Tenn. Mr. Lowe and his two sons were instantly killed, Mr. Lowe's body being thrown to a distance of sixty feet.

(356.) — A boiler exploded on December 4th, in Meyers' sawmill, at Jamestown Center, near Grand Rapids, Mich. John Sneden was bruised and cut about the head. The building was partially wrecked, and the boiler was thrown about 200 feet.

(357.) — On December 5th the boiler of a portable engine exploded on the farm of Mrs. David Springer, in Liberty Township, near Mooresburg, Montour county, Pa. Warren S. Mauger was instantly killed, and his uncle, John Mauger, was badly injured.

(358.) — On December 7th a boiler exploded in D. A. Guider's sawmill, two miles north of McGuffey, Hardin county, Ohio. D. A. Guider, Albert Armentrout, and Oscar Decker were killed. We have not learned further particulars.

(359.) — A boiler exploded on December 8th, in Schmitt & Steinbrecher's sawmill, four miles west of Bruce's Crossing, near Ontonagon, Mich. Henry Steinbrecher, Henry Hawes, and William Kind were instantly killed, and the mill was entirely wrecked.

(360.) — A boiler exploded on December 9th, in a sawmill near Arcola, Warren county, N. C. John W. Williams and Mark Alston were killed.

(361.) — The plant of the Starbird Lumber and Timber Company, of Apopka, Fla., was totally wrecked by the explosion of a boiler on December 9th. F. C. Lovell, W. H. Eavenson, Orange Calloway, and Morris Chisholm were severely injured, and D. W. High, Shelton Hiers, and Samuel Porter were also injured in a lesser degree. We have seen no estimate of the property loss, but we are informed that it was heavy.

(362.) — Otto Pearceburger was painfully injured on December 10th, by the explosion of a portable boiler on the Lewelling place, a short distance west of Wichita, Kans. The damage to property was small.

(363.) — On December 11th a boiler exploded in the Ainslee mill, at Rockland, N. Y. The building was somewhat damaged, but fortunately nobody was injured.

(364.) — On December 13th the boiler of a passenger locomotive exploded on the Chicago, Peoria & St. Louis railroad, between Chesterfield and Medora, Ill. The engineer and fireman were fatally scalded, and the locomotive was completely wrecked.

(365.) — On December 13th the boiler of a passenger locomotive exploded on the Santa Fé Pacific railroad, at Nelson siding, some sixty miles east of Kingman, Ariz. Engineer Thomas Martin and fireman George Van Atta were instantly killed. The explosion consisted in the failure of the crown sheet, which was found wrapped around the trucks of one of the cars. The main portion of the boiler was thrown to a distance of 200 feet.

(366.) — A boiler exploded on December 13th, at the Mitchell mine of the Webster Coal & Coke Company, near Hastings, Pa. Charles Krebs was killed, and Harry Heater was painfully injured. The boiler house was demolished.

(367.) — A boiler exploded on December 15th, at North Bridgewater, N. Y. It was used for grinding grain on the farm of James McDermott. Mr. McDermott was injured so badly that he died a week later.

(368.) — A heating boiler exploded on December 16th, in Harry E. Carpenter's residence, at Attleboro, Mass. Nobody was injured, but the house was damaged to a considerable extent.

(369.) — On December 17th a boiler exploded in Hall & Wallace's cotton gin, at East Dougherty, some ten miles south of Albany, Ga. Charles Seamore was killed, and William Barber was fatally injured. Allen Anderson also received minor injuries. The cotton gin was wrecked, and the property loss is estimated at $3,500.

(370.) — On December 17th a boiler exploded in the Cummer Lumber Company's plant, at East Jacksonville, Fla. The fireman, whose name we have not learned, was badly scalded. Another employé was also injured somewhat by flying bricks. One end of the "No. 2" mill, in which the boiler was situated, was wrecked. We have seen no estimate of the property loss.

(371.) — A boiler exploded on December 18th, in A. A. Lee's sawmill, four and one-half miles south of Elwood, Ind. Albert Lee (a son of the owner of the mill) was fatally injured, and Lemuel Samuels was injured seriously but not fatally. The mill was completely demolished, and one large fragment of the boiler was thrown to a considerable distance.

(372.) — On December 19th the boiler of locomotive No. 502, on the Central Massachusetts division of the Boston & Maine railroad, exploded near Jefferson, Mass. Engineer W. S. Weeks, fireman H. F. Tilly, and brakeman Matthewson were slightly injured, but all three were able to be about again in a day or two.

(373.) — On December 19th the boiler of a locomotive used on a tram road exploded at Moore's Lumber Mills, at Pearson, near Waycross, Ga. Henry Merritt, Angus Gillis, Manning White, Mack Dunbar, and a man named Lewis, were seriously injured.

(374.) — A boiler exploded on December 19th, in H. H. Mathews' red slate quarry at East Whitehall, N. Y. Horace Bemis was killed, his body being thrown 150 feet into the pit. Charles Holcomb was fearfully injured, and at last accounts it was thought that he might die. Daniel Flaherty and Frederick Bemis were also severely burned.

(375.) — A boiler of a steam shovel belonging to a contractor named Kerbaugh exploded on December 20th, at Altoona, Pa. Dominick Springer was fearfully burned about the body, arms, and head, but at last accounts it was thought that he would recover.

(376.) — A small boiler exploded on December 20th, in a sawmill on the Wales ranch, near Milford, Cal. John Yanner and George Wales were seriously injured, and the building in which the boiler stood was wrecked.

(377.) — A heating boiler exploded on December 21st, in the rear basement of the Hotel Hinkle, at Columbus, Ohio. Nobody was injured. Landlord Hinkle estimated the damage to the house at not less than $3,000.

(378.) — On December 21st the boiler of a threshing machine outfit exploded at Innerkip, near Woodstock, Ont. Thompson Walton was seriously injured, and the outfit was destroyed.

(379.) — On December 22d a heating boiler exploded in schoolhouse No. 2, at Fulton, N. Y. Nobody was injured, and the damage to the building was not serious.

(380.) — On December 22d a boiler used for heating water exploded in the basement of the Downs-Kearney block at Medina, N. Y. The boiler was located below the barber shop of John Waldner, which was badly damaged by the explosion. Leo Waldner and John T. Wellbrook were thrown against the ceiling of the shop and slightly injured. Fire followed the explosion, and the total property loss was about $5,000.

(381.) — On December 23d the boiler of locomotive No. 711, on the Denver and Rio Grande railroad, exploded at a little station called Nathrop, some six miles south of Buenavista, Colo. Engineer George Miller was instantly killed, and his body was thrown 300 feet. Brakeman Samuel Potter was fatally injured, and fireman William S. Newby was seriously scalded and otherwise hurt.

(382.) — A small boiler exploded on December 23d, in N. Donough's meat market, at Gloversville, N. Y. The building was badly damaged, and the property loss will amount to several thousand dollars. Nobody was in the place at the time, so there are no personal injuries to record.

(383.) — Two men were killed and another fatally injured, on December 23d, by the explosion of a boiler on the tow boat *Lizzie Massey*, on the southern branch of the Elizabeth River, near Norfolk, Va.

(384.) — On December 24th the boiler of a locomotive exploded at Fort Hill, Somerset county, Pa., on the Cresson branch of the Pennsylvania railroad. The locomotive was wrecked, and the engineer and fireman were slightly injured. They would undoubtedly have been killed but for the fact that they perceived some signs of the impending disaster, and jumped from the cab in time to escape the main force of the explosion.

(385.) — On December 24th a boiler exploded at the Loyal Hanna Coal and Coke Company's plant at Oakville station, on the Ligonier Valley railroad, two miles south of Latrobe, Pa. John Weaver was fatally injured, and William Peters and Joseph Gentz were badly scalded and bruised. The boiler house was entirely demolished, and the tipple thrown down.

(386.) — A boiler used to furnish steam for a large peanut roaster exploded on December 25th, in L. C. McCurdy's confectionery store at Latrobe, Pa. Louis Berlin, who was passing the store at the time, was seriously injured by flying fragments. The total property loss was estimated at $2,000.

(387.) — A heating boiler exploded on December 27th, in the residence of A. F. Scott, at Youngstown, Ohio. One side of the cellar wall was blown out, the plaster was torn from the walls, the floors were rent asunder, the beams were loosened, and, in a word, the house was almost totally wrecked. Mrs. Scott, who was in the kitchen at the time, fortunately escaped with very slight injuries.

(388.) — On December 31st a boiler exploded near the Choctaw chute, at Shawnee, Okla. Nobody was injured, but the building in which the boiler stood was almost entirely demolished.

(389.) — On December 31st a heating boiler exploded in the residence of Antonio G. Pucci, on East 109th Street, New York. The furniture in the house was greatly damaged, and the total property loss due to the explosion and to the slight fire that followed it was about $6,000. Mrs. Theresa Philomine, an aged woman servant, was buried in the débris in the dining-room, and when she was rescued it was found that she was severely injured. Mr. Pucci's son Michael, 13 years of age, was also buried under the wreckage, but he escaped unhurt.

The Only Ray of Hope.

If members of the stock exchange can't peg spitballs any more, nor make paper blizzards with electric fans, what is to become of the old adage that "boys will be boys"? The schoolboy never was allowed to be a boy. The modern college "man" scorns to be a boy; he no longer finds delight in picking upon the freshman; cane sprees are not to him what once they were; Bloody Monday has become a bloodless feast of welcome and ice cream to the new-comer; and even at West Point hazing is dying, like the old cat. Yet in the face of all this, the most despairing prophet of social decay has kept a hopeful eye on Wall Street, and was beginning to say: "Men will be boys." But the board of governors of the stock exchange has decreed otherwise. In future no spitball shall be pegged, no paper blizzard blown. The old proverb in any shape seems to be irrevocably doomed. The only ray of hope comes from the once tender sex. While grown women are so busy usurping the rights of the animal, man, formerly their superior, it is perhaps only natural that tender maidens should be doing likewise. They have scaled the heights of athletics and slang; they are scaling the heights of cigarettes and profanity. Need any degree of horsing and hazing be beyond them? Keep at it, Susy, Madge, and Jane! By and by we shall revise that flower of our common speech and say: "Girls will be boys." — *New York Times.*

The Locomotive.

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

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Obituary.

DANIEL PHILLIPS.

Once again it becomes our sorrowful duty to record the death of a member of the board of directors of the Hartford Steam Boiler Inspection and Insurance Company. Mr. Daniel Phillips, who was not only one of the oldest members of that board, but who was also, at the time of his death, the oldest resident of the city of Hartford, passed away, on May 2d, at his residence on Farmington Avenue. He was born on July 2, 1809, in Charlton, Mass., where his father conducted a large farm. He remained at home, getting such an education as the country schools then afforded, until he was twenty years of age. He then went to Westboro, Mass., where he lived until 1837, when he removed to Boston for a year, afterwards returning again to Westboro, where he remained until October, 1841, at which date he came to Hartford. Sixty-one years ago, in 1842, Mr. Phillips established an express business in Hartford, beginning as a messenger and delivering packages at residences, at first without a wagon or conveyance of any kind. The business grew and prospered, and he continued in it under the firm name of Phillips & Co. until 1854, in which year he consolidated his business with that of others in the same line, under the name of the Adams Express Company; this consolidation being the origin of the great corporation of that name, which does so much of the modern interstate carrying of the nation. He was one of the first directors of the Adams Express Company, and continued to be its agent at Hartford until 1870, when he practically retired from business. He was also identified with the manufacture of iron in the town of Shelby, Ala.

Mr. Phillips was one of the original members of the republican party in the state of Connecticut, and was one of the signers of the call for the first republican mass meeting held in the state. He was a member of the common council, sitting in the lower board in 1853, 1854, and 1858, and in the board of aldermen in 1859. He was a member of the board of water commissioners in 1854, 1857, 1868, and 1869, and was a street commissioner in 1872 and 1873. Together with the late David F. Robinson, he represented Hartford in the General Assembly in 1854, and was a member of the committees on military affairs, and the state hospital. Mr. Phillips was one of the earliest policy-holders in the Charter Oak Life Insurance Company, and was one of its directors. He was also a member of the building committee which had charge of the erection of the granite building that once belonged to that company, and is now the home of the Ætna Life Insurance Company, and of the Hartford Steam Boiler Inspection and Insurance Company. He also served as a director or trustee of many other important institutions in Hartford and its vicinity, his sound judgment and thorough business knowledge making him an invaluable man for positions of this sort.

On April 6, 1836, Mr. Phillips married Miss Mary M. Forbush of Westboro, Mass., who died in Hartford on February 29, 1896. Five children were born to them, but none are now living. Mr. Phillips and his wife were for many years members of Dr. Horace Bushnell's church, and later united with the Center Church, in which Mr. Phillips continued his interest and membership up to the time of his death.

It is difficult to give a just estimate of the character and attainments of a man of Mr. Phillips' high standing and wide experience. His achievements, the honorable services that he rendered to his city and his state, and the esteem that he won from his associates, speak more highly for him than any eulogy that we can frame.

The Water Supply of Ancient Jerusalem.

Information obtained in recent years indicates that Jerusalem was a strategic point in Palestine at an early period, but its importance as a metropolis was, as usual, of slow growth. For many centuries the city has been little more than a sacred memory. It received severe treatment at the hands of the Cæsars; the Emperor Hadrian, in the second century of the Christian era, destroyed it as far as he could, and renamed the site. This attempt to efface the Holy City from the memory of man failed miserably, but the material evidences of its golden era were largely obliterated.

We know comparatively little of the ancient world, but one fact stands out in strong contrast to the conditions of medieval life, and even of many modern cities; — namely the care taken to secure a good water supply. The highest honor for this sanitary measure is justly given to the city of Rome, but this was by no means the first. It is only of late years that the details of the water supply of ancient Jerusalem have been unearthed. The following description is compiled from various recent sources.

Jerusalem is on high ground, and is surrounded by valleys. Its walls enclose a space of less size and population than some of the wards of Philadelphia. It is known that in some of the severe sieges the inhabitants suffered most for want of food, while the besieging armies suffered most for want of water. From this it is to be inferred that either springs existed in the city or that water was conveyed in concealed conduits. The latter view is now known to be correct; possibly the former is also.

It is believed by the authorities that the earliest efforts at impounding natural waters so as to secure a constant supply for use at or near Jerusalem began in Solomon's time, by the building of reservoirs in the Kedron Valley (east and southeast of the city) for the supply of water to the royal gardens. This reservoir, called "Solomon's Pool" by Josephus, cannot now be found. Later an open channel was cut in the rock forming the west slope of the Kedron Valley, by which the water was led to a point where it was easily available to the residents of the city. It has been suggested that the words of Isaiah, viii, 6, "the waters of Shiloh that go softly," are an allusion to the flow in this conduit, which has but a slight grade. The original channel was identified in 1866. A more interesting and imposing work was carried out some 300 years after Solomon's time by Hezekiah, who, prior to the Assyrian invasion, impounded the water of a spring to the east of Jerusalem and brought it down to the east side of the city. This work is mentioned in both the accounts of Hezekiah's reign; thus, in ii Kings, xx, 20, we read: "Now the rest of the acts of Hezekiah and all his might, and how he made the pool and conduit and brought water into the city, are they not written in the book of the Chronicles of the kings of Judah?" Turning to ii Chronicles, xxxii, 30, we read that Hezekiah "stopped the upper spring of the waters of Gihon and brought them straight down on the west side of the City of David." Palestine archæologists regard Gihon as identical with a spring now just outside the city wall and known as the Fountain of the Virgin. The operation of Hezekiah involved the construction of a tunnel through rock in a tortuous course of over 1,000 feet, leading the water into two reservoirs near the southeast corner of the city. About twenty years ago [1880] an inscription in archaic Hebrew was found on the tunnel-wall near the lower end. The following is a translation of this inscription from a French version in the Revue des Etudes Juives: "End of the boring. Here is what relates to the boring. While the borers worked their picks in opposing directions, and there were yet three cubits to break through, they heard one another's voices; for a fault was disclosed in the rock on the right and left; and on the day of completion the borers met one another, face to face. The waters ran from the pool-spring 1,200 cubits. The height of the rock above the borers' heads was one cubit."

The tortuous course appears to have been intentional, for shafts were driven at two different points. It has been suggested that this course was rendered necessary in order to avoid rock-hewn tombs. The spring was intermittent, and has even been supposed to have a symbolic periodicity. It is an interesting example of how a legend may arise and be propagated, that a traveler who visited Jerusalem in A. D. 333, and who is known in history as the Bordeaux Pilgrim, states that the pool of Siloam was inside the walls of the city, and that the waters did not flow on the Sabbath.

Excavations along the southern wall of Jerusalem have brought to light an aqueduct passing along the northern slope of the Hinnom Valley, penetrating the wall, and passing towards the southeast corner of the city. This aqueduct is well built, being hewn out of a rock with rather steep incline. The upper and lower sides were extended by walls, so that flat cover-stones might be used. The cross-section of the channel is rectangular, with a depression in the center line of the floor. The dimensions are about 3 feet high and 2¼ feet wide. Rock-hewn manholes were provided. At one point there is a chamber 5½ feet long, 4 feet wide, and 9 feet high. F. J. Bliss, whose excellent work on the excavations at Jerusalem gives much information, thinks that this aqueduct is also the work of Solomon's time, but further information on this point is required.

In addition to these constructions, Bliss gives the lines of an aqueduct beginning to the west of Jerusalem, passing around by the south in the Hinnom Valley, and entering the city toward the east. This he terms the lower-water aqueduct, but gives no special information about it. We know from Josephus that Pontius Pilate "brought water into Jerusalem"; but detailed information on this point is not available. His action provoked much dissatisfaction, possibly owing to exactions and oppressions practiced in carrying out the work. The name of this man has been anathema for so many centuries that we should not grudge him some honor for bringing in a new supply of water.

More extended excavations may be expected to yield still further interesting results as to the sanitary conditions of this ancient city. — HENRY LEFFMANN, in the *Journal of the Franklin Institute*.

[The passage above, relating to the meeting of the workmen in the tunnel, is interesting enough to merit a few further remarks. Mr. Leffmann credits Prof. Morris Jastrow with the reference to the French version of the inscription, in which the voices are said to have been heard through an "accident" in the rock. Jastrow and Leffmann translate the French word "accident" as "blind alley," or "cul-de-sac"; but we are of the opinion that "fault" is a far better translation, and we have rendered the word thus in the text above. The idea appears to be that the tunnel was worked from both ends, and that as the two gangs of workmen came together, and while there were yet three cubits (five or six feet) of rock separating them, they ran into a fissure in the rock, through which the sound of their voices could be heard. It appears probable that the two tunnels did not meet centrally, as they should, but that when the sounds showed that the gangs were opposite to one another, a lateral cut was made to unite the two sections. — *Editor* THE LOCOMOTIVE.]

Costly Mistakes.

The tendency to overlook a glaring error in the search for a trifling one is so old that we are ever warned in Holy Writ in the well-known verse about the beam and the mote. It would seem, however, that in modern engineering the numerous safeguards of the system in an up-to-date works would take pretty good care of such oversights. That this is not true, none of us who have ever been employed in such places will doubt for a moment. Frequently errors of this sort are spotted by the careful foreman or mechanic, even when they have slipped past the watchful eyes of the draftsman, the checker, the designer, the chief draftsman, the chief engineer, the general superintendent, etc., and they are then mainly useful as an aid to the clumsy wit of the outside man in his efforts to belittle the "white shirts" in the office. Sometimes, though, the error goes right through, and is brought to light only when the erring pieces are finished and assembled; and then — somebody is in trouble.

The writer knows of one case, in a prominent English shipyard, where it was not discovered until the trial trip of a ship that a right-hand engine had been equipped with a left-hand propeller. The latter was a four-bladed solid casting, and there was trouble for many persons, and a great many dollars (or pounds sterling) were expended in making things right. In another large foreign yard one of the finest modern English cruisers was building in a rush, and when the engines were erected in the shops it was discovered that the cranks would not clear the columns. There was no time to make new parts, so the columns and cranks were both chipped, with the old hammer and chisel, until they cleared. As this had to be done on twelve columns and six cranks it is likely that it was not a very cheap job, to say nothing of the weakening of the parts chipped and of the additional expense for strengthening them. What her majesty's inspector had to say about the job was not quoted.

For some time the writer was employed as an engineer on a modern 20-knot liner. Her propellers had been giving some trouble and she was ordered to dry-dock to have new blades fitted, the six blades, of manganese bronze, being put aboard of her in her home port. The dry-dock was a trifle over 3,000 miles from that port; and when she arrived and the six shiny blades had been carefully taken out, a close inspection convinced the authorities that there were four right-hand and two left-hand blades, instead of three of each. There being no time to waste, as she was allowed only a week off the line, three of the right-hand blades were fitted and two of the left-hand ones. For a third left-hand blade, one of the old ones was used, with the holes in the boss enlarged so that it could be brought into approximate pitch with the two new ones, the new wheel being nearly two feet coarser in pitch than the old. Then she left the dock and went to her dock to load. A few days later her sister ship arrived with orders for a similar job, and a careful inspection of her new blades showed that she had been given four left-hand and two right-hand ones. An exchange was made, and ship No. 1 went back into dry-dock and had the new blade exchanged for the makeshift. Just what this little mistake cost I do not know; but dry-dock privileges are not the cheapest things in the world. And it takes a good mechanic, too, to distinguish between a right-hand and left-hand blade of the sort used on these particular ships.

Another ship on which the writer was employed belonged very nearly to the genus tramp. She had a small triple engine of about 1,200 I. H. P., and by shaking her up, and feeding the two firemen and the coal-passer a little "Dutch courage," we could, in the current and with a fair wind, get nearly eleven knots out of her. She would have been just about the home a seagoing man yearns for except for the metallic packing on her valve spindles. This was contained in the usual casing, and just below the casing was the guide bracket for the spindle. This allowed the casing to be dropped such a small distance that it was next to impossible to see anything inside, and all inspection and fitting had to be done by crooking one's fingers over the edge and feeling around inside. Thus what should have been a comparatively easy job was one of the meanest on the ship. Moreover, there was no necessity in the design of the engine for causing this inconvenience, and we used fervently to pray that the man who made her drawings might be obliged to get out and put in that valve-spindle packing.

During my early seagoing days it was always a mystery to me why chief engineers and second engineers had such a cynical and distrustful way of coming around with lamps and candles, and looking into every cylinder, steam chest, boiler, and pipe that I had opened in port. I discovered why in this wise: An engineer, and an experienced one at that, had taken out the low-pressure valve in port. Before closing the chest he had called the second engineer, who approved it, the valve at that time hanging partly lowered into place. It was a large, flat valve of the trick pattern, and was taken out by means of two ⅝in. eyebolts, screwed into the top end. It was lowered into place, and the chest closed. Before sailing the engine was turned over by a hand-turning gear, and everything seemed clear and easy. Less than twenty miles from port, being still in the river, the engine set up such a row that the chief came down himself and took a card off the low-pressure cylinder. When he looked at the diagram he sent word to the skipper that it was best to anchor, which we did. An investigation showed that the eyebolts had not been removed when the chest was closed, and while the ease with which she could be turned over by hand proved that they must have cleared at first the subsequent vibration had loosened them so that a hole about six by four inches was knocked into the hollow top of the valve and the loose pieces were caught in the ports and had broken chunks out of them, the ports being bolted to the cylinder casting instead of forming a part of it. One of the fragments got over on top of the low-pressure piston, which was a hollow casting, and had punched a hole in it, besides slightly springing the rod. Luckily we were not far from shore, so a small boat hunted up a landing and the state of affairs was telegraphed to the office. A tug responded, and the damaged piston, rod, and valve were sent away to the shop for repairs. The edges of the broken ports were chipped clean, and wooden templets were prepared, from which brass castings were made ashore, and put in place with countersunk screws. This was a number of years ago, and the last time I saw the ship these patched-up parts were still giving a good account of themselves. The delay, I think, was just 52 hours, a small percentage of the time usually allowed for the voyage. This turned out pretty badly for the second engineer and for the man who did the job, but it was a beautiful lesson to the rest of us.

More than once, since then, have I sneaked out in the night before sailing, and, with a friendly oiler to help, opened up steam-chests, cylinder-cover manholes, evaporator doors, and so on, in the dread suspicion that there might have been a hammer, a monkey-wrench, an eyebolt, a chisel, a rope sling, or even a stray bunch of waste overlooked when I had closed it up. This was especially the case under one second engineer, who had been thriving so upon the company's bill of fare that one day when he had dropped through the manhole in the low-pressure cylinder head it took two burly firemen and myself to get him out, and, when he came, he left behind the nether half of his boiler suit, and all his peace of mind. He would never go in there again, but instead, upon my reporting that I was ready to close up, he would fix a stern eye upon me and go on thus:

"Ye're pairfectly sure ye left no gear in there?"

"Yes, sir."

"Verra well; remimber, I thrust ye absolutely, an' tek yer word for it. Away doon and close 'er up, and dinna fergit to swab her oot well wi' cylinder ile and black lead." — *Marine Engineering.*

Practical Liquid Air Possibilities.

Ever since the appearance on the market of machines capable of producing almost any desired quantity of liquid air, the services likely to be rendered by this new medium have been talked and written about in a more or less extravagant manner, partly from ignorance and partly from desire for gain. Many claims have been made for it, which, like soap bubbles, have vanished most disappointingly. Several points of timely interest will therefore be found in the following extracts from a recent address made before the Ice and Cold Storage Association of London by Dr. Carl von Linde, who has personally done much towards the development of the liquid air industry.

One of the claims made for liquid air (he says) was that it would be "the cold-producing medium of the future." Not only would the working of our modern refrigerating and freezing stores be accomplished by means of liquid air, but everybody — the manufacturer in his workshop and alike the agriculturist on his farm —might, at trifling cost, procure a cool and pure atmosphere for himself. Considering that liquefied air, vaporising at atmospheric pressure, possesses a temperature of — 191° C., it is hardly a matter for surprise that, with such an energetic cooling medium in view, the problem of applying liquid air for refrigerative purposes is raised again and again.

In the consideration of the merits of any particular source of cold two points require especial attention. First, the quantity of cold produced, *i. e.*, the number of heat-units eliminated per unit of time; and, second, the intensity of the cold, *i. e.*, the temperature at which heat is removed.

It is well known that the second law of thermodynamics proves that the expenditure of energy necessary to the production of a certain amount of cold increases in direct ratio with the difference between the lower temperature (in the refrigerator) at which the heat is taken away and the upper temperature (in the condenser or cooler) at which heat is transferred to the cooling water or to the atmosphere. Now, if the refrigerative purpose be the production or the maintenance of a temperature only a few degrees below the freezing-point of water, then, according to the law referred to, it must be exceedingly irrational to employ liquid air, seeing that for its attainment we are compelled to descend to — 191° C. (— 312° F.). If anyone had to provide a well for obtaining surface-water from a depth of 10 feet, it would be insane to sink a shaft 300 feet, to let the water run from its surface level down this pit, and then to raise it through a height of 300 feet. But this exactly corresponds to the idea of persons recommending the use of liquid air as a substitute in all the refrigerating machines of today. If we were to work our ice factories, our cooling and freezing stores, and our other cooling plants by liquid air, the requisite expenditure would be from thirty to fifty times greater than that of our modern refrigerating installations.

In view of such a disproportion, we must put the question whether any cases at all are conceivable for which the employment of liquid air appears suitable for the purposes of refrigeration. Here we may recollect, firstly, that the disproportion in question is based upon the considerable difference between the temperature of liquid air and the temperatures required from technical refrigerating plants. Hence, if there be found cases where the degree of cold obtained by present cooling machines is insufficient, and where we are compelled to descend to the very low temperature of liquid air, then the large expenditure of work involved will not appear as being spent irrationally. Hitherto such a requirement has been felt only in scientific research laboratories. The higher scientific schools of the majority of cultured nations now possess machines for liquefying air, and use them more or less diligently for investigating physical and chemical phenomena. The future must reveal whether such scientists' work will produce results of a kind valuable for technical application and industry.

But, setting the domain of lowest temperatures apart, various other applications of liquid air are conceivable for cooling purposes. The cooling of sick rooms and hospitals is a case in point, because only relatively small quantities of cold are required for this purpose, and, moreover, the evaporation of the liquid air would not only not vitiate the atmosphere of the sick room in any way, but would even improve it.

The problems involved in the storage of liquid air are serious, and are not very well understood by the general public. It is frequently assumed that liquid air can be stored and shipped in steel bottles, and in a state of permanent liquefaction, like liquefied ammonia, carbonic acid, and nitrous oxide. This, however, is not so. For every liquefied gas there is a certain upper temperature, above which it can exist only in the gaseous state, no matter how high the pressure to which it is subjected. This temperature (which is known as the "critical temperature" of the gas) is about + 130° C. (+ 266° Fahr.) for ammonia gas and + 31° C. (88° Fahr.) for carbonic acid; but for liquid air it is — 140° C. (— 220° Fahr.), and the air cannot be preserved in the liquid condition unless its temperature can be kept below that point. As it is impossible to protect vessels so completely against the influx of heat as to maintain this low temperature permanently in their interior, it is consequently also impossible to preserve liquid air in a closed vessel. If we place it in a steel bottle and seal the bottle tightly, the contents, after a time, will consist only of gaseous air of ordinary composition, and under a pressure depending upon the quantity of air imprisoned. If the steel bottle has been entirely filled with liquid air, the pressure will eventually rise to about 800 atmospheres, provided the bottle is strong enough to resist such a pressure; the temperature meanwhile rising to that of the surrounding atmosphere.

Yet, notwithstanding these facts, we rightly speak of liquid air as being preservable for days in proper vessels. For the accomplishment of this we are indebted to Dewar, who invented a glass containing-vessel with double walls, the air between the two walls being exhausted as perfectly as possible, in order to prevent conduction and convection of heat, and the outer wall being silvered so as to reflect a large proportion of the rays of radiant heat that strike the vessel from outside sources. The access of heat to the contents of such a vessel is so slow, that a small quantity of liquid air (say a quart) may be preserved in it so well that some small fraction of the liquid will remain, even after the lapse of ten days or more. These vessels must always remain open, however, to allow of the escape of gaseous air; for the constantly inflowing heat, however small it may be in amount, will be expended in evaporating some of the liquid, and any sealing of the bottles must result in their being burst. The double-walled and silvered containing-vessels of Dewar, when conveniently packed, are adapted for transporting small quantities of liquid air from a central station to any number of consumers within a certain radius, and can be used to establish a sale similar to that of an ice factory. This has been actually accomplished at several places — for instance, at Berlin, Munich, and Antwerp.

With regard to the expectations that have been held as to the use of liquid air for motive purposes, it may be said that the same question of economy is raised here as was suggested, at the outset of this article, with regard to the use of liquid air for purposes of refrigeration. If we cause liquid air to evaporate in a closed vessel, we thereby obtain a large quantity of gas under a great pressure, and there is no doubt that this can be used to run an engine. But this possibility has been invested, by the general public, with far too great an importance. When we consider that the mechanical work that such a mass of gas can do is only a small part of the preliminary work that is indispensable to the original liquefaction, we shall be convinced that we can never hope to develop power economically by the use of liquid air. But, as in the case of refrigeration, under special circumstances economy may be a secondary consideration, and in that event liquid air may offer special advantages. In submarine vessels, for example, liquid air motors are among the promising things of the future. Mention may also be made of the more or less successful experiments that have been made with such motors on automobile cars. — ADAPTED FROM *Cassier's Magazine*.

We have received, from Mr. George H. Barrus, a copy of his little book, entitled *The Star Improved Steam Engine Indicator*. Although this book is primarily an advertisement of the Star indicator, it contains much information that should be useful to engineers generally, who have to do with indicator diagrams; and for this reason we take pleasure in calling attention to it. Mr. Barrus has had very extensive experience with the indicator, and what he has to say about it is always of interest and value. His little book contains 140 pages, is well and clearly illustrated, and sells for $1.00. It may be had of the author, 12 Pemberton Square, Boston, Mass., or of the Star Brass Manufacturing Company, 108-114 East Dedham Street, Boston, or of the D. Van Nostrand Company, 27 Warren Street, New York.

Incorporated 1866.

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The Locomotive

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The Growth of the Hartford Company.

(FIRST PAPER.)

It has been our custom, for many years, to publish, shortly after the beginning of each year, a summary showing the work done during the preceding twelve months by the inspectors of the Hartford Steam Boiler Inspection and

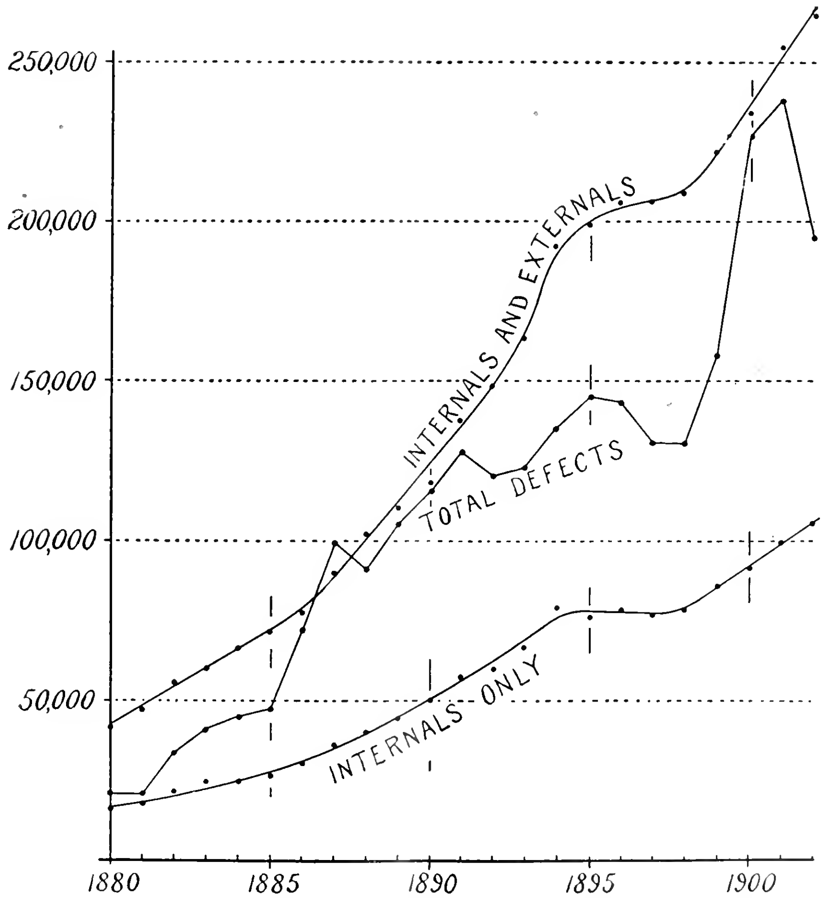

FIG. 1.—INSPECTIONS AND TOTAL DEFECTS.

Insurance Company; and at frequent intervals we have extended the statistics so as to show the work done, per annum, since 1870. (See, for example, The Locomotive for May, 1903.) The numerical data given in our summaries illustrate the growth of the Hartford Company very well, but we have thought that a graphical analysis of the same results would bring them out more clearly to the eye, and we have accordingly prepared diagrams for this purpose, two of which are presented herewith.

In Fig. 1 we have shown the total number of defects found during the several years represented, and also the number of complete internal inspections, and the total number of inspections of all kinds, whether internal or not. We begin the diagram with the year 1880, partly because the data at hand for 1876 and 1878 are not complete in all respects, and partly because it was the custom of the company to publish its reports for the year ending with the 31st of August, previously to 1875; this custom being afterwards changed so that the summaries given for years subsequent to 1875 extend from January 1st to December 31st, so as to agree with the calendar year.

The diagrams were prepared as follows (taking the case of "internals only," in Fig. 1, for the purpose of illustration): Along a horizontal line a series of equidistant points was laid off to represent the respective years that have elapsed since 1880. A vertical line (shown on the left of the diagram) was then drawn, and upon it another series of points was laid off to represent the number of complete internal inspections. In the year 1890, for example, our inspectors made 49,983 complete internal inspections; and to represent this fact in the diagram a vertical line was drawn through the point "1890" on the date line, and on this vertical line a height was measured off, by reference to the scale on the left of the diagram, which should represent 49,983; the point so located being the one in Fig. 1, which appears to coincide with the intersection of the line marked "internals only" with the dotted horizontal line which corresponds to 50,000 on the vertical scale. The same process was repeated for all the other years, from 1880 down to 1902, inclusive; the points that were obtained in this manner being represented by the dots along the line marked "internals only."

In all such graphical representations, it is to be expected that the representative points will show a general tendency to lie along a curved line, which will trend upward, as we go toward the right, if the business is increasing, and downward if it is decreasing; but it is not to be expected that the curve to which they approximate will be followed with absolute fidelity. The curve which has been drawn in the diagram is intended to represent the law of growth of the Hartford Company, as deduced from the number of complete internal inspections that it has made from year to year, without paying heed to the trifling and irregular variations that have been due to transient and insignificant causes. This line shows that the number of complete internal inspections made per annum increased with marked regularity from 1880 up to about 1894. From 1894 to 1897 the number of complete internal inspections made per annum remained practically stationary, or even fell off slightly; and beginning with about 1898 the growth was again resumed, and it has progressed since that time at practically the same rate that was observed previously to 1894.

The line marked "internals and externals," in Fig. 1, was obtained in a manner precisely similar to that already explained in connection with "internals only." By "internals and externals" we mean the total number of inspections made during any given year, whether they were complete internal inspections, or external inspections, or hydrostatic tests. We have drawn a smooth curve so as to show the general law of increase of the "internals and externals," as thus defined, and it will be seen that this curve, between the years 1894 and 1898, shows a discontinuity somewhat similar to that observed at about the same period in connection with the "internals only." We have no special hypothesis to offer concerning the temporary modification of the law of growth between 1894 and 1898, except that we think it probable that it was the result of the general business depression which prevailed at about that time.

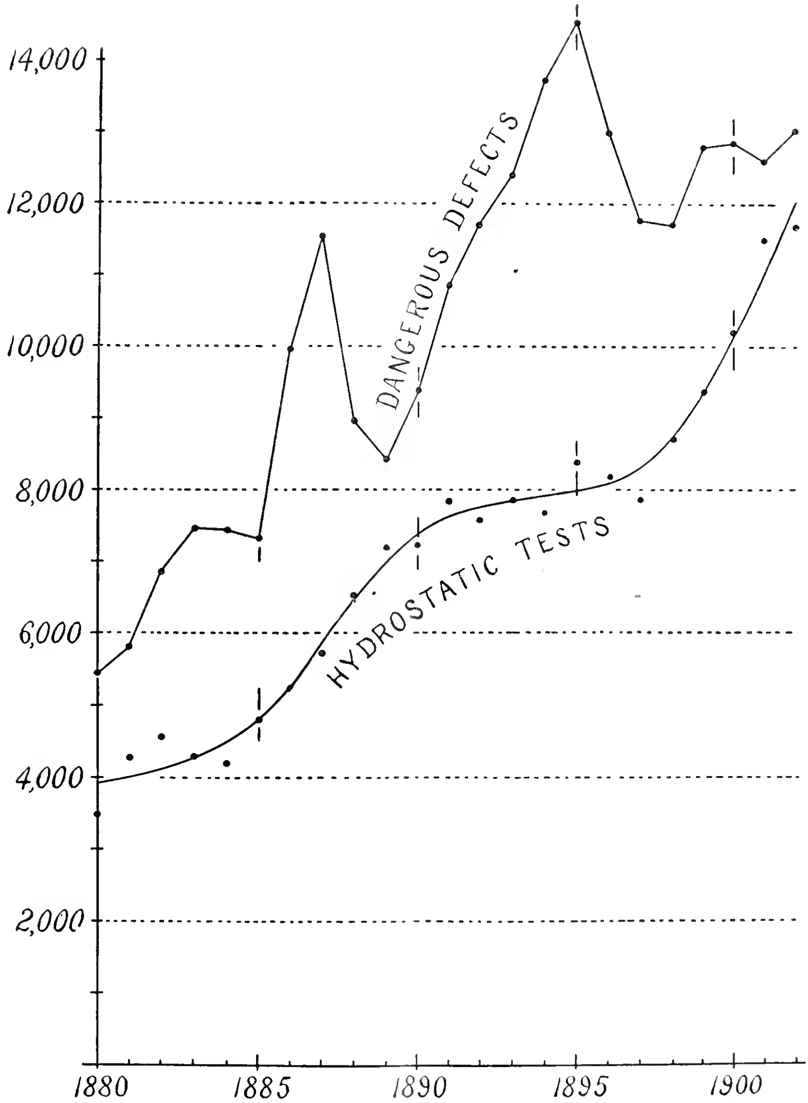

FIG. 2.—DANGEROUS DEFECTS AND HYDROSTATIC TESTS.

In Fig. 1 we have also plotted the total number of defects found by our inspectors during the several years between 1880 and 1902; but the results are so irregular that we have not tried to draw a smooth curve through them, but have merely joined the successive points by a zigzag line.

The number of dangerous defects can hardly be shown to advantage on the scale to which Fig. 1 is drawn, and we therefore present these in Fig. 2, in which the vertical scale is better adapted to the exhibition of the law of their variation. As might be expected, the dangerous defects are distributed quite as irregularly as the total defects, and hence in this case also we have merely joined the points by a zigzag line, without attempting to indicate their course by a smooth curve. In Fig. 2 we have also plotted the number of hydrostatic tests that have been made by our inspectors since 1880. A falling off in the rate of increase of these will be observed during the period between 1891 and 1897; but after the latter year the increase in the number of hydrostatic tests applied per annum was even more rapid that it was previously to 1891.

It will be seen, by a study of the two diagrams, that the number of dangerous defects found by inspection has not increased, since 1880, in as great a proportion as the number of inspections. In fact, the number of complete internal inspections in 1902 was 6.6 times as great as in 1880; while the number of dangerous defects in 1902 was only 2.4 times as great as in 1880. Stating the matter in a different way, in 1880 our inspectors found one dangerous defect to every three internal inspections; while in 1902 they found only one dangerous defect to every eight internal inspections. This marked decrease in the proportion of dangerous defects to internal inspections we believe to be due, in large measure, to an actual improvement in the condition of steam boilers throughout the United States. We trust that we have been responsible for some part of this improvement; but even if that honor be denied to us, the fact that such an improvement has taken place cannot be doubted by anyone who has been in touch with steam engineering for the past quarter of a century.

Inspectors' Report.

FEBRUARY, 1903.

During this month our inspectors made 11,697 inspection trips, visited 22,933 boilers, inspected 7,293 both internally and externally, and subjected 733 to hydrostatic pressure. The whole number of defects reported reached 9,781, of which 1,029 were considered dangerous; 76 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	918	51
Cases of incrustation and scale,	2,503	115
Cases of internal grooving,	114	9
Cases of internal corrosion,	712	42
Cases of external corrosion,	479	45
Broken or loose braces and stays,	172	69
Settings defective,	338	32
Furnaces out of shape,	428	15
Fractured plates,	261	38
Burned plates,	334	31
Blistered plates,	79	4

Nature of Defects.	Whole Number.	Dangerous.
Cases of defective riveting,	293	16
Defective heads,	61	14
Serious leakage around tube ends,	1,403	159
Serious leakage at seams,	494	18
Defective water-gauges,	327	74
Defective blow-offs,	265	83
Cases of deficiency of water,	20	7
Safety-valves overloaded,	84	28
Safety-valves defective in construction,	71	31
Pressure-gauges defective,	408	131
Boilers without pressure-gauges,	17	17
Unclassified defects,	0	0
Total,	9,781	1,029

Boiler Explosions.

JANUARY, 1903.

(1.) — On or about January 1st a boiler exploded at Marion, Ind. Chester Crow was killed. We have not learned further particulars.

(2.) — On January 1st a slight boiler explosion occurred in the basement of the police headquarters at Rochester, N. Y. No great damage was done, and nobody was injured.

(3). — On January 3d the boiler of a locomotive, drawing an east-bound passenger train on the Norfolk & Western railroad, exploded at Bedford City, Va., while running at about twenty miles an hour. Fireman C. E. Gill and engineer Joseph Myers were killed, and a tramp named Tilson was seriously injured. The locomotive was turned completely around, and some of the cars left the track. Many of the passengers were badly shaken up, but none of them was injured.

(4). — A slight boiler explosion occurred on January 6th, in the electric plant at Dekalb, Ill. Fireman Charles Nelson was badly burned about the face, neck, and arms, but will recover.

(5.) — One of the three boilers in the sawmill owned by the J. L. Gibbs estate at Mayfield, near Traverse City, Mich., exploded on January 8th. The boiler room was completely demolished, and the mill itself was severely damaged. Engineer Richard Marshall was fatally injured. Thirty men were employed at the mill, but Marshall was the only one injured at all seriously.

(6.) — A boiler exploded on January 8th, in a wood yard owned by W. H. Smith and Leavett Luce of Auburn, Me. The building in which the boiler was located was completely ruined, but nobody was injured.

(7.) — A slight boiler explosion in the heating plant of the Tilton school, at Danville, Ill., on January 9th, caused the closing of the building temporarily, but did not result in injury to any of the pupils.

(8.) — The heating boiler in the Central school building, at Findlay, Ohio, gave out on January 9th. No person was injured, and the damage was small.

(9.) — A boiler connected with the heating apparatus in the Emerson school building at Altoona, Pa., exploded on January 11th. The accident occurred at six o'clock in the morning, and no person was injured.

(10.) — On January 12th a small upright boiler exploded in Richard Slater's barber shop, at Argentine, Kans. Thomas Fife was seriously scalded.

(11.) — A boiler exploded on January 13th in the Rossville distillery, at Lawrenceburg, Ind. Several workmen were slightly injured, and the boiler room was badly damaged. The property loss is estimated at $3,000.

(12.) — A boiler exploded on January 13th, in J. R. Whaley's cotton gin, at Jarrett, near Gainsville, Ga. L. B. Cato and Freeman Deason were severely scalded and otherwise injured, and the boiler was thrown fifty feet from its setting.

(13.) — A heating boiler exploded on January 14th, in J. H. Smith's residence, at Muncie, Ind. We have not learned particulars, save that no person was injured.

(14.) — On or about January 15th a sawmill boiler exploded at Middleburg, N. Y. Nobody was injured; the property loss was not large.

(15.) — On January 16th the boiler of one of the Seaboard Air Line's locomotives exploded, near Darien Junction, Ga. Fireman Thomas White was blown over the tender and was severely injured. The engineer was also injured to a lesser extent.

(16.) — A boiler exploded on January 16th, at Bell's Mills, in South Huntingdon township, near West Newton, Pa. William Hunter and Robert Poor were killed, and A. B. Hunter was injured so badly that his recovery is doubtful. James Dyke was also injured to a lesser extent. The building and machinery were destroyed.

(17.) — A heating boiler exploded on January 17th, in the United Brethren Church, at Palmyra, Pa. No person was injured, as the explosion occurred on Saturday, while the sexton was endeavoring to heat the empty church.

(18.) — On January 17th a digester exploded in the plant of the Dexter Sulphite Pulp and Paper Company, at Watertown, N. Y. One man was killed, and the damage to the mill is estimated at $75,000.

(19.) — On January 17th two boilers exploded in the Ranney Refrigerator Factory, known as "Factory A," at Greenville, Mich. Charles Price and R. A. Stanton were killed, and Edward Hammond and Matthew Bailey were seriously injured. Some ten other men were also injured to a lesser extent. The building was badly damaged, and the property loss is estimated at $25,000.

(20.) — On January 17th a boiler belonging to Munroe Carroll, used in connection with an oil well, exploded on the Yellow Pine tract on Spindle Top, near Beaumont, Texas. Fireman William Vickers was seriously bruised and scalded. The boiler was thrown to a distance of 75 feet.

(21.) — On January 18th a boiler exploded in Charles Jones' sawmill, some five miles north of Chaires, Fla. Grover Jones and a child five years of age were instantly killed, and Isaac Gaynor was scalded very severely.

(22.) — The boiler of locomotive No. 1965, of the Baltimore & Ohio railroad, exploded on January 18th, at Monrovia, Frederick county, Md. Louis

Hahn and James Graham were killed, and Charles Cutsail and J. Newman were injured very seriously and perhaps fatally.

(23.) — A boiler belonging to a threshing machine outfit, and used for grinding feed on Frederick Roecker's farm, exploded on January 18th, at Clear Lake, South Dakota. Albert Klewin, who was firing the boiler, was blown through the side of the building and instantly killed.

(24.) — On January 19th a boiler exploded in J. W. Neesom's sawmill, three miles west of Landersville, Miss. Austin Carlisle, James Carlisle, and Smith Carlisle were killed, and Judge Carlisle and G. W. Carlisle were somewhat injured. The mill was a small one, manned almost entirely by members of the Carlisle family.

(25.) — The boiler of locomotive No. 1667, of the New York Central railroad, exploded on January 19th, near Castleton, N. Y. Engineer Patrick Kenney and fireman George W. Woolock were instantly killed, and traffic was greatly delayed.

(26.) — On January 19th a boiler, used in drilling an oil well, exploded on the Hammersmith farm, near Terryville, Pa. Louis Eauber was instantly killed.

(27.) — The boiler of locomotive No. 8069, of the Pan Handle railroad, exploded on January 20th, near Bowerstown, Ohio. The boiler was hurled sixty feet into the air and crashed down upon a west-bound freight train, smashing the second car behind the engine. Twenty-six cars were thrown down an embankment in consequence. Fireman J. G. McCurdy and brakeman Frank Clemens, who were on the locomotive whose boiler exploded, were killed, and so also were engineer J. D. Ward and brakeman Petrie of the other train. Engineer Daniel O'Connell was fatally injured. Both tracks were torn up for a distance of 300 yards. The explosion consisted in the failure of the crown-sheet.

(28.) — The boiler of locomotive No. 914, of the Grand Trunk railroad, exploded on January 20th, at Berlin, N. H., about 100 rods below the station. Fireman G. C. Munch was killed, and engineer Harvey G. Cross, brakeman George Goodwin, and conductor John Fitzsimmons were seriously injured. The locomotive, which was a big compound of the Brooks type, was raised into the air and turned half around so that it lay crosswise of the track.

(29.) — A boiler exploded on January 20th, in the plant of the Pittsburg Plate Glass Company, at Elwood, Ind. Sidney White and Robert Gammons, Jr., were fatally injured, and William Hutt, Prudence Guyeaux, Rye Huggins, and John Ossman were seriously injured. The boiler room was completely demolished.

(30.) — A slight boiler explosion occurred on January 20th, in a grain elevator at Kearney, Neb. Nobody was injured, and the property loss was small.

(31.) — On January 20th a boiler exploded in Huntley Rogers' sawmill, four miles south of Bardstown, Ky. Charles Linton was fatally injured, and Bernard Boone and Samuel Greenwell were seriously scalded. The mill was wrecked.

(32.) — On January 21st a boiler exploded in Peter Gehl's sawmill, near Jasper, Ind. Nobody was seriously injured.

(33.) — The large grain elevator belonging to the Spencer Grain Company of Minneapolis, and situated at McGregor, Iowa, was destroyed by fire on

January 21st. During the course of the fire a boiler exploded, fatally injuring foreman Davidson.

(34.) — A boiler exploded on January 22d, in Bartlett's sawmill, at Waterloo, Ind. Arthur Till was seriously but not fatally scalded, and the contents of the mill was considerably damaged.

(35.) — On January 22d a locomotive boiler exploded on the Missouri Pacific railroad, at Yates Center, Kans. The engineer and fireman were killed.

(36.) — A boiler, used by the Chlopeck Fish Company to furnish steam for cooking clams for canning, exploded on January 22d, at Seattle, Wash. Julius Richter was injured so badly that he died in about two hours. We understand that the boiler was being tested by steam pressure, to see if it was safe. We infer that it was adjudged dangerous.

(37.) — A small boiler explosion occurred on January 23d, in H. M. Kopf's bakery, at Lancaster, Pa. Nobody was present at the time. The property loss was about $700.

(38.) — On January 24th a boiler exploded in Butner & Lyster's feed grinding establishment, Thorntown, Ind. Engineer William Masters was killed, and Herbert Roberts and William Burnett were seriously injured. The building in which the boiler stood was totally wrecked.

(39.) — On January 26th a slight boiler explosion occurred at the Monarch coal mine, Clarion, Pa. We have not learned further particulars.

(40.) — A boiler explosion occurred on January 27th, in the pumping station of the Southwestern Pennsylvania Pipe Line, at Ellwood, Penn. Elmer Ruchner was killed and John Bayne and Ray Covert were seriously injured.

(41.) — On January 28th a boiler exploded in the plant of the Southwestern Car Foundry Company, at Anniston, Ala. Thomas Birch, Isaac Hardy, J. A. Forte, John Mitchell, Charles Strong, and one other man, whose name we do not know, were killed, and W. H. Lewis, Clyde Price, Anthony McKinney, and C. F. Hall were fatally injured. Robert Haynie, Baucher Brazier, Samuel Peak, Jesse Kilgore, John Shepard, E. L. Clancy, Harry Kilgore, J. S. Manley, Joseph Fonfrassen, Howard Collins, George Green, William Small, William Jackson, William Wrigler, Lewis Brooks, and Henry Hudgins were injured. The boiler room was wrecked, and so also were the car room and one end of the car wheel foundry. One fragment of the boiler weighing over 500 pounds was thrown nearly two blocks. It is said that a leak had been observed in the boiler, and that some of the men were endeavoring to repair it while the boiler was under pressure. If such was the case, the explosion that we are describing is a fearful exemplification of the danger of this practice, which we have repeatedly condemned in past issues of THE LOCOMOTIVE. No attempt should ever be made to repair a boiler until the pressure has been removed from it.

Boiler Explosions During 1902.

We present, herewith, our usual annual summary of boiler explosions, giving a tabulated statement of the number of explosions that have occurred in the United States during the year 1902, together with the number of persons killed and injured by them. We desire to say, once more, that it is by no means easy to make out accurate lists of boiler explosions, because the accounts that we receive are often unsatisfactory; but, as usual, we have spared no pains to make the present summary as nearly correct as possible. In preparing the detailed monthly lists upon which it is based (and which are published from month to month in THE LOCOMOTIVE), it is our custom to obtain as many distinct accounts of each explosion as possible, and then to compare these different accounts diligently, in order that the general facts may be stated with some considerable degree of accuracy. We do not pretend that this summary includes all of the boiler explosions of 1902. In fact, it is likely that only a fraction of these explosions are here represented; for many accidents have doubtless occurred that were not considered by the newspapers to be sufficiently "newsy" to interest the general public.

The total number of boiler explosions in 1902, according to the best information we have been able to obtain, was 391, which is 32 less than were recorded for 1901. There were 423 in 1901, 373 in 1900, 383 in 1899, and 383 in 1898. In two instances during the year 1902, two boilers exploded simultaneously. In each case we have counted each boiler separately in making out the summary.

The number of persons killed in 1902 was 304, against 312 in 1901, 268 in 1900, 298 in 1899, and 324 in 1898; and the number of persons injured in 1902 was 529, against 646 in 1901, 520 in 1900, 456 in 1899, and 577 in 1898.

SUMMARY OF BOILER EXPLOSIONS FOR 1902.

Month.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January,	36	24	45	69
February,	38	22	48	70
March,	32	22	32	54
April,	29	14	29	43
May,	33	22	33	55
June,	17	9	12	21
July,	34	28	71	99
August,	32	35	44	79
September,	33	22	37	59
October,	37	25	48	73
November,	34	53	90	143
December,	36	28	40	68
Totals,	391	304	529	833

The most serious explosions of the year, so far as loss of life and personal injuries are concerned, were as follows: On November 13th a boiler exploded over a puddling furnace at Lebanon, Pa., killing ten persons and injuring thirty others; and on August 20th two huge pulp digesters exploded at Wilmington, Del., killing sixteen persons and injuring two others. In each of these cases a property loss estimated at $35,000 also resulted.

We are aware that it would increase the interest of this annual summary if we could give some estimate of the total property loss from boiler explosions during the year. We are often asked about this point, and we should be glad to give the desired information, if we could get it. Usually, however, it is very difficult to obtain reliable estimates of the loss resulting from a boiler explosion, unless the boiler is insured; and hence it is impossible to arrive at any trustworthy figures for the total destruction of property for the year.

The Locomotive.

HARTFORD, JULY 15, 1903.

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Strange Facts About the Eucalyptus.

Mr. D. E. Hutchins of Cape Colony, who in 1882, in conjunction with Sir A. Brandis, discovered the remarkable sun-power storage capacity of the eucalyptus, has again been drawing attention in *Nature* to this extraordinary feature of the tree. According to Mr. Hutchins, a eucalypt plantation in tropical mountains, such as in South Africa, under favorable circumstances, stores up about one per cent. of the solar energy received on the unit of area and it is considered much cheaper in some parts of Cape Colony to plow up the land and plant a forest of quick-growing trees than to import coal.

In 1882 Mr. Hutchins and Sir A. Brandis, as the result of their experiments, discovered that eucalypts planted on tropical mountains produce fuel at the rate of 20 tons — dry weight at 60 pounds per cubic foot — per acre per year in perpetuity. The eucalypt plantation reproduces itself when cut without further expense, and its dry timber, heavier than coal, has an equal or a higher thermal power, bulk for bulk, than coal. This result was obtained as a measurement of the maximum yield of *Eucalyptus globulus* on the Nilgiris, southern India. If a chance tree on a chance mountain in a chance soil can produce the equivalent of 20 tons of coal per acre per year, it seems not unreasonable to suppose, as Mr. Hutchins suggests, that by selection double this, or 40 tons, can be produced. A powerful sun, a heavy rainfall, and a very rapid forced growth are the essentials of such a production of wood fuel. A glance over the rainfall map of the world shows these conditions are fulfilled over about 8,000,000,000 acres of its surface, which is between one-fourth and one-fifth of the total land surface of 35,200,000,000 acres. One-half of this area under forest might thus yield the equivalent of 160,000,000,000 tons of coal yearly, which is more than 288 times the world's present consumption of coal, assuming that coal and eucalypt timber are of approximately equal heating power. On the basis of the actual forest yield of the present day, we have half of this, or the equivalent of 80,500,000,000 tons. In Germany, one-fourth of the total area is under forest, and taking the German standard of one-fourth forest, on the basis of the present maximum yield we should obtain 40,250,000,000 tons; while if the maximum forest yield be converted to an average forest yield there would still remain a yearly product of 20,175,000,000 tons, which is rather more than thirty times the world's present consumption of coal. Thus it is seen that the yield of firewood from the world's tropical and extra-tropical forests, wherever they are fully stocked and scientifically worked, will yield the equivalent of from 30 to 122 times the present consumption of coal, or even up to 243 times that consumption, if the present timber yield be doubled by cultivation. — *Journal of the Franklin Institute.*

Early Submarine Navigation.

Mr. Alan H. Burgoyne has written an exhaustive and instructive work in two volumes, entitled *Submarine Navigation,* in which the subject is considered in both its historical and its scientific aspects. We present herewith some of the historical data that Mr. Burgoyne has gathered, acknowledging at the same time our indebtedness to Mr. M. W. Hazeltine's lengthy and appreciative review in the *New York Sun.*

Diving bells have long been known. They were used with some degree of success (according to Aristotle) by Alexander the Great, at the siege of Tyre, B. C. 332. The credit of building the first actual submarine boat, however, belongs to Cornelius van Drebel, a Dutch physician, whose first successful attempt at submarine navigation was made in 1620. Two other boats were afterwards constructed by him on the same plans, and in one of them James I of England, who was an intimate friend of Van Drebel, made a long trip. These early craft were built of wood, and rendered watertight by greased leather stretched all over the hull. According to a nearly contemporary description of the largest of these submarine boats, she carried twelve rowers besides passengers, and made a journey of several hours, at a depth of from twelve to fifteen feet. The holes for the oars were made watertight by leather joints. The success which attended Van Drebel's attempts is wonderful indeed, if we bear in mind the limited resources of the period.

In April, 1632, one Richard Norwood took out a patent for a submarine invention in which he proposed "making and using engines or instruments for diving and for raising or bringing out of the sea and other deep water any goods lost or cast away by shipwreck or otherwise." He was the first to patent an idea relative to submarine navigation. In 1634, two priests of the order of Minims wrote a small book on mathematical and physical, as well as theological and moral questions, in which a description of a submarine boat is given. One of these priests, Father Mersenne, was the first to propose a metallic hull for submarine craft. He likewise pointed out that all vessels of this nature should be pisciform. The two extremities, he thought, ought to be spindle-shaped, so that progress might be equally easy in either direction.

In the records of the English patent office there is, under the date of 1691, a reference to one John Holland, who patented an engine for submarine navigation. It is a curious coincidence that the vessel of a present-day John Holland should be accepted by the British Admiralty as the most advanced type of submarine.

With Bushnell's *Turtle* begins, in 1773, the long list of metallic-hulled submarine boats. David Bushnell, to whom belongs the honor of having invented the first submarine craft which really navigated under serious conditions, and gave incontestably valuable results, was an American engineer. His little boat, which took four years to make, had the form of a turtle, and was named after that amphibian. The shape, though not, of course, conducive to great speed, favored stability. The *Turtle* could hold only one man, with a sufficient supply of air for half an hour's submersion. At the lower extremity of the hull was placed the safety-weight, a mass of lead, which also acted as ballast. The mode of propulsion employed has been the subject of some dispute, apparently because Bushnell is credited with providing two methods. According to one design, which is probably authentic, propulsion was obtained by oars fixed in the sides of the boat by watertight joints. Steering was effected by a rudder, or rather paddle, at the back, the operator sitting on a seat. The conning tower was just large enough for the head of the occupant, and was fitted with lookout windows. In this design the *Turtle* is equipped with a bomb, or detachable charge of powder, with which it was intended to blow in the bottom of an enemy's ship. The fact is recalled that in 1776 David Bushnell obtained the permission of Gen. Parsons to make use of his submarine against the English fleet, then anchored to the north of Staten Island. He instructed Sergeant Ezra Lee in the working of his little craft. After several trial trips the sergeant tried one calm night to attack one of the blockading ships, a 64-gun frigate. He was towed as close to the ship as possible by two rowboats, and he manœuvred so as to sink just under his enemy. He could not fix his torpedo, however, as the English ship was sheathed with copper, and his boat did not offer enough resistance for him to pierce a hole in her hull. Carried along by the current, the sergeant soon lost sight of his adversary, while the torpedo floated about on the surface of the water, blowing up an hour later with a terrific explosion, to the great terror of the English, to whom this kind of warfare was unknown.

In 1780, seven years after Bushnell's first experiments, a Frenchman named Sillon de Valmer proposed to the French government to construct a vessel which could navigate the surface of the sea safely, and which could also sink below the surface and move about freely. De Valmer's boat was to be barrel-shaped, terminated at each end by a pointed cone. For this reason Mr. Burgoyne accords him the credit of first suggesting the shape now so common in submarine vessels; but we should be inclined to assign this credit to the priest Mersenne, of whom mention is made above. De Valmer's plans were detailed, sound, and mechanically practicable; and it is probably for this reason that Mr. Burgoyne gives him the credit, in preference to Mersenne, whose ideas appear to have been far more hazy and indefinite.

In March, 1795, M. Armand-Mazière placed before the French Committee of Public Safety the plans of a submarine vessel which was to be propelled by oars actuated by a steam engine, the steam being generated in a strongly-bound wooden boiler, heated by a stove. It is worthy of note that he contemplated the use of separate oars to aid in submerging the vessel, and that it was nearly a century before inventors again proposed to provide their vessels with separate motors for this purpose.

The American engineer, Robert Fulton, so well known in connection with the early history of steam navigation, was also greatly attracted by the possibilities of submarine navigation. He submitted his plans to the French government in 1797, and a commission appointed to examine them made a favorable report. The Minister of the Marine, however, was inflexibly opposed to the innovation. Fulton then made a model of his submarine, which again was received with favor by the commission chosen to report upon it. Nevertheless, Fulton's proposal was again rejected, and the same ill luck awaited him at the hands of the Dutch government. Undiscouraged by these rebuffs, he applied in 1800 to Bonaparte, then First Consul, who, after due consideration, appointed three eminent men, Laplace, Monge, and Volney, to examine Fulton's plans, and also gave the inventor 10,000 francs to carry out experiments. By May, 1801, Fulton had completed a submarine boat, which he called the *Nautilus*. A first trial took place in the Seine, opposite the Invalides. We should note that the *Nautilus* was a cigar-shaped boat, about 21 feet 7 inches long and 7 feet in diameter. The hull, as in the case of the *Turtle*, was of copper, but supported by iron ribs. The steering was effected by a rudder and the propulsion, when the boat was submerged, by a wheel fixed in the center of the elliptically shaped stern. This wheel was rotated by a hand-winch: On the first trial of the *Nautilus,* Fulton and one sailor formed the crew, and with nothing but a candle to light the interior they remained submerged twenty minutes. Having made some alterations in his boat, the inventor, accompanied by three other persons, descended on June 3, 1801, at Brest, whither the submarine had been conveyed. At a depth of twenty-five feet he accomplished various evolutions, remaining submerged for over an hour. On June 26th he succeeded in blowing up an old hulk, placed at his disposal by the French government. On August 7th, having introduced air at high pressure into the *Nautilus,* Fulton stayed under water five hours without suffering the slightest inconvenience. Just as his efforts, however, were crowned with all the success he had hoped for, the French authorities ceased to take much interest in his project, and declined to adopt it. All that Fulton asked was a reward for each vessel that he destroyed; the reimbursement of the cost of his boat, that is to say, $8,000, one-quarter of which had been advanced by the Minister of the Marine; and, lastly, a patent, giving himself and his crew the quality of belligerents, so that, if they were captured, they would not be hanged as pirates. Curiously enough, it was the question of a patent that raised the most difficulty. In a letter of the Minister of the Marine, the opinion was expressed that it was impossible to serve a commission for belligerency to men who should employ such a method of destroying the fleets of the enemy. Caffarelli, Maritime Préfet at Brest, took the same ground. Whatever the cause, Fulton was definitely rebuffed, and an invention that might have rendered possible an invasion of England by Bonaparte was brushed aside. Even after his return to the United States, Fulton did not entirely renounce the study of submarine boats, but in 1814 produced the *Mute,* a huge vessel, capable of holding a hundred men. The *Mute* was 80 feet 6 inches long, 21 feet wide, and 14 feet deep. This submarine was armored on the top with iron cleats, beneath which was a wood lining almost a foot in thickness. The name *Mute* was given to the vessel on account of the silent engine which propelled it. The trials of the craft were not completed when Fulton died.

Germans have the right to boast that their country bred the man who did more toward effecting a solution of submarine navigation than any other. We refer to Wilhelm Bauer, who, in 1850, built his first submarine at Kiel. He was unfortunately persuaded to alter certain details in the construction of his vessel by one Dr. G. Karsten, a professor of science at Kiel. The boat proved a failure, and sank in Kiel harbor in 1851. After an unsuccessful attempt to induce the Austrian government to accept the plan of an improved submarine, Bauer went to London, where a vessel was built, nominally after his plans. As a matter of fact, however, modifications were introduced by Lord Palmerston, Pausmore, and Scott-Russell, with disastrous results, for the boat sank at one of its trials, drowning a large number of persons. After an ineffectual attempt to persuade the American government to adopt his invention, Bauer, as a last resource, went to Russia. A boat was built after his designs at the Leuchtenberg Works, St. Petersburg, in 1855, and was accepted by the Russian government in November of that year. This boat had a length of 52 feet, a beam of 12 feet, and a depth of 11 feet, and was called *Le Diable Marin* ("The Marine Devil"). It was provided with a propeller, actuated by means of four wheels, which were worked on the principle of the treadmill. In May, 1856, the boat began its trials at Kronstadt, and at the coronation of Alexander II, on September 6, 1856, Bauer remained submerged for four hours with a band of four musicians, who, when the first gun of the imperial salute was fired, played the Russian imperial hymn. No fewer than 134 experiments in submarine navigation were made by Bauer in Russia. On the last occasion he had the ill luck to lose his vessel by allowing it to go too near the bottom, the result being that the propeller was caught in a mass of seaweed and could not be freed. He escaped, and managed to refloat the vessel after four weeks' work, but it was again lost off Ochda, and there it remains to this day. Bauer left Russia in 1858, after which he was obliged to abandon his experiments, for the reason that he had reached the end of his resources. He unquestionably pushed forward the science of submarine navigation many steps, and conclusively proved that to live under water in comfort is not impossible. His splendid energy and dogged determination should never be overlooked in the history of the evolution of the submarine boat.

We conclude with a mention of one or two trials of submarine boats that were made during our own Civil War. On February 17, 1864, the *Housatonic,* a fine, newly built ship of the Union navy, was destroyed under the following circumstances, while anchored off the harbor of Charleston. About a quarter before 9 o'clock in the evening the officer of the watch descried a suspicious object making for the ship. The object resembled a flat plank moving on the water. In two minutes from the time when it was first sighted, it had reached the ship's side. The submarine boat, to which the name *David* had been given, hit the *Housatonic* a little forward of the mainmast, in close proximity to the magazine. When the commander of the *David* fired, the *Housatonic* leaped violently in the air, after which it began at once to settle down by the stern. The ship quickly sank and only a part of the crew were saved. Not a trace could anywhere be found of the assailants, and it was generally supposed that they had escaped during the confusion. When, however, about three years later, divers were sent down to the *Housatonic*, the truth was discovered. Fixed in the hole that it had itself created and into which it had been sucked by the tremendous inrush of water, was the ill-fated submarine, its crew of nine men having all been drowned like rats. Between 1860 and 1864 several so-called "submersible monitors" were constructed in Northern shipyards. Of these the most curious was undoubtedly the *Keokuk*, which, on April 7, 1863, was ordered, in conjunction with other ironclads, to attack Fort Sumter. She was struck by a storm of projectiles, was riddled like a sieve, and had to be withdrawn.

The Marine Steam Turbine.

The history of the use of the steam turbine for marine purposes is thus briefly recapitulated by Mr. G. L. Parsons, in *Cassier's Magazine:*

"In January, 1894, a syndicate was formed for the purpose of applying the steam turbine to the propulsion of ships. The *Turbinia* was the first vessel to be constructed, her dimensions being, length, 100 feet; beam, 9 feet; draught of hull, 3 feet; and displacement, 44 tons. The engines consisted of three turbines, high-pressure, intermediate, and low, on three separate shafts, each fitted with three propellers, the low-pressure turbine and also the reversing turbine being coupled to the central shaft. The boiler was of the express small-tube type, without feed-water heater. With a maximum power of 2,300 horse power, a speed of 34.5 knots was obtained. At a speed of 31 knots the total consumption of steam was 14.5 pounds per horse power per hour.

"In 1898-9 the torpedo-boat destroyer *Viper* was constructed for the [British] Admiralty. Her dimensions were, length, 210 feet; beam, 21 feet; displacement, 370 tons. On trial she attained a mean speed of 36.87 knots, and a speed of 36.58 knots was maintained during a one-hour run at full power, the horse-power developed being about 12,300.

"In 1901 the first mercantile ship, the *King Edward*, was fitted with turbines. The principal dimensions in this case were, length, 250 feet; beam, 30 feet; depth, 17 feet 9 inches. With a maximum of 3,500 horse-power, a speed of 20.48 knots was attained. The *King Edward* ran on the Clyde during the whole summer, averaging 18 knots. The following summer a second ship of slightly larger dimensions (270 feet by 32 feet by 18 feet 9 inches) was built. Her speed on the measured mile was 21.63 knots.

"At present the *Velox* torpedo-boat destroyer is making her trials, while another destroyer, the *Eden*, and a third-class cruiser, the *Amethyst*, are now also building for the British government. Several private yachts have been engined with turbines, including the *Tarantula*, of 25.5 knots. A few months ago two cross-channel steamers, of 21 knots each, were ordered. One, for the London, Brighton & South Coast Railway, for the Newhaven-Dieppe route, is to be ready in May. Her dimensions are, length, 280 feet; beam, 34 feet; depth, 22 feet. The other boat was ordered by the South-Eastern & Chatham Railway company, for the Dover-Calais route, her dimensions being, length, 310 feet; beam, 40 feet; height, to the promenade deck, 25 feet."

The Distribution of Anthracite Coal.

Anthracite differs from bituminous coal, as is well known, in that it contains only a small percentage of volatile combustible matter. Commercial anthracite varies from the hard, dry Lehigh, with little more than one per cent. of such volatile matter, to the easily-lighted Bernice coals of Sullivan county, Pennsylvania, with ten per cent. The Lackawanna and Lykens Valley coals, so much prized for domestic use, are midway between Lehigh and Bernice.

The use of hard coal has become so nearly universal in the eastern towns and cities, that one hardly understands how the community could become accustomed to the use of soft coal; yet the available supply of anthracite in America is so small that, unless some other fuel be discovered, the use of bituminous coal must prevail within seventy-five years at the most. The anthracite fields of Pennsylvania within this time, even though the annual production should not exceed that of 1901 — which is improbable. There is no other deposit of anthracite in the United States, aside from some wholly unimportant patches in North Carolina, New Mexico, and Colorado — patches so unimportant that all combined would yield hardly enough for one year's consumption.

Europe has very little anthracite. Most of the Welsh coal is bituminous, the anthracite of the South Wales field being confined to the western end of that field. The Worm basin of Prussia yields perhaps 2,000,000 tons per annum of a semi-anthracite, and near Ostrau in the Silesian field, and in the Donetz field of South Russia, anthracite occurs in small quantities. But these supplies are all unimportant. China, however, has vast fields, compared with which our Pennsylvania fields are mere dots upon the map; there being upwards of 40,000 square miles underlaid by anthracite coals in the provinces of Hunan, Honan, and East Schansi. — *Popular Science Monthly.*

The Locomotive

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The Growth of the Hartford Company.

(SECOND PAPER.)

In our last issue we gave a graphical analysis of the work accomplished by our inspectors since 1880. We have thought it would also be of interest to trace the growth of the Company in a similar manner by plotting the number of boilers under insurance at different times, and also the total amount of money that the Company has had at risk; — that is. the aggregate insurance in force

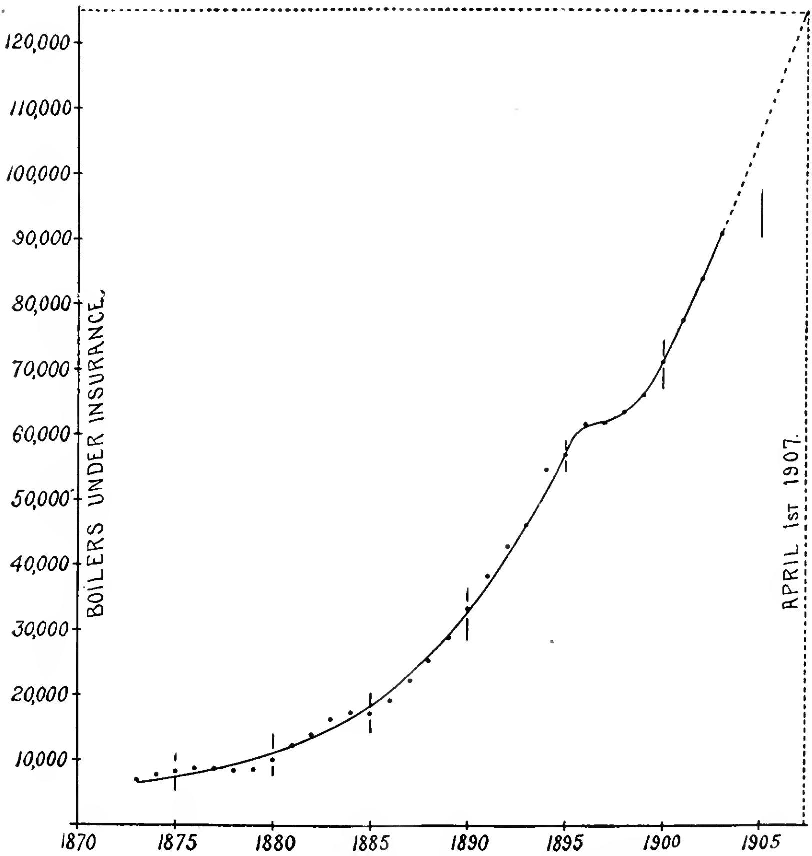

Fig. 1. — Total Number of Boilers under Insurance.

at different dates. The accompanying table gives the number of boilers under insurance, and the amount at risk upon them, for every six months from 1872 down to the present time; the data being given for the 30th of June and the 31st of December, for each year. In Fig. 1 the number of boilers under insurance has been plotted in the following manner: The years have been laid off on a convenient scale along a horizontal line, and the number of boilers under insurance has been laid off in a similar manner on a vertical line. The position of every fifth year has been indicated by figures along the horizontal line, and figures have also been given on the vertical line for every 10,000 boilers. The dates given on the horizontal line are supposed to refer to the 1st of January,

NUMBER OF BOILERS INSURED, AND AMOUNT AT RISK.

Date.	No. of Boilers.	Amount at risk.	Date.	No. of Boilers.	Amount at risk.
1872, June 30,	5,944	$10,467,557	1888, June 30,	27,292	$77,542,846
" Dec. 31,	6,922	11,854,076	" Dec. 31,	28,875	91,102,143
1873, June 30,	7,620	12,996,711	1889, June 30,	31,556	109,147,232
" Dec. 31,	7,746	13,281,143	" Dec. 31,	33,440	121,200,690
1874, June 30,	8,003	13,777,392	1890, June 30,	35,821	135,582,772
" Dec. 31,	8,270	14,682,443	" Dec. 31,	38,341	149,598,954
1875, June 30,	8,564	15,014,146	1891, June 30,	40,274	162,016,346
" Dec. 31,	8,705	14,415,449	" Dec. 31,	42,611	173,675,908
1876, June 30,	8,738	14,279,899	1892, June 30,	44,664	183,935,676
" Dec. 31,	8,674	13,958,269	" Dec. 31,	46,128	193,415,052
1877, June 30,	8,703	13,606,465	1893, June 30,	48,182	204,791,768
" Dec. 31,	8,342	12,955,908	" Dec. 31,	54,678	232,844,521
1878, June 30,	8,371	12,957,169	1894, June 30,	56,240	242,371,271
" Dec. 31,	8,500	13,053,534	" Dec. 31,	56,923	244,868,481
1879, June 30,	8,899	13,296,150	1895, June 30,	59,240	254,804,889
" Dec. 31,	10,082	14,632,302	" Dec. 31,	61,581	265,519,189
1880, June 30,	11,122	16,065,728	1896, June 30,	62,563	269,835,668
" Dec. 31,	12,320	17,483,267	" Dec. 31,	61,615	268,495,300
1881, June 30,	13,184	18,728,441	1897, June 30,	62,850	270,923,869
" Dec. 31,	14,022	20,106,732	" Dec. 31,	63,578	274,330,707
1882, June 30,	15,450	22,193,109	1898, June 30,	64,718	277,659,614
" Dec. 31,	16,366	23,464,719	" Dec. 31,	65,969	279,700,096
1883, June 30,	16,923	24,398,795	1899, June 30,	68,549	291,494,117
" Dec. 31,	17,426	25,371,802	" Dec. 31,	71,303	303,422,520
1884, June 30,	17,651	26,341,820	1900, June 30,	74,067	313,508,211
" Dec. 31,	17,267	26,900,121	" Dec. 31,	77,618	324,845,424
1885, June 30,	17,949	29,768,446	1901, June 30,	81,203	337,627,659
" Dec. 31,	19,190	33,415,396	" Dec. 31,	83,907	352,000,960
1886, June 30,	20,972	40,239,754	1902, June 30,	85,473	361,229,899
" Dec. 31,	22,126	46,119,104	" Dec. 31,	90,938	387,437,622
1887, June 30,	23,658	55,528,328	1903, June 30,	93,533	399,068,673
" Dec. 31,	25,113	63,844,675			

in each case. The data, as taken from our books, however, give the number of boilers for December 31st, instead of for January 1st; but it has been assumed, for the purpose of diagram, that the number of boilers does not change sufficiently in one day to make any sensible difference in the general form of the curve. To make the construction of the diagram clear, let us take a particular illustration, — say year 1890. The point marked 1890 on the horizontal line in the diagram refers to January 1, 1890; but the precise data for that day not being known, we assume that the number of boilers then under insurance was 33,440, that being the number under insurance on the previous day, — namely, on

December 31, 1889. A vertical line being drawn through the point marked 1890, we turn next to the point on the vertical line corresponding to 33,440 boilers under insurance; and through this point we draw a horizontal line until it cuts the vertical line through 1890. Where these two lines intersect, a dot appears on the diagram. The same construction has been adopted for every year from January 1, 1873, down to January 1, 1903; the data given in the table for June 30th, in each year, being omitted so that the diagram may not become so elaborate as to confuse the eye.

To read from the diagram the number of boilers under insurance at any

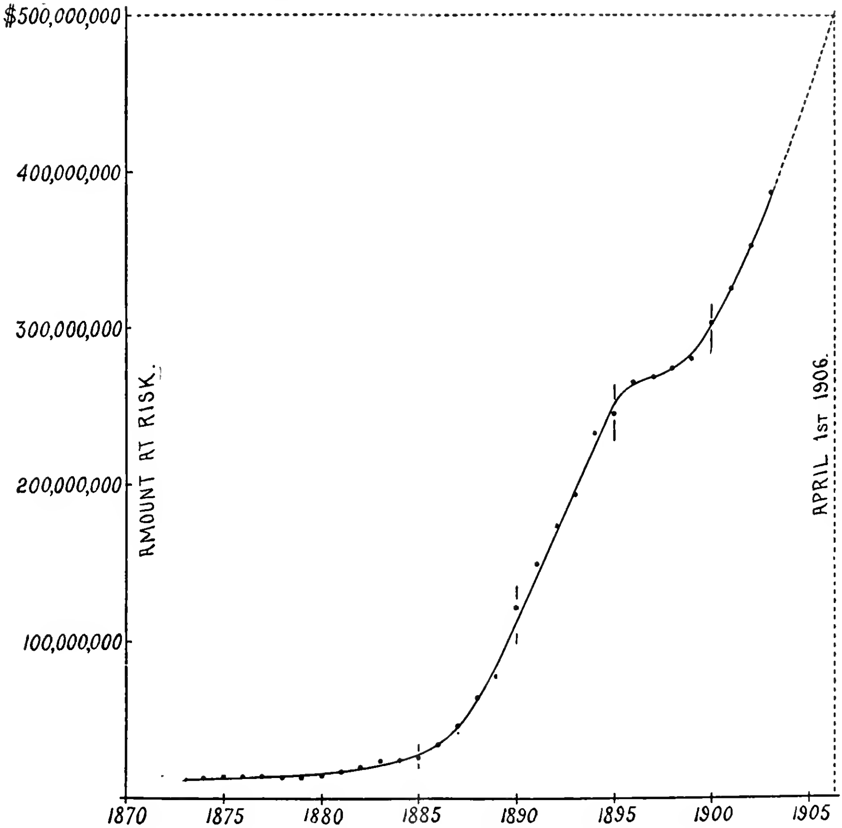

Fig. 2. — Total Amount of Money at Risk.

given date, we have only to find, on the horizontal line, the point corresponding to this date, and then draw through it a vertical line intersecting the curve. The height of this point of intersection, as read off from the scale on the left, gives the number of boilers under insurance at the date in question. Of course, the growth of the Company would be most accurately shown by joining the different points with a zig-zag line; but as we have conceived that the main point of interest is to trace the general law of progress, without reference to the slight irregularities that must necessarily be observed from year to year, we have drawn a smooth curve so as to pass as nearly as possible through all of the points, and show the general law of their distribution without attempting to follow every little variation with microscopic accuracy. To assist the eye in identifying the dots, short vertical lines have been drawn along the curve at intervals of five years. In fact, the diagram is constructed similarly, in all respects, to those given in our previous issue for the work of the inspectors; but it has been thought best to describe the construction again, for the benefit of those who may not have seen the previous article.

In Fig. 2 the same process has been applied to the study of the amount of money that the Company has had at risk during the same period. No special explanation is needed here, because the method of drawing this diagram will be sufficiently evident from the explanation given in connection with Fig. 1.

In looking over these two diagrams, we notice that the number of boilers under insurance increased with very fair uniformity from 1873 to 1896, and again from 1899 down to the present time. (Reference will be made, presently, to the interval between 1896 and 1899.) In Fig. 2, we see that the amount at risk increased from 1873 to 1885 rather slowly; but that beginning with 1886 the increase in the total amount at risk was exceedingly rapid until 1896, when it fell off for a few years, resuming its former rate of increase at about the year 1899. It will be remembered that similar irregularities were observed, at about these dates, in the diagrams showing the work of our inspectors. It is not easy to determine with positiveness all the causes that contributed to this temporary disturbance of growth, but the period at which it appears was one of considerable business depression generally, and the probability is that the irregularities in the curves merely represent the effect of this depression upon our business in particular. That this explanation is probably sufficient is indicated by the fact that the growth, as observed in either diagram, was promptly resumed after 1899, the increase thereafter being sensibly identical in rapidity with that observed immediately previous to 1895.

The regularity of these curves (assuming the adequacy of the explanation just given of the irregularity between 1895 and 1899) tempts one to venture a short distance into the deep waters of prophecy. Prophecy is a difficult and notoriously uncertain art, and hence we shall not venture far beyond the limits of the diagrams. Another business depression may come, bringing with it another irregularity in the curve, which no man can at present foresee; but in the absence of any such unexpected departure from the uniform rate at which the business is increasing at the present time, we can make some sort of a forecast that may be expected to reasonably conform with the facts. For dates in the near future, let us extend the curve in Fig. 1, as shown by the dotted part, preserving, so far as we can, the general trend that the curve might be expected to have, if the effects which led to the modified form between 1895 and 1899 are considered to be no longer sensible. To determine the date at which the Company may be expected to have 125,000 boilers under insurance, we mark the point on the vertical line on the left which corresponds to 125,000, and through it we draw a horizontal line (shown dotted) to the dotted part of the curve of progress. From the point at which this line intersects the curve, we draw a vertical line (also shown dotted) down to the line of dates; and the point where this vertical line intersects the line of dates gives the date at which it may be expected that the Hartford Company will have 125,000 boilers under insurance. The date so determined, as measured with as much precision as possible on the large diagram of which the present cut is a photographic reduction, is not far from April 1, 1907. In a similar way we may estimate, from Fig. 2, when the total amount that the Hartford Company has at risk may be expected to amount to $500,000,000; the result in this case being April 1, 1906.

As we have said, the art of prophecy is notoriously uncertain, and it may come to pass that there is a special significance in the fact that the deduced date is "April 1st" in both cases. However, when the proper time comes, we shall take pleasure in reporting the number of boilers under insurance, and the total amount at risk, so that mathematically inclined readers may have an opportunity of seeing for themselves what degree of accuracy a forecast of this sort may actually possess.

Inspectors' Reports.

March, 1903.

During this month our inspectors made 13,953 inspection trips, visited 25,776 boilers, inspected 9,736 both internally and externally, and subjected 1,031 to hydrostatic pressure. The whole number of defects reported reached 12,594, of which 880 were considered dangerous; 79 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,270	51
Cases of incrustation and scale,	3,480	102
Cases of internal grooving,	215	17
Cases of internal corrosion,	970	40
Cases of external corrosion,	787	43
Broken or loose braces and stays,	197	68
Settings defective,	410	30
Furnaces out of shape,	551	10
Fractured plates,	346	50
Burned plates,	397	38
Blistered plates,	100	9
Cases of defective riveting,	399	51
Defective heads,	119	16
Serious leakage around tube ends,	1,532	114
Serious leakage at seams,	505	22
Defective water-gauges,	270	51
Defective blow-offs,	280	63
Cases of deficiency of water,	31	7
Safety-valves overloaded,	90	23
Safety-valves defective in construction,	87	32
Pressure-gauges defective,	543	30
Boilers without pressure-gauges,	10	10
Unclassified defects,	5	3
Total,	12,594	880

We desire to acknowledge a copy of *The Slide-Valve and Its Functions*, by Mr. Julius Begtrup. Whatever Mr. Begtrup may have to say about the slide-valve is well worthy of the attention of anybody. In the present work he discusses the subject in practically all of its phases. Beginning with the common slide-valve, he passes on to the discussion of various forms of improved valves, and then to four-valve systems. In the fourth chapter he takes up independent cut-offs, and in the sixth he treats of the effects of angularity in the connecting rod and eccentric rod. The fifth chapter is devoted to the consideration of the slide-valve as applied to pumps. The book, considered as a whole, is a valuable and useful one. It is clearly written, well printed on good paper, and fully illustrated by the aid of diagrams to whose preparation a great deal of attention has evidently been given. (143 pages; price, $2.00. The D. Van Nostrand Co., 27 Warren St., New York.)

Boiler Explosions.

February, 1903.

(42.) — A boiler exploded, on February 2d, in R. R. Minton's sawmill, at Mason Hall, five miles east of Trimble, Tenn. Clifford Minton and Frederick Ward were killed, and three other men were injured. The mill was almost entirely destroyed.

(43.) — A boiler exploded, on February 5th, in Luke's sawmill, at Shallowford, on Pearl River, some ten miles east of Canton, Miss. One man was fatally injured, and two others were seriously scalded. We have seen no estimate of the property loss.

(44.) — On February 5th a boiler exploded in the power house at Little Valley, near Buffalo, N. Y. It does not appear that anybody was injured.

(45.) — A heating boiler exploded, on February 5th, in the residence of W. E. Sellman, at Bloomington, Ill. Nobody was injured, but the house was almost completely wrecked. One fragment of the boiler, weighing about 200 pounds, was blown up through the house into the attic. The steel range in the kitchen was demolished, and the total property loss was about $2,000. One account that we have received says that "if Mr. Sellman's residence had been a frame building instead of a brick one, he would probably have been compelled to take out a search warrant to find any of it."

(46.) — On February 5th a boiler exploded in Briggs & Walters' handle factory, at Edgerton, Ohio, wrecking the boiler room and seriously damaging the main factory. George Eager, Alexander Donaldson, Lee Gabriel, Hiram Scribner, and Jacob Keiser were seriously injured. Parts of the boiler were found half a mile from the original site.

(47.) — On February 7th a boiler exploded in Henry Morlang's slaughter house, at Parkersburg, W. Va. According to the earlier reports Andrew Still was fatally injured, but later advices indicate that this is not true. The building in which the boiler stood was badly damaged.

(48.) — A boiler exploded, on February 9th, in Charles Helminger's foundry, at Adell, near Plymouth, Wis. Vernon Wieting, a six-year-old boy, was instantly killed. David Hass, William Burke, Mrs. William Burke, Charles Helminger, Anton Helminger, Mrs. R. T. Franey, and Abraham Denering were injured. The foundry was demolished, and a neighboring hotel was also partially wrecked. The estimates of the property loss are quite conflicting, but the majority of them indicate that it was about $25,000.

(49.) — A boiler exploded, on February 12th, in Delaney Bros.' cotton gin, at Ely, seven miles southeast of Bonham, Texas. Engineer Dee Mathews was seriously scalded, but will recover. The plant was almost totally destroyed.

(50.) — Two hot-water boilers, located immediately under the rotunda of the main building of the Medico-Chirurgical Hospital, at Philadelphia, Pa., exploded on February 12th, causing considerable damage to a portion of the building. Nobody was injured.

(51.) — On February 13th a boiler exploded in Spence & Dean's basket factory at Waterdown, near Hamilton, Ont. Frank Edge was thrown to a considerable distance, and received painful injuries. Mr. Dean, one of the owners of the factory, was scalded, and a man named Webb was slightly injured. The plant, which was a small one, was badly damaged. The property loss is estimated at $1,200.

(52.) — On February 14th a boiler exploded in the foundry of Berns, Schlee & Brother, at Lyons, near Rochester, N. Y. All the men were in the moulding room at the time, and nobody was injured.

(53.) — A boiler exploded, on February 14th, in Thomas G. Cathcart's sawmill, at Adamsville, ten miles east of Greenville, Pa. Claire Cathcart was instantly killed, and his brother, John Cathcart, was badly injured. Thomas Cathcart and Hugh Cathcart also received lesser injuries. The mill was completely wrecked, and the sound of the explosion was heard for miles.

(54.) — A boiler exploded, on February 18th, in the Port Susan Mill Company's plant, at Port Susan, near Seattle, Wash. The fireman and engineer were painfully scalded, but will recover.

(55.) — On February 18th a boiler, used in connection with an oil well, exploded on the Tippey farm, near Marion, Ind. William Morrical was seriously burned and otherwise injured, and it is believed that he cannot recover.

(56.) — A heating boiler exploded, on February 18th, in the Ursuline Convent, at Miles City, Mont. Considerable damage was done to the lower part of the building, but it does not appear that anybody was injured.

(57.) — A boiler exploded, on February 19th, in the Porter-Carroll Boiler Works, at Wellsville, near Lisbon, Ohio. Albert Meredith was terribly scalded, and may die.

(58.) — A heating boiler exploded, on February 19th, in the William Connell Hose Company's house, at Scranton, Pa. The explosion was followed by a fire, but no great damage was done, and nobody was injured.

(59.) — A locomotive boiler exploded, on February 19th, on the Philadelphia & Reading railroad, at Pottsville, Pa. Bernard Rabb was instantly killed, and John Alexander and Joseph Gillespie were fatally injured. Several of the passengers also received minor injuries.

(60.) — On February 21st a boiler exploded at the Midway or Arbuthnot mine, on the Bray farm, at Alba, near Joplin, Mo. The fires had been banked for the night, and nobody was near at the time. The building in which the boiler stood was destroyed.

(61.) — On February 22d a heating boiler exploded in the Baptist church at Du Bois, Pa. The explosion took place during services, but the church was emptied without panic, and nobody was injured.

(62.) — Wilbur Lawrence was seriously injured, on February 23d, by the explosion of a boiler in the power house of the electric station at Forestdale, Vt.

(63.) — A boiler exploded, on February 24th, on I. B. Kellogg's farm, at Riga, near Blissfield, Mich. Ira Stevens was fatally injured. Stevens and another man were repairing the boiler at the time of the explosion, apparently not being aware that it is always dangerous to make repairs of any kind upon a boiler that is under pressure.

(64.) — William Price was seriously and perhaps fatally injured, on February 25th, by the explosion of a boiler at the Scott shaft, Shamokin, Pa.

(65.) — A boiler exploded, on February 26th, in Stevenson's sawmill, at Notasulga, Ala. The fireman, whose name we have not learned, was killed, and Superintendent W. P. Dowling was seriously injured.

(66.) — The boiler of locomotive No. 135 of the Wabash railroad exploded, on February 26th, at Berlin, Ill. Engineer George Lester and fireman Frank Clark were stunned and bruised, but were not otherwise injured. A woman in a house near by was also injured slightly. The explosion consisted in the failure of the front end of the boiler shell.

(67.) — A slight explosion occurred, on February 27th, in a boiler at the mill of the Wickford Worsted Company, at Providence, R. I. We have not learned of any personal injuries.

(68.) — A boiler exploded, on February 27th, in the Neis flouring mill, at Kausauqua, Iowa. Anton Neis and his son, George Neis, were in the boiler room at the time, and both were killed. The roof of the mill was blown off, and the building was badly wrecked.

(69.) — A tube failed, on February 28th, in the boiler of locomotive No. 324 of the Louisville & Nashville railroad, at Magazine Point, near Mobile, Ala. Engineer W. J. Prendergast and fireman George Dunson were severely scalded.

(70.) — On February 28th a boiler exploded in Bare's sawmill, at Greenville, five miles southeast of Meyersdale, Pa. Francis W. Bare was instantly killed, and his son, Marshall Bare, was injured so badly that it was necessary to amputate both his legs. Another son, George Bare, also received minor injuries. The mill was blown to atoms.

(71.) — A heating boiler exploded, on February 28th, in a big apartment house on Manhattan Avenue and One Hundred and Thirteenth Street, New York. Window panes were shattered up to within two floors of the eaves, and pictures and bric-a-brac were thrown about promiscuously in the building. A small panic resulted among the tenants, but it does not appear that anyone was seriously injured, although Samuel Cohen, a tailor, was somewhat bruised. The property loss is estimated at $2,000.

March, 1903.

(72.) — On March 4th a boiler exploded in James Dougherty's lumber mill, in Duplin county, N. C. Mr. Dougherty was slightly burned, and two other men also received minor injuries.

(73.) — A heating boiler exploded, on March 6th, in the basement of St. Paul's Evangelical Church, at Lebanon, Pa. We have not heard of any personal injuries, and the property loss was small.

(74.) — On March 6th a heating boiler exploded in the new courthouse at Bryan, Ohio. Nobody was near the boiler at the time, and no great damage was done.

(75.) — The boiler of a traction engine, owned by W. A. Carey, exploded, on March 7th, at the Western Ohio stone quarry, near Lima, Ohio. The damage was confined to the boiler and engine.

(76.) — A boiler exploded, on March 8th, in Washington Spencer's grist mill, at Halcomb, Md. Floyd Godfrey and Mr. Spencer, the owner of the boiler, were injured so badly that at last accounts it was thought that they could not recover. The building was badly wrecked.

(77.) — The boiler of an engine used for hoisting purposes exploded, on March 10th, on the first floor of the new building of the Dodge Dry Goods Company, at Troy, N. Y. Engineer William Blair was seriously injured, and Frederick Heitman, superintendent of the Atlas Fireproofing Company, was painfully bruised. The boiler was owned by the Atlas company, and was in use temporarily, during the construction of the building.

(78.) — A boiler exploded, on March 12th, in the Taugwauk creamery, at North Stonington, Conn. Nobody was injured. The property loss was not very severe, but it was reported that the creamery may be abandoned on account of the explosion.

(79.) — On March 14th a boiler exploded in McGuire's sawmill, at Beattyville, near Lexington, Ky. John Birch was badly injured about the face and body. We have not learned further particulars.

(80.) — On March 16th a boiler exploded in the East Toledo mills of the Republic Iron and Steel Company, at Toledo, Ohio. John Thompson was killed, and Melvin Updegraff and Henry Fust were seriously injured. The south section of the mill was completely demolished, and the total property loss was estimated at $40,000. One large section of the boiler was blown a distance of half a mile or more.

(81.) — On March 19th a heating boiler exploded in the rear of the Howard hotel, Chicago, Ill. The guests of the Howard and Newberry hotels were awakened, but there was no panic. Engineer John Lamaroux, who lives over the boiler room, escaped from the building by leaping through a window. He had barely reached the ground when the roof of the boiler house fell in, its supports having been weakened by the explosion. He escaped injury.

(82.) — A small boiler exploded, on March 19th, at the works of the Minneapolis desk factory, Minneapolis, Minn. John Hayes was scalded so badly that he died from the effects of his burns, some two weeks later.

(83.) — A boiler exploded, on March 19th, in the Austin Lumber Company's plant, at Cranbury, near Trenton, N. J. Nobody was injured.

(84.) — On March 19th a boiler exploded in the Readicker packing house, near Iola, Kans. The explosion occurred during the night, and nobody was injured.

(85.) — A boiler used for heating purposes exploded, on March 21st, in the roundhouse of the New York, New Haven & Hartford railroad, at Taunton, Mass. Fireman Elisha C. Chase was instantly killed, and Frank Smith, Michael Kelley, and Lawrence Lynch were seriously injured. The entire west end of the roundhouse was destroyed. The roof of the building, at this end, was blown off, and the walls near the exploded boiler were reduced to atoms.

(86.) — A heating boiler exploded, on March 23d, in Henry Smith's greenhouses, one mile west of Grand Rapids, Mich. Fire followed the explosion, and the greater part of the entire plant, which covered five acres and was the largest of its kind in the state, was reduced to ruins. Fireman Daniel McQueen was burned to death during the fire. The property loss is estimated at $30,000.

(87.) — On March 24th a boiler exploded in John McCauley's sawmill, six miles east of Wickliffe, Ky. John Byrd and Arthur Stark were instantly killed, and Warren May was injured so badly that he died within a short time. George Marshall and John McAuley, the owner of the mill, were also injured to a lesser degree.

(88.) — A boiler exploded, on March 25th, in the pail department of the C C. Mengel box factory, at Louisville, Ky. Samuel Blair and Michael Bush were killed, and Frank Nagle and James Blair were painfully scalded. We have seen no estimate of the property loss, but we believe that it was not large.

(89.) — On March 25th a boiler exploded in a mill belonging to John D Pretlow of Pretlow, Va. Anthony Griffin and William Scott were killed.

(90.) — A tube failed, on March 26th, in the boiler of a locomotive on the Erie railroad, at Canisteo Station, near Hornellsville, N. Y. Fireman Thomas Hennessey was fearfully burned and scalded, and at last accounts was in a critical condition.

(91.) — On March 27th a boiler exploded at an oil well on the M. E. Knowlton farm, at Friendly, near Sistersville, W. Va. Dee Jack, the tool dresser, was fatally scalded, and died about twenty-four hours later.

(92.) — A boiler exploded, on March 30th, in the wood and coal yard of Mr. James Longhurst, at Niagara-on-the-Lake, Ont. Mr. Longhurst was badly scalded, and several other men received slight injuries. The building in which the boiler stood was wrecked.

(93.) — On March 31st a boiler exploded at the New London copper mines, New London, Md., badly and perhaps fatally injuring engineer Harry Baker. Both heads of the boiler were blown out, and the building in which the boiler stood was destroyed.

(94.) — On March 31st a wildcat engine collided with an accommodation train on the Naugatuck division of the New York, New Haven & Hartford railroad, at Waterbury, Conn., and almost simultaneously the boiler of the wildcat engine exploded. Henry Chapman and Herbert Neuman were killed, and Joseph J. Skelly, Dennis Flaherty, and A. W. Gagin were fatally injured; but it is probable that these fatalities were due primarily to the collision, rather than to the incidental explosion of the boiler.

Brass Lullabies for Babies.

Further cause for indignation among the cult that is for getting back to nature and old-fashioned ideas as fast as possible will be supplied by the newly invented machine of a Swiss mechanic. It is an automatic nurse for babies, and is attached to the cradle. If the baby cries, the air waves cause specially arranged wires to operate a phonograph, which croons a lullaby, while clockwork that is simultaneously released causes the cradle to rock. How the heart will be stirred at the sight of the motherless brass phonograph bending over the grieving pink and white mite in the cradle, "crooning" a lullaby. Did you ever hear a phonograph croon? It croons in a sad, low tone, like an X-ray machine and a tomcat singing a duet. — *St. Louis Globe-Democrat.*

The Locomotive.

HARTFORD, AUGUST 15, 1903.

J. M. ALLEN, A.M., M.E., *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.)

The Transmutation of the Elements.

The alchemists, who laid the foundations upon which the modern science of chemistry was subsequently erected, believed it to be possible to transmute the baser metals into the nobler ones, and many of these men devoted years of their lives to a vain search for the mythical "philosopher's stone" (otherwise known as the "red tincture" or the "great elixir"), a small quantity of which, when stirred into melted silver or lead, was supposed to be competent to transform those metals into gold. With the decay of alchemy and the rise of chemistry it became increasingly evident that no such substance exists, and most of the chemists of recent times have held that matter is composed of a finite number of essentially distinct substances, called "elements," no one of which can be transformed into any other. Certain of the elements resemble one another so closely that some fundamental similarity in their ultimate structure has been strongly suspected; it is hard to believe, for example, that chlorine, bromine, and iodine can have properties so nearly identical and yet be absolutely distinct from one another. But the point is that, whether there is any ultimate relationship or not, all the evidence that chemists have been able to obtain indicates that the transmutation of any one of these elements into any other one cannot be performed by any experimental means at our disposal. And it may be said, in general, that chemists had pretty definitely abandoned the idea that it would ever be possible to transform lead into gold, all chemists, at least — save a certain dreamy few like Sir William Crookes — who have pointed out that the impossibility of transmutation is not so certain in the cases of the rare elements like yttrium and ytterbium as it is in the cases of the more familiar ones, such as sodium and potassium, chlorine and bromine, or nickel and cobalt.

The newly-discovered element, radium, has made all these things uncertain. In fact, the properties of this marvelous substance are so unprecedented, and so perplexing, that those who prize their peace of mind more highly than they do the advance of scientific knowledge (though let us hope there are none such!) must surely regret that it was ever discovered. It is known, for example, that radium gives out at least three different kinds of emanations, and perhaps four; some of these being in all probability analogous to light-waves, while others are almost certainly material in nature, and composed either of molecules like a gas, or of the still smaller units called "electrons," of which it is now fashionable to believe that molecules and atoms are composed. Much attention has been devoted to these emanations, and the material ones have been greatly studied by different investigators, though with somewhat conflicting results; and, on the whole, the labors of the Curies, and of Rutherford, Ramsay, Soddy, Huggins, and others, may be said to indicate that radium is continually giving off the recently discovered gaseous element helium. It is not known how the helium and the radium are related, but it is not at all improbable that the radium is actually breaking up and becoming partially transformed into helium, although the transformation is very slow indeed. One experiment made by Huggins, and bearing upon this point, is especially worthy of attention. He placed a specimen of cold radium bromide before the slit of the spectroscope provided with two quartz prisms, and received the spectrum (which was too faint to be visible to the eye) upon a sensitive photographic plate. After an exposure of 72 hours, the plate, when developed, showed eight bright lines and at least eight other faint ones. If we are not mistaken, this is the first known case in which a cold solid body has been shown to give a line spectrum, although a few incandescent solids are known to do so. An examination of the sixteen or more lines yielded some very curious and at present unintelligible results. Thus it was found that the two lines that are prominently characteristic of the spark spectrum of radium did not show at all, while some of the lines that did show were found, strangely enough, to coincide with the lines of helium. In a subsequent experiment of the same sort it was found that the seven strongest lines in the spectrum given by cold radium bromide agree with the absorption bands of nitrogen, provided the whole radium spectrum is shifted bodily by a very small amount. No justification for making such a shift has been imagined thus far, and we know nothing at all about the significance of this curious fact.

There is an apparently real relation of some kind between radium and helium; and this is especially remarkable on account of the enormous difference between these two elements, so far as their physics and chemistry are concerned. Helium, for example, is a monatomic gas, which has not yet been made to combine with any other known substance, and which has a density only about twice as great as that of hydrogen, and an atomic weight, therefore, of about 4. Radium, on the other hand, appears to be of the nature of a metal, and it enters into chemical combinations freely, resembling barium in its general chemical deportment. It has an atomic weight of 225, according to some authorities, or 258, according to others. If the latter estimate is correct, then radium has a higher atomic weight than any other known element; while if the former is correct, it comes third in the order of descending atomic weights, the atomic weight of uranium being about 240, and that of thorium about 232.

Radium is a very rare element. Perhaps it occurs most abundantly in certain varieties of the uncommon mineral known as uraninite; though even here it is present in such small quantity that it has been aptly said that there is more gold in sea-water than there is radium in an equal weight of uraninite. Many chemists and physicists have extracted small quantities of radium for purposes of study, and it is probable that two or three thousand tons of uraninite have been worked over by them, with a resulting total production of radium not materially exceeding one pound. It is evident that the material available for study is so small in quantity that we cannot hope for any very rapid progress towards the solution of the mysteries hinted at above. Sooner or later, however, we shall know whether radium is continuously emitting helium, or not; and if such transpires to be the case, we shall have before us the first known instance in which one element has been transmuted into another one. Of course, it may be said that the very fact that such a transformation turns out to be possible will show that one or the other of these substances is not a true element; but there are no two elements in the admitted list of such bodies which are more widely different from each other than these two, nor any between which (apart from these latest developments) a relation would be less likely to be suspected. Helium and radium appear to be as distinct from each other as nitrogen and lead. Hence, if it finally appears that transmutation is possible in this case, there is no sufficient reason for longer denying its possibility in every other case; and we may logically hope to be able, one day, to discover the alchemistic secret of changing a base metal like lead into a nobler one like gold. But this discovery, if ever made, will not be made by chance. It will be the outcome of profound study, and it will be made by a man who has thoughtfully considered every fact that the chemists and physicists of the world shall discover with regard to the relation between helium and radium. We shall continue to find out strange and unexpected things about these substances for a considerable time, and then some bright mind will perceive a fundamental unity underlying all these data, and will, perhaps, show us how to penetrate into the very heart of the Mystery of Matter.

The Completion of the Pacific Cable.

It is characteristic of the American people (as we have had occasion to remark before) to show a proper enthusiasm when some great engineering task is completed, and thereafter to expect that all similar works will be performed with like success and expedition, as a matter of course. The completion of the first length of the Commercial Pacific cable, extending from San Francisco to Hawaii, attracted great attention from the general public, and a keen interest was felt in the work at that time. (For an account of the completion of this section, on the first day of last January, see The Locomotive for February, 1003.) When, on July 4th, the far longer section, extending from Hawaii to Manila, was completed, its success was taken, as usual, as nothing but what was to be expected. The line from San Francisco to Hawaii has a total length of 2,412 nautical miles, while that extending from Hawaii to Manila is more than twice as long. The Hawaii-Manila cable is divided into three sections; the first of these, with a length of 1,384 miles, extends from Hawaii to Midway Island; the second, 2,693 miles long, extends from Midway Island to the Island of Guam; and the third section, from Guam to Manila, has a length of 1,709 miles.

We do not need to dwell upon the commercial importance of the new cable, but a word may be said with regard to its scientific importance. Differences of longitude are most accurately measured by the transmission of electric signals between the places whose longitudes are to be compared; and the various Atlantic cables have been repeatedly pressed into service for comparing the longitudes of places in the eastern and western hemispheres. By making use of the land telegraphic lines, and also of some of the shorter cables that intervene between the Philippine Islands and Europe, we have been enabled to compare the longitude of Manila and San Francisco, through New York, London, Suez, and India. A more direct comparison of the longitudes of Manila and San Francisco by means of the new Pacific cable may be expected in the near future, and it will serve as a valuable check upon the earlier determinations made by means of the electric lines passing around the earth the other way. In the language of the mathematician, such a direct comparison will furnish a valuable "condition equation," which must lead to a distinct improvement in our knowledge of trans-Pacific differences of longitude.

The story of the completion of the Commercial Pacific cable is given in the *Electrical World,* from which we reprint the following paragraphs.

A great many interesting features have attended this work — political, financial, electrical, geographical, and commercial. The extreme depth of the Pacific interposed many unusual difficulties. The route has four great ocean stretches of 2,270, 1,254, 2,593, and 1,490 miles. Between San Francisco and Hawaii, the mean depth is 2,500 fathoms, with a maximum of 3,073; between Hawaii and Midway Island the mean depth is 2,000, the maximum 3,026; from Midway Island to Guam the mean depth is 2,600, with a maximum of 4,900, and with sudden and great fluctuations; from Guam to Luzon the average depth is 2,200, the maximum 3,400 fathoms. In 2,900 fathoms, with the ship steaming at 8 knots an hour, no less than 25 miles of cable are in suspension in the water. Two and a half hours elapse, in such a case, between the time when any particular point in the cable leaves the ship, and the time when it comes to rest upon the ocean bottom. Midway Island is virtually a new American colony, created by the Commercial Company, and consists of two small islands surrounded by a coral reef eighteen miles in circumference. Buildings have been erected for the cable staff, the colony has been put under the care of the United States navy department, and Lieutenant-Commander Hugh Rodman has been appointed first governor.

The cable itself has been made and laid with great care, the contractors being the India Rubber & Gutta Percha Telegraph Works Company of England, and the work being begun by the cable steamer *Silvertown,* which left the Thames with the first section, 2,413 nautical miles, on September 23, 1902. The cable proper, of copper, is sheathed in gutta percha. To protect these two, known technically as the core, brass sheathing is used. Next comes a cushion of jute yarn, and outside of all an armor of iron and steel wires. In the construction of the cable, which is 8,300 nautical miles (or nearly 9,600 land miles) in length, the following materials have been used: Nineteen million pounds of iron and steel wires, 2,010,000 pounds of jute yarn, 306,000,000 yards of preservative tape, weighing 5,090,000 pounds; 52,000 [52,000,000?] pounds of brass sheathing; 3,600,000 pounds of copper; 2,310,000 pounds of gutta percha; and 4,220,000 pounds of preservative compounds. The whole work has been completed in eighteen months from the date of the signing of the contract. A separate contract was awarded to the Telegraph Construction & Maintenance Company to lay the sections of the cable from Honolulu to Midway, Guam, and the Philippines. On the 9th and 10th of April last the steamships *Colonia* and *Anglia,* belonging to the manufacturers, left London with more than 6,000 miles of cable in their tanks. The *Colonia,* which laid the longest section, that between Guam and Midway, 2,606 nautical miles, is the largest cable ship afloat.

The political and international fight over this cable has been long, and its close was hastened by the Spanish war and the acquisition of the Philippines, at which time the United States government alone found itself to be paying out at least $400,000 for messages to and from the new possessions. Between September 20, 1895, and December 14, 1896, no fewer than twelve bills were introduced in the United States Senate and the House, relating to the construction of a cable across the Pacific. Bills were reported and passed in one house, only to fail in the other. In the winter of 1901 Mr. John W. Mackay offered to lay the cable without subsidy or guarantee of any kind, as a private business enterprise. The bill favoring government ownership finally came to a vote, and was rejected by 116 to 77. Meanwhile, the Commercial Pacific Cable Company was incorporated under the laws of the state of New York on September 23, 1901, with a charter authorizing it to lay and operate a submarine cable from California to the Philippine Islands, by way of the Hawaiian Islands.

On July 4th circuits were completed and the first messages were flashed, the time occupied in the circle around the world being stated as 12 and 14 minutes for the 25,835 miles, with 20 transmitting and receiving stations. The president's message was as follows:

OYSTER BAY, N. Y., July 4.

GOVERNOR TAFT, MANILA:

I open the American-Pacific cable with greetings to you and the people of the Philippines.

THEODORE ROOSEVELT.

This was Governor Taft's reply, sent from Manila over the new cable:

The Philippine people and the Americans resident in the islands are glad to present their respectful greetings and congratulations to the President of the United States, conveyed over the cable with which American enterprise has girdled the Pacific, thereby rendering greatly easier and more frequent communication between the two countries. It will presently lead to closer union and a better mutual understanding of each other's aims and sympathies, and of their common interest in the prosperity of the Philippines and the education and development of the Filipinos.

It is not inappropriate to incorporate in this the first message across the Pacific from the Philippines to America an earnest plea for the reduction of the tariff on Philippine products, in accordance with the broad and liberal spirit which the American people desire to manifest toward the Filipinos, and of which you have been an earnest exponent.

TAFT.

Not long after the president's message had been sent, another message was started, this one to go around the globe. It was from the President, and was addressed to Clarence Mackay at Oyster Bay. Mr. Mackay was in the telegraph office there and watched the sending of the message, which was to come back to him after circling the earth, it was hoped within an hour. This was the message:

Congratulations and success to the Pacific cable, which the genius of your lamented father and your own enterprise have made possible.

THEODORE ROOSEVELT.

Mr. Mackay announced the official time for the president's message, going from east to west, as twelve minutes. It left Oyster Bay at 11.21 and returned at 11.33. Mr. Mackay addressed a reply as follows to the president:

OYSTER BAY, July 4.

To the President:

I thank you deeply for your message, and I earnestly hope the Pacific cable, by opening the wide horizon of the great East, may prove a useful factor to the commerce of the United States.

CLARENCE H. MACKAY.

This message was sent eastward, going over the old European route to Manila, and back by way of the new Pacific cable to San Francisco. It started at 11.55 o'clock, and at 12.04 it came ticking back again — just nine minutes being consumed in its journey around the world. A number of other messages were exchanged with the Philippines and Governor Taft, by ex-President Cleveland, Secretary of War Elihu Root, General Miles, Mayor Low, Archbishop Ireland, and others. All the officials of the commercial and postal telegraph companies participated actively in the memorable exercises.

The Locomotive

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Boiler Explosion in an Electric Plant.

The photoengravings presented herewith illustrate a boiler explosion which occurred recently in the plant of an electric light and power company, at Tuscaloosa, Ala. The power house of the plant was wrecked, as shown in Fig. 1, and a large quantity of electrical machinery was ruined. A considerable amount of damage was also done to other buildings in the vicinity.

The exploded boiler was thrown high into the air, and after passing through

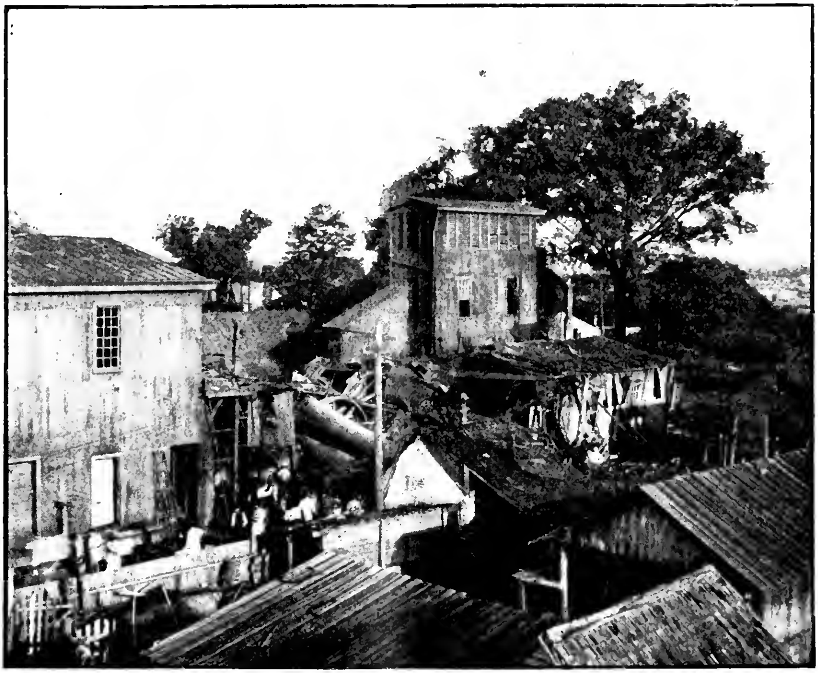

FIG. 1. — GENERAL VIEW OF THE WRECKED PLANT.

three brick walls it eventually landed in the second story of Friedman & Rosenau's department store, nearly two blocks away, its appearance after this terrific journey being represented by Fig. 2. The total property loss, including that sustained by the plant in which the boiler originally stood, and by the other buildings that were damaged, was from $25,000 to $30,000. Adolph Johnson and N. D.

Johnson were also killed instantly, and E. W. Housman, A. M. McGhee, and Crawford McCloskey were somewhat injured.

We are informed that an expert (Mr. J. S. Clark) who examined the wreckage after the accident is of the opinion that the explosion was primarily due to lightning. He is reported as saying that he found the marks of lightning upon the stack, and that the armature of one of the dynamos was also burned out, although it was safeguarded against the effects of short-circuiting. He is of the opinion that the lightning struck the stack first, and then passed down it to the boiler room, where its influence upon the boiler, when superadded to the steam pressure of 120 pounds that was regularly carried, brought about the explosion. The precise mode of action of the lightning upon the boiler is not explained; but it cannot be denied that such a cause is possible, although we cannot speak from personal knowledge, since we have not had an opportunity to inspect the ruins ourselves.

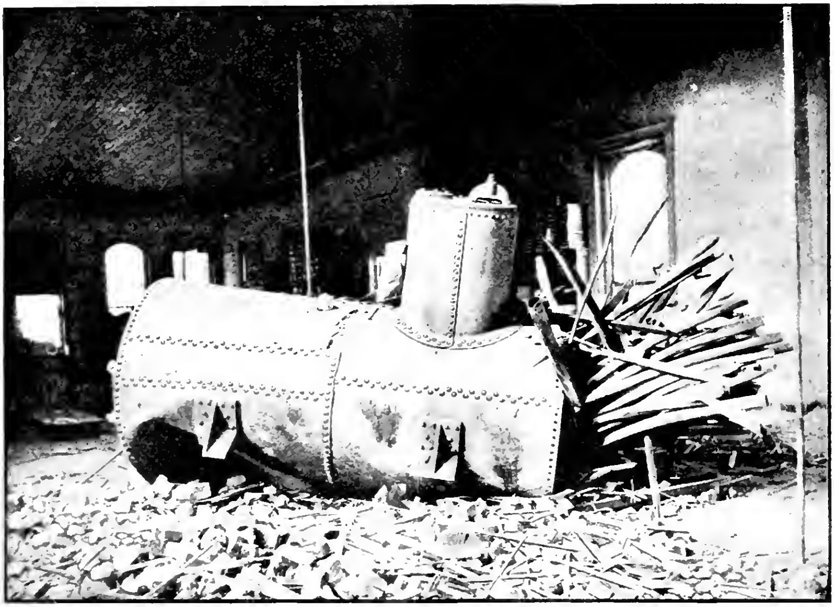

FIG. 2. — THE BOILER, AFTER ITS FLIGHT.

Boiler Explosions.

APRIL, 1903.

(95.) — On April 2d a boiler exploded on the barge *J. C. Fitzpatrick*, off Shinnecock, L. I. The barge was sunk, and her captain and the crew of four men were drowned. She was bound from Philadelphia to New Bedford with 2,400 tons of bituminous coal, and was owned by the Boutelle Transportation Co.

(96.) — A boiler exploded, on April 3d, in Julius Dunn's sawmill, at Birmingham, near Benton, Ky. Harrison News was fatally injured, and William McAtee, Warren Watkins, Claude Heath, and five other men, whose names we have not learned, were injured to a lesser extent. The mill was completely wrecked, and the property loss was some thousands of dollars.

(97.) — A heating boiler exploded, on April 4th, in Frank Smith's greenhouses, at Cumminsville, near Dansville, N. Y. The boiler was destroyed, and a considerable proportion of the contents of the plant was destroyed by frost as the result of the explosion.

(98.) — On April 7th a boiler exploded in Angus MacKinnon's sawmill, at Coleman, some thirty miles from Charlottetown, P. E. I. Frederick Profit was instantly killed, and John McKay received injuries from which it was thought he could not recover. The owner of the mill was also injured by flying débris, though not seriously. The building in which the boiler stood was badly shattered.

(99.) — On April 7th the boiler of locomotive No. 108 of the Cincinnati Northern railroad exploded in the roundhouse at Van Wert, near Toledo, Ohio. Andrew A. Stutz and John Welch were seriously injured, and F. A. Miller, Elmer Councellor, and Walter Sargent received minor injuries. The roundhouse was totally wrecked, and two locomotives were damaged, in addition to the one which exploded. The property loss was about $20,000. We do not know precisely how the explosion came about, but one account that we have received states that Welch and Stutz were on top of the boiler at the time, doing some repairing If this is true, the explosion here recorded may be one more example in the already painfully long list of those that have occurred as the result of making repairs under pressure.

(100.) — A portable boiler exploded, on April 8th, on Renshaw's farm, some five miles southwest of Utica, Mich. Several men were injured, and the boiler was blown to fragments. We have not learned further particulars.

(101.) — On April 9th a portable boiler exploded on George L. Booth's farm, in the town of Fabius, near Syracuse, N. Y. Clinton C. Penoyer, Hiram Widger, and Walter J. Pierce were seriously injured. The boiler was thrown 200 feet, landing in the top of a tree, after cutting off a limb eight inches in diameter.

(102.) — A boiler exploded, on April 9th, on the Moses Bradford farm, near Marion, Ind. The explosion was exceedingly violent, but, fortunately, nobody was injured. The boiler was used in connection with an oil well.

(103.) — On April 11th a boiler exploded at the pumping station in the cemetery at Salina, Kans. W. H. Crissman and one other man whose name we have not learned were injured slightly. The boiler was used for pumping water for irrigation purposes.

(104.) — A small boiler, used for supplying hot water, exploded, on April 13th, in an office building at 331 Madison Ave., New York, causing considerable damage to the tailor shop of Marcus Saul, on the ground floor. Luke Pierson, employed in the tailor shop, was slightly injured. The total property loss was estimated at about $1,500.

(105.) — A boiler exploded, on April 14th, at the plant of the Crescent Foundry Company, near Eden Park, South Wilmington, Del. The main plant was not damaged, but the small corrugated iron building in which the boiler stood was blown down. Nobody was injured.

(106.) — The boiler of a portable sawmill belonging to Charles Bevan exploded, on April 14th, at Ruby, in Harrison township, Gallia county, Ohio. Rufus

Houck, Richard Houck, and Charles Bevan were instantly killed, and Edward Houck, Frank Wells, and Butler Bevan were seriously injured. The property loss is said to have been large.

(107.) — On April 15th a boiler exploded in Chase's feed and lumber mill, at South Columbia, N. Y. Jacob Goodhine received injuries from which he died some two hours later. We have not learned further particulars.

(108.) — John Stoll was killed by a boiler explosion, on April 15th, at Oaktown, near Vincennes, Ind. We have not learned further particulars.

(109.) — A boiler exploded, on April 16th, in the Big Four pumping station, at Marion, Ind., injuring George Shedron so badly that he died a few hours later. The boiler was thrown to a distance of 200 feet.

(110.) — A boiler exploded in Frederick Nicholls' sawmill, at Williamsburg, Md., on April 16th, instantly killing engineer Herbert Milligan, and injuring Mr. Nicholls slightly. The mill had closed down for the noon hour, and Mr. Milligan had barely finished banking the fires.

(111.) — On or about April 18th an agricultural boiler exploded on a farm near Truxton, N. Y., killing one man and seriously injuring three others.

(112.) — A few choice spirits gathered in Madison Hall, Chicago, on April 21st, to see a couple of gentlemen discuss matters according to the parliamentary principles enunciated by one Queensbury. The soirée was enlivened by several features that were not advertised in advance. For example, certain individuals connected with the police department entered the hall without invitation, and remonstrated with the disputants, and with the management generally. It is said that several revolver shots were fired as a part of the festivities, and as a grand finale the heating boiler exploded.

(113.) — On April 22d a boiler exploded in Shore & Moser's sawmill, at Bethania, near Winston-Salem, N. C. Gideon T. Shore, Luther George, and William Logan were killed, and Samuel Moser and Grant Clayton were injured. The mill was completely wrecked. The main part of the boiler was thrown to a distance of 300 feet, and one piece of it was found a quarter of a mile away.

(114.) — A heating boiler exploded, on April 22d, in the residence of William F. Dreer, at Rosemont, Pa. The explosion wrecked the boiler room in the basement, and also the room above it, which is used as a laundry. Nobody was in the path of the flying wreckage, so there are no personal injuries to record.

(115.) — A boiler exploded, on April 23d, in Petit Bros.' sawmill, about four miles from Comber, Ont. The explosion occurred during the noon hour. Herbert Manley was seriously but not fatally injured.

(116.) — On April 23d a boiler exploded in the plant of the Merchants' Distillery, at Terre Haute, Ind., scalding and bruising Silas Jones and Nelson Clark. A portion of the boiler house roof was blown off, and one of the walls was also partially thrown down. The property loss was estimated at about $4,000.

(117.) — The boiler of locomotive No. 875 of the Erie railroad exploded, on April 23d, between Miller's Station and Mill Village, near Meadville, Pa. Engineer F. S. Penfield, fireman Charles Van Slyke, and brakeman M. L. Gilvair were seriously injured. The explosion appears to have been due to the failure of the crown-sheet. The boiler was thrown clear of the frame, and four of the six driving-wheels remained on the rails.

(118.) — On April 25th the boiler of a sand dredge exploded on the Susquehanna river, at Harrisburg, Pa. The dredge was in use by Payne & Co., contractors, in obtaining sand from the river bed for use on the new capitol building. Frank S. Feterow, Harry Bogner, and James Gardner were painfully injured, and John Seer and Harry Berrier were slightly scalded and bruised.

(119.) — A boiler exploded, on April 27th, at the Niggertown mine, six miles east of Sullivan, Ind. We have not learned of any personal injuries.

(120.) — A boiler exploded, on April 29th, at the Chincle clay works, at Clearfield, Pa. Fire followed the explosion, and the total property loss was about $2,000.

(121.) — On April 29th a boiler exploded in the Scheidler machine shops, at Newark, Ohio. Reinhard Scheidler was almost instantly killed, and Bert Vial, James Kane, and James Markham were seriously injured. August Hess and several other men also received minor injuries. The exploded boiler belonged to a traction engine which had been undergoing repairs at the machine shops, and we understand that it was being tested by steam pressure to see if it was safe. We infer that it was concluded to be dangerous.

(122.) — On April 30th a boiler exploded in the Lee & Jones lumber company's plant, at Orange, eight miles north of Leesville, La. Rufus Carroll and Joseph Hickman were instantly killed, and Hosea Kay was injured so badly that he died in about two hours. Samuel Sanders and Ira Grelett were hurt so seriously that at last accounts it was thought that they could not recover, and several other persons also received lesser injuries. The mill was totally demolished.

May, 1903.

(123.) — On May 2d a boiler exploded in the Krell-French piano factory, at Newcastle, Ind. Three men were slightly injured.

(124.) — A boiler exploded, on May 3d, in the municipal electric light plant, at Normal, near Bloomington, Ill. The engineer, John Butler, was seriously injured. The plant was completely wrecked, and the property loss is variously estimated at from $10,000 to $25,000.

(125.) — On May 4th a boiler exploded in the Tytus paper mill, at Middletown, Ohio. Engineer Eugene Lewis was fearfully scalded and otherwise injured, and it is doubtful if he recovers. The explosion consisted in the bursting of a tube in a safety boiler.

(126.) — Lee Myers was seriously scalded, on May 5th, by the explosion of a boiler at his bicycle shop at Elmhurst, near Oakland, Cal.

(127.) — On May 6th a boiler exploded in the Oregon Lumber Company's plant, at Viento, near Portland, Ore. J. Hanson and F. W. Link were badly injured, and Charles Walker, M. Phillips, and Frederick Powell received lesser injuries. The property loss is estimated at $2,000.

(128.) — A boiler exploded, on May 8th, on the government tug *Cynthia*, engaged in towing a dredge on the shoals at Cape Fear, ten miles below Wilmington, N. C. Engineer Augustus Dicksey was scalded to death, and J. C. Warren, Tobias Jackson, and Ambrose Lovenier were seriously injured. Warren and Jackson may not recover.

(129.) — A boiler exploded, on May 9th, in the Indianapolis hominy mills, at Indianapolis, Ind. Charles Bowers was killed, and Ernest L. Shelton was fatally injured. Paul Storm, Frank Starkey, William McDonald, Eugene Hutchison, Robert Emmings, and Aaron Klingensmith were scalded and bruised. The plant was partially wrecked, and the property loss is estimated at $5,000.

(130.) — On May 9th a boiler exploded on the steam yacht *Lena,* at the foot of Randolph Street, Chicago. George F. Lorenz was seriously injured, and the interior of the yacht was wrecked.

(131.) — A boiler exploded, on May 9th, in the Sanitary Creamery Company's plant, at Amboy, near Dixon, Ill. Nobody was injured, and the damage was chiefly confined to the boiler.

(132.) — A small boiler exploded, on May 10th, at Cambridge, Mass. Kendall Thompson and John Mahoney were seriously scalded, and at last accounts both were said to be in a serious condition.

(133.) — A boiler exploded, on May 11th, in a sawmill at Chippewa Falls, Wis. We have not learned of any personal injuries, but the mill was considerably damaged.

(134.) — A boiler used in connection with an oil well exploded, on May 13th, on the Cashdollar farm, at Callery Junction, near Butler, Pa. Joseph Ehrhart was seriously and perhaps fatally injured. Fire followed the explosion, and the entire outfit was destroyed, together with 100 barrels of oil.

(135.) — On May 14th a boiler exploded, at Grafton, W. Va., in the shops of the Baltimore & Ohio railroad. Charles Jaco was fearfully injured, and it is believed that he cannot recover. Frank Kane was also injured seriously, and two men named Dawson and Hanston received minor injuries. The building in which the boiler stood was badly damaged.

(136.) — On May 14th a boiler exploded in the American Wood Board Company's plant, at Clark's Mills, near Schuylersville, N. Y. Joseph Brooks and Alonzo Eddy were seriously injured, and the boiler house was completely demolished. The property loss is variously estimated at from $10,000 to $15,000.

(137.) — A boiler exploded, on May 14th, at the Birmingham rolling mills, Birmingham, Ala. William Porter, Hezekiah Watson, and John Wilson were painfully injured, and two other men received slight bruises. We have seen no estimate of the property loss.

(138.) — On May 19th a boiler exploded in Dr. E. B. Harrell's sawmill, near Oakhurst, Texas. One man was slightly injured. We have seen no estimate of the property loss, but the explosion was a violent one, the main portion of the boiler being thrown to a distance of a hundred yards, breaking down trees and carrying destruction in its wake. One of the flues lodged in a pine tree 150 yards away.

(139.) — On May 19th a boiler exploded in Spartan mill No. 2, at Spartansburg, S. C. The accident occurred about ten minutes after the employees had left the mill, and nobody was injured. The boiler room was damaged considerably.

(140.) — A water-tube burst, on May 20th, in a safety boiler at the plant of the American Locomotive Company, at Schenectady, N. Y., scalding and burning fireman W. Quillinan so badly that he died on the following day. The damage to property was small.

(141.) — The boiler of a traction engine exploded, on May 21st, near Taneytown, Md. Marshall Knipple, the owner of the boiler, was injured so badly that he died on the following day.

(142.) — The crown-sheet of a New York Central freight locomotive gave way, on May 22d, at Great Neck, near Fishkill Landing, N. Y. Fireman John Ryan was thrown from the tender and instantly killed, and E. A. Flanagan and James Moran were injured.

(143.) — On May 23d, a boiler exploded in Wilson & Cochran's sawmill, at Wilcox, near Plaquemine, La. William Pearson, James Victor, Philip Archer, William Hill, Richard Hill, and Jesse Thomas were killed. William Prince and William Scott were fatally injured, and John Dallinger, S. Glover, Robert Mills, John Hill, Pleas Dunn, and two other men, whose names we have not learned, were injured to a lesser degree. The mill was totally wrecked, and the property loss was probably about $8,000.

(144.) — On May 24th the boiler of a Philadelphia & Erie freight locomotive exploded, about seven miles west of Kane, near Warren, Pa. Brakeman John Craine was killed, and flagman Henry Gardner and conductor Charles Ownes were fatally injured. Engineer W. J. Swartzfager was also badly injured, and fireman Peter Crossen received minor injuries. The explosion is said to have consisted in the failure of the crown sheet.

(145.) — On May 27th an explosion occurred in the plant of the Moosic Powder Company of Olyphant, near Scranton, Pa. The accident is described as a boiler explosion, and John Hamilton (who was the only person about the plant at the time) is said to have been severely scalded.

(146.) — A boiler exploded, on May 27th, in the ice factory at Antlers, I. T. Night engineer John Goodman was seriously and perhaps fatally injured. The building in which the boiler stood was considerably damaged, and the property loss is estimated at $2,000.

(147.) — On May 28th a boiler exploded in the pumping station of the Southern railway, at Bridgeport, Tenn. Engineer John Blanchard and pump inspector Frank Ownes were killed. We have not learned further particulars.

(148.) — On May 28th a boiler exploded in Shattuck Bros.' feed mill, at Sparta, Wis. Nobody was injured, but the main building of the plant was considerably shaken, and the property loss is estimated at $1,500.

(149.) — A tube burst, on May 28th, in a safety boiler at the power house of the Little Rock Railway & Electric Company, Little Rock, Ark. William Anderson was severely scalded and burned.

(150.) — On May 30th a boiler exploded in Anderson's planing mill, at Brunswick, Tenn. Three men, whose names we have not learned, were injured, and one of them is not expected to recover.

The American Grape Acid Association, 318 Front Street, San Francisco, Cal., offers a premium of $25,000 for any person who devises a process or formula for the utilization of California grapes containing over twenty per cent. of saccharin matter, worth ten dollars a ton, to produce tartaric acid at a price that would permit of exportation without loss. The decision in awarding the amount is to rest with a jury of five, of which Professor E. W. Hilgard of the University of California, is one. The offer expires on December 1, 1904. — *Science.*

The Locomotive.

HARTFORD, SEPTEMBER 15, 1903.

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

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The Electron Theory of Matter.

The ancients used to speculate upon the ultimate structure of matter, and many animated discussions were held with regard to the divisibility of matter, some of the early philosophers holding that however small a particle might be, it would always be possible (at least in the imagination) to divide it into still smaller parts, which should not differ from the original material except in size. Others held that a limiting size would be found, when this process was carried far enough, so that further division would change the substance altogether. We are now reasonably certain that this second view is correct, and we believe that when we have separated a substance into its constituent molecules, we cannot carry the process of division any further without altering its chemical nature.

It has long been recognized that the molecules of bodies are composed of still smaller particles, which are called atoms; but according to the so-called "Electron Theory," which is quite fashionable among physicists at the present time, we shall have to admit that the atoms themselves are also complicated systems, composed of yet smaller bodies called "electrons." We do not know precisely what an electron is, any more than we know what an atom is; but there is some reason for believing that the mass of an electron is only about 1/1,000th as great as that of a hydrogen atom. Indeed, the tendency now is toward the belief that the electrons do not possess any "mass" at all, at least in the usual sense in which we understand that word. It is known that a moving body, when electrified, possesses an apparent "mass" which is somewhat greater than the mass of the same body when motionless, or when devoid of any electric charge. The apparent increase of mass due to the moving charge is too small to be recognized by direct measurements in the case of such bodies as we can handle in the laboratory; but as the size of the body decreases (the electric charge remaining constant) the apparent "mass" due to the electrification becomes much greater. When the body becomes of atomic dimensions, the "mass" due to the electrification may become a very sensible fraction of the total mass; but taking into account what we know of the sizes of the atoms, and of their motions, and of their electric charges, it was evident that the total mass of an atom cannot be accounted for on the electrical theory. If the reasoning upon which the electron theory of the constitution of atoms is based proves to be sound, the case is very different; for the *electrons* are so small (if they exist at all) that we may account for their entire "mass" merely by the fact that they are carrying a moving charge of electricity; and it is no longer necessary to suppose that the electrons, or the atoms and molecules which they compose, possess any mass at all, in the usual sense of the word.

This idea is revolutionary in character, and when it has been fully worked out it promises to teach us very much concerning the machinery of nature. Some of the laws of motion that must be obeyed by the electrons, when they are in their usual rapid state of motion, are given in Drude's *Annalen* for January last, and are reviewed in a recent issue of *Science*. They are sufficiently curious to be worth mention in the present place. When the velocities and accelerations of the electrons are very small, the ordinary laws of motion are applicable to these bodies, just as to the larger bodies of our familiar experience. When the velocity or acceleration becomes great, these ordinary laws of motion are not applicable to the electrons at all. The apparent mass of the electron becomes greater, as the velocity increases. An electron once set in state of steady, uniform motion in a straight line will continue this motion when it is left to itself. An electron that is moving uniformly in a circular orbit, however, radiates its energy continuously, so that its motion must cease, or be maintained by some external cause. Two electrons rotating about each other, like a planet and its satellite, therefore, radiate energy, and behave very much as though they were moving in a resisting medium. An electron, when once set in motion, if quickly stopped and again released, will start up again of itself, and move with diminished velocity in the original direction. If an electron is acted upon by an accelerating force until it gains a certain velocity, and then the force suddenly ceases to act, the electron will not continue to move with the speed that it had at the instant the force was removed, but will lose some of its velocity, and then settle down to a slightly decreased uniform velocity. Many other curious facts about the dynamics of the electrons have been discovered, such as that their "mass" is not what mathematicians call a "scalar quantity," but a "linear vector function." Into these higher parts of the theory, however, we cannot go.

The Germ of Laziness.

Under this sensational heading the daily newspapers have been endeavoring to tell the public something about a discovery recently made by the United States Public Health and Marine Hospital Service. Many persons have been in doubt whether the discovery was a real one or not, and have not known whether to take the newspaper articles seriously or in jest. The *Popular Science Monthly* has taken the trouble to ascertain the real facts of the case, and to that journal we are indebted for the information in the present article.

In an Egyptian manuscript, about 3,500 years old, a peculiar tropical malady is described, which is characterized by an extreme anemia, pains in the abdomen, palpitation of the heart, and certain other symptoms. What is apparently the same disease was described by various authors in the eighteenth century, but its cause was not discovered until 1843, when Dubini, of Milan, found that it is always associated with a parasitic worm in the intestines. It has been thoroughly established that Dubini's worm sucks the blood and produces a poison; also that it causes the conditions known under the various names of St. Gothard anemia, miner's anemia, brickmaker's anemia, Egyptian chlorosis, etc. This disease was known to be very prevalent in tropical countries, but no positive case was recognized in the United States until 1893, when Dr. Blickman of St. Louis found a German who had brought the infection from Europe. Dr. Stiles, the zoölogist of the Public Health and Marine Hospital Service, has maintained for eight or ten years that this disease must be more or less common in the southern part of this country, and that physicians have confused it with malaria. His view was considered, by physicians generally, to be extreme, and between 1892 and 1902 only about thirty-five cases were positively identified in the United States, and the most of these were imported. In May, 1902, Dr. Stiles succeeded in showing that the parasites, in three instances at least, were not identical with those which cause miner's anemia in the Old World; and he named the new parasite *Uncinaria americana.* Having learned this much, he started out, in September, 1902, to demonstrate that this parasite is far more common in the South than was believed; and in eight weeks' time he proved his point. If we go south from Virginia to the Gulf, we meet two totally different kinds of anemia, which can be distinguished by the soils on which they occur, the parasites which cause them, the symptoms which result, and the treatment which is necessary. One of these anemias follows the more impervious soils, such as clay, and is due to malaria which, as is well known, is caused by a minute parasite which lives in the blood. This form of anemia may be cured by a proper use of quinine. The other anemia, which is preëminently a disease of the sandy regions, is caused by Dr. Stiles' parasitic worm, which lives in the intestines, and which is not affected by quinine, but can be killed by the use of thymol. These two anemias have heretofore been confused by most physicians, and Dr. Stiles' discovery probably means a revolution in the treatment of half of the sick people found in the southern sand areas.

One of the most ordinary symptoms of Dr. Stiles' "hook-worm" disease is an extreme lassitude, both mental and physical; this condition being due to the thin, watery character of the blood, which does not properly nourish either the brain or the muscles. Curiously enough, it is especially in the sand areas of the South that the poor whites, known as "poor white trash," are found; and Dr. Stiles has stated, after living among these people, that the hook-worm disease is especially prevalent there, and that it is largely responsible for the poverty of mind, body, and worldly goods which has won for these people their cognomen, "poor white trash." It is not claimed that all poverty and lassitude in the South are due to this one cause, but it may be said to be certain that a very large proportion of these characteristics among the poor whites of the sandy districts is due to Dr. Stiles' hook-worm. In the future we may expect thymol to become as well known throughout the southern states as quinine has been in the past; and we may confidently look for a material improvement in the condition of the poor of those regions.

An Old Clock.

In a recent issue of the *American Machinist*, Mr. W. H. Booth tells of a visit that he made not long ago to the town of Rye, in the eastern end of Sussex, England, and of the old church clock that he saw there. The clock has a pendulum nearly nineteen feet long, and is said to have been presented to the town by Queen Elizabeth.

"It is very difficult to secure accurate information," he says, "concerning old machinery. The clock is said to have been taken out of a ship of the Armada in 1588, yet all the information that I have by me states that the first pendulum clock was made by a London man (one Richard Harris) for the Church of St. Paul's, Covent Garden, in 1641, or eight years before Vincenzo Galileo published his supposed discovery of the pendulum. [On this point, see the note appended to the present article, below.] The going train and the quarter chimes of the Rye clock are wound by pulling on hand-wheels, while the hour strike is wound up with a key. The man who does the winding assured us that among the old church accounts, dated 1558, is an item of 'faure shillinges and six pence payde to ye clockemaker for makynge ye chimes to goe.' If such be the case, the pendulum is older than supposed, and the clock had got out of order in 1558. If the date of repair, 1558, can be substantiated — I have so far been unable to secure any confirmation of this date — then the Rye clock would be the oldest bit of running machinery in the world."

Mr. Booth refers to Baedeker's "Paris," in which he says that the date of the old clock in the Palais de Justice is given as 1370; but he does not know whether this clock had a pendulum or not. It appears to be still in existence, but it is very doubtful if it is running.

"The wheels of the Rye clock," continues Mr. Booth, "appear to be of wrought iron, and the escapement wheel is only some three or four inches in diameter, which is very small for so long a pendulum. The train of wheels is short, and it is necessary to wind the clock daily. The lantern wheel, through which the hands are driven, is like a squirrel cage. The striking gear is singularly like that of modern clocks, with a six-minutes' 'warning.' It is curious to reflect that this clock may have been running before the state of Virginia was founded; and that in Cromwell's time a hundred sail of the line lay up to the town of Rye and took their time from it."

[We do not follow Mr. Booth in what he says with regard to Galileo and the discovery of the isochronism of the pendulum. He intimates that the credit for this discovery is usually assigned to Vincenzo Galilei, but surely this is incorrect. It is to Galileo Galilei, Vincenzo's son, that this honor belongs. Anyhow, Vincenzo died about 1600, and hence he could not have been antedated by Richard Harris and the clock of 1641. Galileo Galilei probably discovered the isochronism of the pendulum in the year 1583, although the tradition that the idea occurred to him while watching a swinging lamp in the cathedral at Pisa may not be true. What Galileo really discovered was that the time of vibration of any given pendulum is sensibly the same, whether the travel of the bob, to and fro, is two inches, six inches, or any other distance that is small in comparison with the pendulum's length. The mere fact that a given pendulum performs its oscillations in the same constant time so long as the *amplitude* of the vibration is kept constant, is so evident, even without experiment, that it must have been known long before the time of Galileo. It is quite possible that pendulums were actually used in clocks before Galileo's discovery was made, and we have an impression that they actually were so used. Whether this was the case or not, there does not appear to be any conflict in the dates, provided it is assumed that the old caretaker at Rye is mistaken about the unverified entry in the church records, and that the tradition connecting the clock with Queen Elizabeth and the Spanish Armada is correct; Galileo's discovery being made in 1583, the Rye clock being taken from the Armada in 1588, and Harris's clock being built in 1641. — *Editor* THE LOCOMOTIVE.]

WHEN kerosene or any other inflammable substance has been used in a boiler in any quantity, care should always be taken, after opening the boiler up, to ventilate it thoroughly before bringing an open light near the manhole. Two fatal accidents from neglect of this precaution came to our attention in the month of May. On the 6th, Benedict Brown was fatally burned, in the Metcalf Building, Providence, R. I., and on the 24th a similar fate befell Andrew Delory, at the American carpet lining factory, Watertown, Mass. In each case kerosene had been used for cleaning the boiler, and the vapors subsequently exploded through contact with an open light.

The Fair of 1846.

It has not been sixty years since the sewing machine made its appearance in Washington, and there are quite a number of very old people who remember the occasion. During the great Mechanics' Fair, which opened in a specially constructed frame building in Judiciary Square on May 21, 1846, the sewing machine was one of the star exhibits. It was said at the time that one of the main objects of the fair was to influence legislation in congress on the tariff, to show what the American workingman could do, and to illustrate how little we were dependent upon other countries for the necessities of life.

I remember that the sewing machine was the greatest attraction of the fair and interested the crowds about it, and there was difficulty experienced in getting near it. As may be supposed, the machine at that period had not been brought to the perfection it reached by subsequent improvement, but it did its work to the amazement of the thousands of visitors, and as a labor-saving machine, together with McCormick's reaper, then first exhibited here, caused much discussion. Among the seamstresses the sewing machine was looked upon as the instrument which would deprive them of a living, and it was predicted that its adoption would drive hundreds to poverty. At that time the price was high, and many hoped that so much would be asked for it as to prevent its general use.

The effect of its introduction was to some extent discussed in the papers of the day, and I believe in some of the manufacturing cities the working people were much excited over the revolution its adoption was expected to bring. I read an abstract of an address by a pastor in one such city, in which he said to the factory people and seamstresses that they had nothing to fear from its introduction. He said notwithstanding so much more sewing could be done by machine, the tastes of the women were such that should the cost of making a dress or other garment be cheapened, more elaborate garments would become the style and there would follow such a demand that instead of taking work from the sewers there would be more. In other words, while the cost of making a plain dress would be lessened, the additional trimmings, extra plaits, seams, etc., would make up for any loss.

There was no fear that the labor-saving mower and reaper would have such an effect upon the masses, for all recognized that should it be effective the cost of daily bread would be lowered. I should mention that the revolving pistol, patented by Colonel Samuel Colt some ten years before, was an object of much interest, especially to military men, and the fact that it was then on trial in warfare — the Texas Rangers of Captain Samuel H. Walker, engaged in the Mexican War, being armed with the pistols — imparted an additional interest to the subject.

There were many other exhibits at the fair mentioned, and the display was a revelation to the masses, a great educational object lesson, and probably the most important exhibits were those named. I should not, however, omit to notice another. As is customary, admission tickets were issued to all exhibitors, and hundreds of our younger people were benefited thereby, these being mostly girls who had specimens of sewing and embroidery on exhibition. There was a boy living in the old Second Ward who got up an elaborate aggregation of cog-wheels, levers, shafts, etc., so intricate in looks as to bewilder any but the initiated, whose sole object was to obtain an admission ticket. This he entered, but not for a prize, and called it a "wing wang." By winding up the motive power, a clock spring, it went into operation with such a clatter as to drown the noise of the larger machines. Curiosity led to many inquiries as to its use, but the only reply obtained was that it would grind smoke when forced in the hopper, and cool the air with its revolving flippers. Useless though the machine was at the time, it drew the attention of an influential gentleman to the boy, who made him his protegé, and the result of the boy's ingenuity was subsequently seen by an improvement in drawbridges and in the matter of lanterns for lighthouses. — *Washington Star.*

Boiler Explosions since 1879.

The tables presented herewith show the number of boiler explosions that have occurred in this country since the beginning of the year 1879, and also the number of deaths that they have caused, and the number of persons that have been injured. Similar tables were published in The Locomotive some time ago, and the interest that they aroused was such that we have thought it well to extend them so as to include the year 1902, and so bring them down to date.

According to Table 1 there were 6,386 boiler explosions during the twenty-four years between January 1, 1879, and January 1, 1903. These explosions, it will be seen from Tables 2 and 3, resulted in the death of 7,002 persons, and in more or less serious injury to 10,346 others; so that the total number of persons killed or injured during this time, by boiler explosions, was 17,348. Many a city has a population not materially greater than this. In 1900, for example, the population of Chicopee, Mass., was 19,167, while that of Rutland, Vt., was only 11,499.

In Table 4 the number of explosions each year, and the number of killed and injured, are shown in such a manner as to facilitate comparison. We see, from the last line of this table, that (on an average) 1.096 persons are killed per explosion, and 1.620 are injured. That is, 2.716 persons are either killed or injured, on an average, by every boiler explosion.

Table 1. — Summary of Boiler Explosions by Months.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1879	10	16	9	12	5	10	7	14	8	10	13	18	132
1880	19	14	11	11	12	10	14	11	16	11	16	25	170
1881	22	16	15	8	8	15	8	11	14	16	13	13	159
1882	26	15	16	13	14	11	9	18	14	13	7	16	172
1883	22	12	16	10	17	17	10	18	17	15	20	10	184
1884	14	10	15	12	16	16	19	14	12	12	6	6	152
1885	14	20	14	7	12	12	10	9	11	14	15	17	155
1886	19	18	18	7	9	13	26	17	15	10	17	16	185
1887	26	12	8	17	18	14	14	10	14	21	28	16	198
1888	29	22	22	18	16	19	24	20	25	13	15	23	246
1889	18	14	17	14	9	5	17	16	14	28	19	9	180
1890	24	26	22	13	18	20	8	21	15	20	18	21	226
1891	21	26	19	14	24	14	24	23	15	26	26	25	257
1892	35	19	20	14	15	11	20	16	25	28	32	34	269
1893	39	29	26	28	23	14	18	29	22	29	33	26	316
1894	30	26	20	23	22	22	25	37	28	62	39	28	362
1895	30	46	26	16	26	23	20	35	26	43	33	31	355
1896	35	30	28	24	24	24	24	42	36	25	28	26	346
1897	27	31	24	16	28	25	31	37	40	27	32	51	369
1898	26	26	25	26	22	26	36	27	49	40	42	38	383
1899	49	29	42	21	28	22	25	43	31	27	29	37	383
1900	36	33	25	27	18	36	32	32	35	31	41	27	373
1901	41	30	45	30	31	23	29	41	29	40	44	40	423
1902	36	38	32	29	33	17	34	32	33	37	34	36	391
Total Number of Explosions,													6,386

TABLE 2. — SUMMARY OF DEATHS BY BOILER EXPLOSIONS.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1879	18	38	4	9	3	34	12	17	12	11	16	34	208
1880	16	22	31	12	30	30	20	9	14	23	18	34	259
1881	38	18	28	6	11	41	16	19	25	15	18	16	251
1882	15	22	27	31	14	18	6	41	18	16	15	48	271
1883	29	18	17	11	30	25	18	18	30	12	37	18	263
1884	17	7	25	18	30	26	37	13	15	31	22	13	254
1885	24	22	20	9	18	14	7	11	11	19	34	31	220
1886	17	6	28	3	18	14	40	30	10	37	26	25	254
1887	27	6	7	14	25	15	15	7	11	71	40	26	264
1888	22	59	23	20	20	20	17	54	37	13	22	24	331
1889	27	45	18	15	7	6	28	27	34	66	21	10	304
1890	24	31	18	11	16	20	12	30	11	28	25	18	244
1891	23	36	11	7	21	22	23	13	19	36	20	32	263
1892	45	22	36	13	12	13	30	11	34	24	32	26	298
1893	29	20	35	20	37	9	17	43	28	22	33	25	327
1894	27	24	19	32	22	22	28	37	35	35	18	32	331
1895	34	28	30	12	23	27	19	70	14	40	60	17	374
1896	40	32	19	28	51	29	15	48	28	35	24	33	382
1897	25	24	28	10	32	43	42	63	41	21	31	38	398
1898	32	15	18	22	17	25	27	23	34	43	45	23	324
1899	21	12	35	21	19	11	26	46	33	28	19	27	298
1900	21	23	19	10	18	27	28	16	25	18	27	27	268
1901	9	13	23	21	22	19	22	45	20	34	56	28	312
1902	24	22	22	14	22	9	28	35	22	25	53	28	304
Total Number of Persons Killed, ...													7,002

TABLE 3. — SUMMARY OF PERSONS INJURED BY BOILER EXPLOSIONS.

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1879	15	36	20	15	10	20	18	19	11	15	10	18	213
1880	44	23	59	46	59	132	41	21	35	25	33	34	555
1881	35	31	51	11	23	38	19	14	19	32	20	20	313
1882	36	38	31	34	17	26	34	55	28	8	8	44	359
1883	63	23	22	24	38	29	35	17	50	24	65	22	412
1884	10	13	27	15	31	23	35	16	20	17	25	10	251
1885	35	30	28	9	32	6	21	21	13	40	22	21	278
1886	64	25	21	12	19	24	33	24	20	17	27	28	314
1887	31	17	23	43	30	41	20	19	19	65	53	18	388
1888	56	68	37	40	35	38	40	41	56	15	29	50	505
1889	40	33	66	24	18	13	105	36	13	48	19	18	433
1890	44	38	44	19	21	37	12	38	10	32	36	20	351
1891	28	43	31	10	27	25	45	31	15	52	34	30	371
1892	46	25	51	24	31	38	36	18	54	49	25	45	442
1893	42	35	30	31	36	13	17	34	26	36	49	36	385
1894	39	27	34	36	42	20	12	54	48	55	51	54	472
1895	32	37	57	22	32	52	30	79	35	58	59	26	519
1896	99	28	36	34	44	18	25	67	46	66	40	26	529
1897	27	59	29	28	43	23	64	51	48	54	48	54	528
1898	52	36	25	27	21	50	68	43	83	58	70	44	577
1899	50	27	41	23	31	19	38	68	47	43	33	36	456
1900	56	41	35	64	22	41	58	41	45	45	50	22	520
1901	54	30	63	37	55	20	48	99	43	78	73	46	646
1902	45	48	32	29	33	12	71	44	37	48	90	40	529
Total Number of Persons Injured, ...													10,346

TABLE 4. — SUMMARY OF EXPLOSIONS AND OF KILLED AND INJURED.

Year.	Explosions.	Killed.	Injured.	Total of Killed and Injured.
1879,	132	208	213	421
1880,	170	259	555	814
1881,	159	251	313	564
1882,	172	271	359	630
1883,	184	263	412	675
1884,	152	254	251	505
1885,	155	220	278	498
1886,	185	254	314	568
1887,	198	264	388	652
1888,	246	331	505	836
1889,	180	304	433	737
1890,	226	244	351	595
1891,	257	263	371	634
1892,	269	298	442	740
1893,	316	327	385	712
1894,	362	331	472	803
1895,	355	374	519	893
1896,	346	382	529	911
1897,	369	398	528	926
1898,	383	324	577	901
1899,	383	298	456	754
1900,	373	268	520	788
1901,	423	312	646	958
1902,	391	304	529	833
Total,	6,386	7,002	10,346	17,348

THE *Annual Report* of the Chief of the Bureau of Steam Engineering of the United States Navy, is at hand. We note with pleasure that the bureau expects, within a few months, to publish the complete report of its experiments upon the use of liquid fuel. The bureau calls attention to the fact that "through the liberality of individuals, combined with the appropriation available for conducting experimental work, over $200,000 was expended in carrying on these tests," and it rightly considers that the results attained will be of inestimable benefit to the manufacturing, maritime, and naval world. The list of war vessels that are now under construction for the United States navy, or for which definite provision has been made, is an impressive one. It includes the following first-class battleships: *Connecticut*, 10,000 tons; *Georgia*, 14,948 tons; *Kansas*, 16,000 tons; *Louisiana*, 16,000 tons; *Minnesota*, 16,000 tons; *Missouri*, 12,500 tons; *Nebraska*, 14,948 tons; *New Jersey*, 14,948 tons; *Ohio*, 12,500 tons; *Rhode Island* 14,948 tons; *Vermont*, 16,000 tons; and *Virginia*, 14,948 tons. These are now in various stages of construction, ranging from the mere awarding of the contract to practical completion. Congress has also made definite provision for two more first-class battleships, the *Idaho* and *Mississippi*, for which the contracts have not yet been awarded. Of the other vessels now actually under construction, we may specially mention the cruisers *Charleston*, 9,700 tons; *California*, 13,680 tons; *Colorado*, 13,680 tons; *Maryland*, 13,680 tons; *Milwaukee*, 9,700 tons; *Pennsylvania*, 13,680 tons; *South Dakota*, 13,680 tons; *St. Louis*, 9,700 tons; *Tennessee*, 14,500 tons; *Washington*, 14,500 tons; and *West Virginia*, 13,680 tons. When these battleships and cruisers are completed, they will constitute a formidable addition to the navy of the United States. We trust that their moral effect may be such as to prevent any but a friendly exhibition of their physical capabilities. "Peace?" said Bismarck, as he strengthened the German army, "you bet we'll have peace."

The Locomotive

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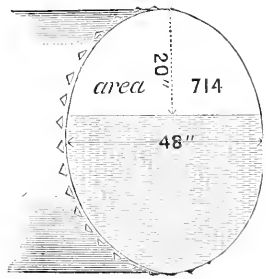
The Tables in the Present Issue.

In this issue of THE LOCOMOTIVE we present a number of tables, which will be found to be serviceable in performing the more common of the calculations that have to be made in connection with steam boiler engineering. We have printed the first one before, but we reproduce it with the others for the sake of making reference to it more convenient.

The first table gives the areas of circular segments when the diameter of the circle is unity, and the height of the segment is expressed as a fraction of the diameter of the circle. The "Heights" are given to three places of decimals, and the "Areas" to six; the six decimals of the "Area" columns being separated by a space, simply to assist the eye in using the table. If a circle is one foot in diameter, for example, and the segment under consideration has a height of 0.256 of a foot, then the table shows that the area of the segment is 0.158763 of a square foot. Similarly, if the circle is one inch in diameter, and the segment has a height of 0.191 of an inch, then the area of the segment is 0.104686 of a square inch.



To make the table apply to circles of diameters different from unity, we have to take account of the fact that the areas of circles, or of similar parts of circles, vary proportionally to the squares of the diameters of the circles. We see from the table, for example, that if a segment has a height equal to 0.250 of the diameter of its own circle, the area of the segment is 0.153546 of a square inch, if the circle is one inch in diameter. From this, and from the geometrical fact just stated, it follows that the area of any segment whose height is 0.250 of the diameter of the circle in which it is drawn may be found by multiplying 0.153546 by the square of the diameter of the circle. The result will be expressed in square inches if the diameter of the circle is taken in inches; and it will be expressed in square feet if the diameter of the circle is taken in feet.

The general use of the table will be made clear, we think, by the following example: Suppose we wish to find the area of a circular segment whose height is 20 inches, the diameter of the entire circle to which it belongs being four feet, or 48 inches. (These dimensions are indicated in the accompanying illustration where the unshaded part represents the segment whose area is desired.) We first express the height of the segment as a fraction of the whole diameter of the circle to which it belongs, both of these magnitudes being expressed in inches. Thus we have $20 \div 48 = 0.417$, if we preserve the nearest unit in the third place of decimals. In other words, the height of the proposed segment is

(Continued on page 150.)

Areas of Circular Segments for Diameter=1.

Height.	Area.	Height.	Area.	Height.	Area.
.001	.000 042	.051	.015 119	.101	.041 477
.002	.000 119	.052	.015 561	.102	.042 081
.003	.000 219	.053	.016 008	.103	.042 687
.004	.000 337	.054	.016 458	.104	.043 296
.005	.000 471	.055	.016 912	.105	.043 908
.006	.000 619	.056	.017 369	.106	.044 523
.007	.000 779	.057	.017 831	.107	.045 140
.008	.000 952	.058	.018 297	.108	.045 759
.009	.001 135	.059	.018 766	.109	.046 381
.010	.001 329	.060	.019 239	.110	.047 006
.011	.001 533	.061	.019 716	.111	.047 633
.012	.001 746	.062	.020 197	.112	.048 262
.013	.001 969	.063	.020 681	.113	.048 894
.014	.002 199	.064	.021 168	.114	.049 529
.015	.002 438	.065	.021 660	.115	.050 165
.016	.002 685	.066	.022 155	.116	.050 805
.017	.002 940	.067	.022 653	.117	.051 446
.018	.003 202	.068	.023 155	.118	.052 090
.019	.003 472	.069	.023 660	.119	.052 737
.020	.003 749	.070	.024 168	.120	.053 385
.021	.004 032	.071	.024 680	.121	.054 037
.022	.004 322	.072	.025 196	.122	.054 690
.023	.004 619	.073	.025 714	.123	.055 346
.024	.004 922	.074	.026 236	.124	.056 004
.025	.005 231	.075	.026 761	.125	.056 664
.026	.005 546	.076	.027 290	.126	.057 327
.027	.005 867	.077	.027 821	.127	.057 991
.028	.006 194	.078	.028 356	.128	.058 658
.029	.006 527	.079	.028 894	.129	.059 328
.030	.006 866	.080	.029 435	.130	.059 999
.031	.007 209	.081	.029 979	.131	.060 673
.032	.007 559	.082	.030 526	.132	.061 349
.033	.007 913	.083	.031 077	.133	.062 027
.034	.008 273	.084	.031 630	.134	.062 707
.035	.008 638	.085	.032 186	.135	.063 389
.036	.009 008	.086	.032 746	.136	.064 074
.037	.009 383	.087	.033 308	.137	.064 761
.038	.009 764	.088	.033 873	.138	.065 449
.039	.010 148	.089	.034 441	.139	.066 140
.040	.010 538	.090	.035 012	.140	.066 833
.041	.010 932	.091	.035 586	.141	.067 528
.042	.011 331	.092	.036 162	.142	.068 225
.043	.011 734	.093	.036 742	.143	.068 924
.044	.012 142	.094	.037 324	.144	.069 626
.045	.012 555	.095	.037 909	.145	.070 329
.046	.012 971	.096	.038 497	.146	.071 034
.047	.013 393	.097	.039 087	.147	.071 741
.048	.013 818	.098	.039 681	.148	.072 450
.049	.014 248	.099	.040 277	.149	.073 162
.050	.014 681	.100	.040 875	.150	.073 875

Areas of Circular Segments for Diameter = 1.

Height.	Area.	Height.	Area.	Height.	Area.
.151	.074 590	.201	.112 625	.251	.154 413
.152	.075 307	.202	.113 427	.252	.155 281
.153	.076 026	.203	.114 231	.253	.156 149
.154	.076 747	.204	.115 036	.254	.157 019
.155	.077 470	.205	.115 842	.255	.157 891
.156	.078 194	.206	.116 651	.256	.158 763
.157	.078 921	.207	.117 460	.257	.159 636
.158	.079 650	.208	.118 271	.258	.160 511
.159	.080 380	.209	.119 084	.259	.161 386
.160	.081 112	.210	.119 898	.260	.162 263
.161	.081 847	.211	.120 713	.261	.163 141
.162	.082 582	.212	.121 530	.262	.164 020
.163	.083 320	.213	.122 348	.263	.164 900
.164	.084 060	.214	.123 167	.264	.165 781
.165	.084 801	.215	.123 988	.265	.166 663
.166	.085 545	.216	.124 811	.266	.167 546
.167	.086 290	.217	.125 634	.267	.168 431
.168	.087 037	.218	.126 459	.268	.169 316
.169	.087 785	.219	.127 286	.269	.170 202
.170	.088 536	.220	.128 114	.270	.171 090
.171	.089 288	.221	.128 943	.271	.171 978
.172	.090 042	.222	.129 773	.272	.172 868
.173	.090 797	.223	.130 605	.273	.173 758
.174	.091 555	.224	.131 438	.274	.174 650
.175	.092 314	.225	.132 273	.275	.175 542
.176	.093 074	.226	.133 109	.276	.176 436
.177	.093 837	.227	.133 946	.277	.177 330
.178	.094 601	.228	.134 784	.278	.178 226
.179	.095 367	.229	.135 624	.279	.179 122
.180	.096 135	.230	.136 465	.280	.180 020
.181	.096 904	.231	.137 307	.281	.180 918
.182	.097 675	.232	.138 151	.282	.181 818
.183	.098 447	.233	.138 996	.283	.182 718
.184	.099 221	.234	.139 842	.284	.183 619
.185	.099 997	.235	.140 689	.285	.184 522
.186	.100 774	.236	.141 538	.286	.185 425
.187	.101 553	.237	.142 388	.287	.186 329
.188	.102 334	.238	.143 239	.288	.187 235
.189	.103 116	.239	.144 091	.289	.188 141
.190	.103 900	.240	.144 945	.290	.189 048
.191	.104 686	.241	.145 800	.291	.189 956
.192	.105 472	.242	.146 656	.292	.190 865
.193	.106 261	.243	.147 513	.293	.191 774
.194	.107 051	.244	.148 371	.294	.192 685
.195	.107 843	.245	.149 231	.295	.193 597
.196	.108 636	.246	.150 091	.296	.194 509
.197	.109 431	.247	.150 953	.297	.195 423
.198	.110 227	.248	.151 816	.298	.196 337
.199	.111 025	.249	.152 681	.299	.197 252
.200	.111 824	.250	.153 546	.300	.198 168

Areas of Circular Segments for Diameter=1.

Height.	Area.	Height.	Area.	Height.	Area.
.301	.199 085	.351	.245 935	.401	.294 350
.302	.200 003	.352	.246 890	.402	.295 330
.303	.200 922	.353	.247 845	.403	.296 311
.304	.201 841	.354	.248 801	.404	.297 292
.305	.202 762	.355	.249 758	.405	.298 274
.306	.203 683	.356	.250 715	.406	.299 256
.307	.204 605	.357	.251 673	.407	.300 238
.308	.205 528	.358	.252 632	.408	.301 221
.309	.206 452	.359	.253 591	.409	.302 204
.310	.207 376	.360	.254 551	.410	.303 187
.311	.208 302	.361	.255 511	.411	.304 171
.312	.209 228	.362	.256 472	.412	.305 156
.313	.210 155	.363	.257 433	.413	.306 140
.314	.211 083	.364	.258 395	.414	.307 125
.315	.212 011	.365	.259 358	.415	.308 110
.316	.212 941	.366	.260 321	.416	.309 096
.317	.213 871	.367	.261 285	.417	.310 082
.318	.214 802	.368	.262 249	.418	.311 068
.319	.215 734	.369	.263 214	.419	.312 055
.320	.216 666	.370	.264 179	.420	.313 042
.321	.217 600	.371	.265 145	.421	.314 029
.322	.218 534	.372	.266 111	.422	.315 017
.323	.219 469	.373	.267 078	.423	.316 005
.324	.220 404	.374	.268 046	.424	.316 993
.325	.221 341	.375	.269 014	.425	.317 981
.326	.222 278	.376	.269 982	.426	.318 970
.327	.223 216	.377	.270 951	.427	.319 959
.328	.224 154	.378	.271 921	.428	.320 949
.329	.225 094	.379	.272 891	.429	.321 938
.330	.226 034	.380	.273 861	.430	.322 928
.331	.226 974	.381	.274 832	.431	.323 919
.332	.227 916	.382	.275 804	.432	.324 909
.333	.228 858	.383	.276 776	.433	.325 900
.334	.229 801	.384	.277 748	.434	.326 891
.335	.230 745	.385	.278 721	.435	.327 883
.336	.231 689	.386	.279 695	.436	.328 874
.337	.232 634	.387	.280 669	.437	.329 866
.338	.233 580	.388	.281 643	.438	.330 858
.339	.234 526	.389	.282 618	.439	.331 851
.340	.235 473	.390	.283 593	.440	.332 843
.341	.236 421	.391	.284 569	.441	.333 836
.342	.237 369	.392	.285 545	.442	.334 829
.343	.238 319	.393	.286 521	.443	.335 823
.344	.239 268	.394	.287 499	.444	.336 816
.345	.240 219	.395	.288 476	.445	.337 810
.346	.241 170	.396	.289 454	.446	.338 804
.347	.242 122	.397	.290 432	.447	.339 799
.348	.243 074	.398	.291 411	.448	.340 793
.349	.244 027	.399	.292 390	.449	.341 788
.350	.244 980	.400	.293 370	.450	.342 783

Areas of Circular Segments for Diameter=1.

Height.	Area.	Height.	Area.	Height.	Area.
.451	.343 778	.471	.363 715	.491	.383 700
.452	.344 773	.472	.364 714	.492	.384 699
.453	.345 768	.473	.365 712	.493	.385 699
.454	.346 764	.474	.366 711	.494	.386 699
.455	.347 760	.475	.367 710	.495	.387 699
.456	.348 756	.476	.368 708	.496	.388 699
.457	.349 752	.477	.369 707	.497	.389 699
.458	.350 749	.478	.370 706	.498	.390 699
.459	.351 745	.479	.371 705	.499	.391 699
.460	.352 742	.480	.372 704	.500	.392 699
.461	.353 739	.481	.373 704	......	....
.462	.354 736	.482	.374 703	......	....
.463	.355 733	.483	.375 702	......	....
.464	.356 730	.484	.376 702	......	....
.465	.357 728	.485	.377 701	......	....
.466	.358 725	.486	.378 701	......	....
.467	.359 723	.487	.379 701	......	....
.468	.360 721	.488	.380 700	......	....
.469	.361 719	.489	.381 700	......	....
.470	.362 717	.490	.382 700	......	....

Decimal Equivalents of Common Fractions.

Common Fraction.	Decimal Equivalent.	Common Fraction.	Decimal Equivalent.	Common Fraction.	Decimal Equivalent.	Common Fraction.	Decimal Equivalent.
1/16	0.0625	1/32	0.03125	1/64	0.015625	33/64	0.515625
1/8	.1250	3/32	.09375	3/64	.046875	35/64	.546875
3/16	.1875	5/32	.15625	5/64	.078125	37/64	.578125
1/4	.2500	7/32	.21875	7/64	.109375	39/64	.609375
5/16	0.3125	9/32	0.28125	9/64	0.140625	41/64	0.640625
3/8	.3750	11/32	.34375	11/64	.171875	43/64	.671875
7/16	.4375	13/32	.40625	13/64	.203125	45/64	.703125
1/2	.5000	15/32	.46875	15/64	.234375	47/64	.734375
9/16	0.5625	17/32	0.53125	17/64	0.265625	49/64	0.765625
5/8	.6250	19/32	.59375	19/64	.296875	51/64	.796875
11/16	.6875	21/32	.65625	21/64	.328125	53/64	.828125
3/4	.7500	23/32	.71875	23/64	.359375	55/64	.859375
13/16	0.8125	25/32	0.78125	25/64	0.390625	57/64	0.890625
7/8	.8750	27/32	.84375	27/64	.421875	59/64	.921875
15/16	.9375	29/32	.90625	29/64	.453125	61/64	.953125
1	1.0000	31/32	.96875	31/64	.484375	63/64	.984375

0.417 of the diameter of the circle. We next seek this quotient, 0.417, in the columns marked HEIGHT in the table, and opposite it, in the AREA column, we find 0.310082. The diameter of the circle being 48 inches, and the square of 48 being 48×48=2304, we have next to multiply 0.310082 by 2304. The multiplication gives 0.310082×2304=714.428928; or, in round numbers, 714.43 square inches, which is the desired area of the segment.

The second table in the present issue gives the decimals equivalents of common fractions, and a method of arrangement has here been adopted, which is believed to possess some undeniable advantages. The table includes every sixty-fourth; but, as will be seen, the sixteenths are grouped together in the first column, since these will be most often used. The odd thirty-seconds, which come next in frequency of reference, are then grouped together in the third column; and, finally, those sixty-fourths which cannot be expressed, integrally, either as sixteenths or as thirty-seconds, are given in the fifth and seventh columns.

The third table gives the shearing strengths, in pounds, of rivets of various diameters, and of various strengths of material, when these are subjected to ordinary single shear, as in common single-riveted and double-riveted joints.

Shearing Strengths, in Pounds, of Rivets Exposed to Single Shear.

DIAMETER IN INCHES.	SHEARING STRENGTH OF RIVET MATERIAL, IN POUNDS PER SQUARE INCH.							
	38,000	39,000	40,000	41,000	42,000	43,000	44,000	45,000
1/4	1,865	1,914	1,963	2,012	2,062	2,111	2,160	2,209
5/16	2,915	2,992	3,068	3,144	3,221	3,298	3,375	3,452
3/8	4,197	4,308	4,418	4,528	4,639	4,750	4,860	4,971
7/16	5,713	5,863	6,013	6,163	6,314	6,464	6,615	6,765
1/2	7,461	7,657	7,854	8,050	8,247	8,443	8,639	8,836
9/16	9,443	9,691	9,940	10,188	10,437	10,685	10,934	11,182
5/8	11,658	11,965	12,272	12,578	12,885	13,192	13,499	13,806
11/16	14,107	14,478	14,849	15,220	15,591	15,962	16,334	16,705
3/4	16,788	17,230	17,672	18,113	18,555	18,997	19,439	19,881
13/16	19,703	20,221	20,739	21,257	21,776	22,294	22,813	23,331
7/8	22,850	23,452	24,053	24,654	25,255	25,856	26,458	27,059
15/16	26,231	26,921	27,612	28,302	28,992	29,682	30,373	31,063
1	29,845	30,630	31,416	32,201	32,987	33,772	34,558	35,343
1 1/16	33,692	34,579	35,466	36,352	37,239	38,125	39,012	39,898
1 1/8	37,773	38,767	39,761	40,755	41,749	42,743	43,737	44,731
1 3/16	42,086	43,194	44,302	45,409	46,516	47,624	48,732	49,839
1 1/4	46,633	47,860	49,088	50,315	51,542	52,769	53,996	55,223
1 5/16	51,413	52,766	54,119	55,472	56,825	58,178	59,531	60,884
1 3/8	56,426	57,911	59,396	60,881	62,366	63,850	65,335	66,820
1 7/16	61,672	63,295	64,918	66,541	68,164	69,787	71,410	73,033
1 1/2	67,152	68,919	70,686	72,453	74,220	75,987	77,754	79,521

In determining the strength of a driven rivet, the diameter of the rivet *hole* should be sought for in the first column, rather than the diameter of the undriven rivet; because the rivet is supposed to fill its hole, when the work is well done, and hence its actual diameter, when driven, is equal to that of the hole.

The remaining pages of the present issue contain a table of the circumferences and areas of circles. It will be seen that the diameters increase by thirty-seconds of an inch up to 3 inches, then by sixteenths up to 15 inches, and then by eighths up to 105 inches. This table is believed to be very accurate, because it was calculated expressly for this present issue, and we have also compared it, so far as possible, with other tables which had been calculated previously and independently. The possibility of a typographical error must always be admitted in work of this kind, but we have taken great pains in reading the proofs of all of these tables, and it is believed that they are free from such errors.

Circumferences and Areas of Circles.

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
1/32	0.0982	0.00077	1 1/32	3.2398	0.8352	2 1/32	6.3814	3.2405
1/16	.1964	.00307	1 1/16	3.3379	.8866	2 1/16	6.4795	3.3410
3/32	.2945	.00690	1 3/32	3.4361	.9396	2 3/32	6.5777	3.4430
1/8	.3927	.01227	1 1/8	3.5343	.9940	2 1/8	6.6759	3.5466
5/32	0.4909	0.01918	1 5/32	3.6325	1.0500	2 5/32	6.7741	3.6516
3/16	.5890	.02761	1 3/16	3.7306	1.1075	2 3/16	6.8722	3.7583
7/32	.6872	.03758	1 7/32	3.8288	1.1666	2 7/32	6.9704	3.8664
1/4	.7854	.04909	1 1/4	3.9270	1.2272	2 1/4	7.0686	3.9761
9/32	0.8836	0.06213	1 9/32	4.0252	1.2893	2 9/32	7.1668	4.0873
5/16	.9818	.07670	1 5/16	4.1233	1.3530	2 5/16	7.2649	4.2000
11/32	1.0799	.09281	1 11/32	4.2215	1.4182	2 11/32	7.3631	4.3143
3/8	1.1781	.11045	1 3/8	4.3197	1.4849	2 3/8	7.4613	4.4301
13/32	1.2763	0.12962	1 13/32	4.4179	1.5532	2 13/32	7.5595	4.5475
7/16	1.3744	.15033	1 7/16	4.5160	1.6230	2 7/16	7.6576	4.6664
15/32	1.4726	.17258	1 15/32	4.6142	1.6943	2 15/32	7.7558	4.7868
1/2	1.5708	.19635	1 1/2	4.7124	1.7672	2 1/2	7.8540	4.9087
17/32	1.6690	0.22166	1 17/32	4.8106	1.8415	2 17/32	7.9522	5.0322
9/16	1.7671	.24850	1 9/16	4.9087	1.9175	2 9/16	8.0503	5.1572
19/32	1.8653	.27688	1 19/32	5.0069	1.9949	2 19/32	8.1485	5.2838
5/8	1.9635	.30680	1 5/8	5.1051	2.0739	2 5/8	8.2467	5.4119
21/32	2.0617	0.33824	1 21/32	5.2033	2.1545	2 21/32	8.3449	5.5415
11/16	2.1598	.37122	1 11/16	5.3014	2.2365	2 11/16	8.4430	5.6727
23/32	2.2580	.40574	1 23/32	5.3996	2.3202	2 23/32	8.5412	5.8054
3/4	2.3562	.44179	1 3/4	5.4978	2.4053	2 3/4	8.6394	5.9396
25/32	2.4544	0.47937	1 25/32	5.5960	2.4920	2 25/32	8.7376	6.0753
13/16	2.5525	.51849	1 13/16	5.6941	2.5802	2 13/16	8.8357	6.2126
27/32	2.6507	.55914	1 27/32	5.7923	2.6699	2 27/32	8.9339	6.3515
7/8	2.7489	.60132	1 7/8	5.8905	2.7612	2 7/8	9.0321	6.4918
29/32	2.8471	0.64504	1 29/32	5.9887	2.8540	2 29/32	9.1303	6.6337
15/16	2.9452	.69029	1 15/16	6.0868	2.9483	2 15/16	9.2284	6.7771
31/32	3.0434	.73708	1 31/32	6.1850	3.0442	2 31/32	9.3266	6.9221
1	3.1416	.78540	2	6.2832	3.1416	3	9.4248	7.0686

Circumferences and Areas of Circles.

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
3	9.4248	7.0686	5	15.7080	19.6350	7	21.9911	38.4845
3 1/16	9.6211	7.3662	5 1/16	15.9043	20.1289	7 1/16	22.1875	39.1748
3 1/8	9.8175	7.6699	5 1/8	16.1007	20.6290	7 1/8	22.3838	39.8712
3 3/16	10.0138	7.9798	5 3/16	16.2970	21.1352	7 3/16	22.5802	40.5738
3 1/4	10.2102	8.2958	5 1/4	16.4934	21.6475	7 1/4	22.7765	41.2825
3 5/16	10.4065	8.6179	5 5/16	16.6897	22.1660	7 5/16	22.9729	41.9973
3 3/8	10.6029	8.9462	5 3/8	16.8861	22.6906	7 3/8	23.1692	42.7183
3 7/16	10.7992	9.2806	5 7/16	17.0824	23.2214	7 7/16	23.3656	43.4454
3 1/2	10.9956	9.6211	5 1/2	17.2788	23.7583	7 1/2	23.5619	44.1786
3 9/16	11.1919	9.9678	5 9/16	17.4751	24.3013	7 9/16	23.7583	44.9180
3 5/8	11.3883	10.3206	5 5/8	17.6715	24.8505	7 5/8	23.9546	45.6635
3 11/16	11.5846	10.6796	5 11/16	17.8678	25.4058	7 11/16	24.1510	46.4152
3 3/4	11.7810	11.0447	5 3/4	18.0642	25.9672	7 3/4	24.3473	47.1730
3 13/16	11.9773	11.4159	5 13/16	18.2605	26.5348	7 13/16	24.5437	47.9369
3 7/8	12.1737	11.7932	5 7/8	18.4569	27.1085	7 7/8	24.7400	48.7070
3 15/16	12.3700	12.1767	5 15/16	18.6532	27.6884	7 15/16	24.9364	49.4831
4	12.5664	12.5664	6	18.8496	28.2743	8	25.1327	50.2655
4 1/16	12.7627	12.9621	6 1/16	19.0459	28.8665	8 1/16	25.3291	51.0539
4 1/8	12.9591	13.3640	6 1/8	19.2423	29.4647	8 1/8	25.5254	51.8486
4 3/16	13.1554	13.7721	6 3/16	19.4386	30.0691	8 3/16	25.7218	52.6493
4 1/4	13.3518	14.1863	6 1/4	19.6350	30.6796	8 1/4	25.9181	53.4562
4 5/16	13.5481	14.6066	6 5/16	19.8313	31.2963	8 5/16	26.1145	54.2692
4 3/8	13.7445	15.0330	6 3/8	20.0277	31.9191	8 3/8	26.3108	55.0883
4 7/16	13.9408	15.4656	6 7/16	20.2240	32.5480	8 7/16	26.5072	55.9136
4 1/2	14.1372	15.9043	6 1/2	20.4204	33.1831	8 1/2	26.7035	56.7450
4 9/16	14.3335	16.3492	6 9/16	20.6167	33.8243	8 9/16	26.8999	57.5826
4 5/8	14.5299	16.8002	6 5/8	20.8131	34.4716	8 5/8	27.0962	58.4263
4 11/16	14.7262	17.2573	6 11/16	21.0094	35.1251	8 11/16	27.2926	59.2761
4 3/4	14.9226	17.7205	6 3/4	21.2058	35.7847	8 3/4	27.4889	60.1320
4 13/16	15.1189	18.1899	6 13/16	21.4021	36.4504	8 13/16	27.6853	60.9941
4 7/8	15.3153	18.6655	6 7/8	21.5984	37.1223	8 7/8	27.8816	61.8624
4 15/16	15.5116	19.1472	6 15/16	21.7948	37.8004	8 15/16	28.0780	62.7367
5	15.7080	19.6350	7	21.9911	38.4845	9	28.2743	63.6173

Circumferences and Areas of Circles.

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
9	28.2743	63.6173	**11**	34.5575	95.0332	**13**	40.8407	132.7323
9 1/16	28.4707	64.5039	**11** 1/16	34.7539	96.1162	**13** 1/16	41.0371	134.0116
9 1/8	28.6670	65.3967	**11** 1/8	34.9502	97.2053	**13** 1/8	41.2334	135.2971
9 3/16	28.8634	66.2956	**11** 3/16	35.1466	98.3006	**13** 3/16	41.4298	136.5887
9 1/4	29.0597	67.2006	**11** 1/4	35.3429	99.4020	**13** 1/4	41.6261	137.8865
9 5/16	29.2561	68.1118	**11** 5/16	35.5393	100.5095	**13** 5/16	41.8225	139.1903
9 3/8	29.4524	69.0291	**11** 3/8	35.7356	101.6232	**13** 3/8	42.0188	140.5004
9 7/16	29.6488	69.9526	**11** 7/16	35.9320	102.7430	**13** 7/16	42.2152	141.8165
9 1/2	29.8451	70.8822	**11** 1/2	36.1283	103.8689	**13** 1/2	42.4115	143.1388
9 9/16	30.0415	71.8179	**11** 9/16	36.3247	105.0010	**13** 9/16	42.6078	144.4672
9 5/8	30.2378	72.7598	**11** 5/8	36.5210	106.1392	**13** 5/8	42.8042	145.8018
9 11/16	30.4342	73.7078	**11** 11/16	36.7174	107.2835	**13** 11/16	43.0005	147.1425
9 3/4	30.6305	74.6619	**11** 3/4	36.9137	108.4340	**13** 3/4	43.1969	148.4893
9 13/16	30.8269	75.6222	**11** 13/16	37.1101	109.5907	**13** 13/16	43.3932	149.8423
9 7/8	31.0232	76.5886	**11** 7/8	37.3064	110.7534	**13** 7/8	43.5896	151.2014
9 15/16	31.2196	77.5611	**11** 15/16	37.5028	111.9223	**13** 15/16	43.7859	152 5667
10	31.4159	78.5398	**12**	37.6991	113.0973	**14**	43.9823	153.9380
10 1/16	31.6123	79.5246	**12** 1/16	37.8955	114.2785	**14** 1/16	44.1786	155.3156
10 1/8	31.8086	80.5156	**12** 1/8	38.0918	115.4658	**14** 1/8	44.3750	156.6992
10 3/16	32.0050	81.5127	**12** 3/16	38.2882	116.6592	**14** 3/16	44.5713	158.0890
10 1/4	32.2013	82.5159	**12** 1/4	38.4845	117.8588	**14** 1/4	44.7677	159.4849
10 5/16	32.3977	83.5253	**12** 5/16	38.6809	119.0645	**14** 5/16	44.9640	160.8870
10 3/8	32.5940	84.5407	**12** 3/8	38.8772	120.2764	**14** 3/8	45.1604	162.2952
10 7/16	32.7904	85.5624	**12** 7/16	39.0736	121.4943	**14** 7/16	45.3567	163.7095
10 1/2	32.9867	86.5901	**12** 1/2	39.2699	122.7185	**14** 1/2	45.5531	165.1300
10 9/16	33.1831	87.6240	**12** 9/16	39.4663	123.9487	**14** 9/16	45.7494	166.5566
10 5/8	33.3794	88.6641	**12** 5/8	39.6626	125.1851	**14** 5/8	45.9458	167.9893
10 11/16	33.5758	89.7103	**12** 11/16	39.8590	126.4276	**14** 11/16	46.1421	169.4282
10 3/4	33.7721	90.7626	**12** 3/4	40.0553	127.6763	**14** 3/4	46.3385	170.8732
10 13/16	33.9685	91.8210	**12** 13/16	40.2517	128.9311	**14** 13/16	46.5348	172.3243
10 7/8	34.1648	92.8856	**12** 7/8	40.4480	130.1920	**14** 7/8	46.7312	173.7816
10 15/16	34.3612	93.9563	**12** 15/16	40.6444	131.4591	**14** 15/16	46.9275	175.2450
11	34.5575	95.0332	**13**	40.8407	132.7323	**15**	47.1239	176.7146

Circumferences and Areas of Circles.

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
15	47.124	176.715	**20**	62.832	314.159	**25**	78.540	490.874
1/8	47.517	179.672	1/8	63.225	318.099	1/8	78.933	495.795
1/4	47.909	182.654	1/4	63.617	322.062	1/4	79.325	500.740
3/8	48.302	185.661	3/8	64.010	326.051	3/8	79.718	505.710
1/2	48.695	188.692	1/2	64.403	330.064	1/2	80.111	510.705
5/8	49.087	191.748	5/8	64.795	334.101	5/8	80.503	515.724
3/4	49.480	194.828	3/4	65.188	338.163	3/4	80.896	520.768
7/8	49.873	197.933	7/8	65.581	342.250	7/8	81.289	525.836
16	50.265	201.062	**21**	65.973	346.361	**26**	81.681	530.929
1/8	50.658	204.216	1/8	66.366	350.496	1/8	82.074	536.046
1/4	51.051	207.394	1/4	66.759	354.656	1/4	82.467	541.188
3/8	51.444	210.597	3/8	67.152	358.841	3/8	82.860	546.355
1/2	51.836	213.825	1/2	67.544	363.050	1/2	83.252	551.546
5/8	52.229	217.077	5/8	67.937	367.284	5/8	83.645	556.761
3/4	52.622	220.353	3/4	68.330	371.542	3/4	84.038	562.001
7/8	53.014	223.654	7/8	68.722	375.825	7/8	84.430	567.266
17	53.407	226.980	**22**	69.115	380.133	**27**	84.823	572.555
1/8	53.800	230.330	1/8	69.508	384.465	1/8	85.216	577.869
1/4	54.192	233.705	1/4	69.900	388.821	1/4	85.608	583.207
3/8	54.585	237.104	3/8	70.293	393.202	3/8	86.001	588.570
1/2	54.978	240.528	1/2	70.686	397.608	1/2	86.394	593.957
5/8	55.371	243.977	5/8	71.079	402.038	5/8	86.786	599.369
3/4	55.763	247.450	3/4	71.471	406.493	3/4	87.179	604.805
7/8	56.156	250.947	7/8	71.864	410.972	7/8	87.572	610.266
18	56.549	254.469	**23**	72.257	415.476	**28**	87.965	615.752
1/8	56.941	258.016	1/8	72.649	420.004	1/8	88.357	621.262
1/4	57.334	261.587	1/4	73.042	424.557	1/4	88.750	626.797
3/8	57.727	265.182	3/8	73.435	429.134	3/8	89.143	632.356
1/2	58.119	268.802	1/2	73.827	433.736	1/2	89.535	637.940
5/8	58.512	272.447	5/8	74.220	438.363	5/8	89.928	643.548
3/4	58.905	276.117	3/4	74.613	443.014	3/4	90.321	649.180
7/8	59.298	279.811	7/8	75.006	447.689	7/8	90.714	654.838
19	59.690	283.529	**24**	75.398	452.389	**29**	91.106	660.520
1/8	60.083	287.272	1/8	75.791	457.114	1/8	91.499	666.226
1/4	60.476	291.039	1/4	76.184	461.863	1/4	91.892	671.957
3/8	60.868	294.831	3/8	76.576	466.637	3/8	92.284	677.713
1/2	61.261	298.648	1/2	76.969	471.435	1/2	92.677	683.493
5/8	61.654	302.489	5/8	77.362	476.258	5/8	93.070	689.297
3/4	62.046	306.355	3/4	77.754	481.105	3/4	93.462	695.126
7/8	62.439	310.245	7/8	78.147	485.977	7/8	93.855	700.980
20	62.832	314.159	**25**	78.540	490.874	**30**	94.248	706.858

Circumferences and Areas of Circles.

Diameter.	Circum-ference.	Area.	Diameter.	Circum-ference.	Area.	Diameter.	Circum-ference.	Area.
30	94.248	706.86	**35**	109.956	962.11	**40**	125.664	1256.64
1/8	94.640	712.76	1/8	110.348	969.00	1/8	126.056	1264.50
1/4	95.033	718.69	1/4	110.741	975.91	1/4	126.449	1272.39
3/8	95.426	724.64	3/8	111.134	982.84	3/8	126.842	1280.31
1/2	95.819	730.62	1/2	111.526	989.80	1/2	127.234	1288.25
5/8	96.211	736.62	5/8	111.919	996.78	5/8	127.627	1296.21
3/4	96.604	742.64	3/4	112.312	1003.79	3/4	128.020	1304.20
7/8	96.997	748.69	7/8	112.705	1010.82	7/8	128.413	1312.22
31	97.389	754.77	**36**	113.097	1017.88	**41**	128.805	1320.25
1/8	97.782	760.87	1/8	113.490	1024.96	1/8	129.198	1328.32
1/4	98.175	766.99	1/4	113.883	1032.06	1/4	129.591	1336.40
3/8	98.568	773.14	3/8	114.275	1039.19	3/8	129.983	1344.52
1/2	98.960	779.31	1/2	114.668	1046.35	1/2	130.376	1352.65
5/8	99.353	785.51	5/8	115.061	1053.53	5/8	130.769	1360.81
3/4	99.746	791.73	3/4	115.454	1060.73	3/4	131.162	1369.00
7/8	100.138	797.98	7/8	115.846	1067.96	7/8	131.554	1377 21
32	100.531	804.25	**37**	116.239	1075.21	**42**	131.947	1385.44
1/8	100.924	810.54	1/8	116.632	1082.49	1/8	132.340	1393.70
1/4	101.316	816.86	1/4	117.024	1089.79	1/4	132.732	1401.98
3/8	101.709	823.21	3/8	117.417	1097.12	3/8	133.125	1410.29
1/2	102.102	829.58	1/2	117.810	1104.47	1/2	133.518	1418.62
5/8	102.494	835.97	5/8	118.202	1111.84	5/8	133.910	1426.98
3/4	102.887	842.39	3/4	118.595	1119.24	3/4	134.303	1435.36
7/8	103.280	848.83	7/8	118.988	1126.66	7/8	134.696	1443.77
33	103.673	855.30	**38**	119.381	1134.11	**43**	135.088	1452.20
1/8	104.065	861.79	1/8	119.773	1141.59	1/8	135.481	1460.66
1/4	104.458	868.31	1/4	120.166	1149.09	1/4	135.874	1469.14
3/8	104.851	874.85	3/8	120.559	1156.61	3/8	136.267	1477.64
1/2	105.243	881.41	1/2	120.951	1164.16	1/2	136.659	1486.17
5/8	105.636	888.00	5/8	121.344	1171.73	5/8	137.052	1494.72
3/4	106.029	894.62	3/4	121.737	1179.32	3/4	137.445	1503.30
7/8	106.422	901.26	7/8	122.129	1186.94	7/8	137.837	1511.90
34	106.814	907.92	**39**	122.522	1194.59	**44**	138.230	1520.53
1/8	107.207	914.61	1/8	122.915	1202.26	1/8	138.623	1529.18
1/4	107.600	921.32	1/4	123.308	1209.96	1/4	139.016	1537.86
3/8	107.992	928.06	3/8	123.700	1217.67	3/8	139.408	1546.56
1/2	108.385	934.82	1/2	124.093	1225.42	1/2	139.801	1555.28
5/8	108.778	941.61	5/8	124.486	1233.19	5/8	140.194	1564.03
3/4	109.170	948.42	3/4	124.878	1240.98	3/4	140.586	1572.81
7/8	109.563	955.25	7/8	125.271	1248.80	7/8	140.979	1581.61
35	109.956	962.11	**40**	125.664	1256.64	**45**	141.372	1590.43

Circumferences and Areas of Circles.

Diameter.	Circum-ference.	Area.	Diameter.	Circum-ference.	Area.	Diameter.	Circum-ference.	Area.
45	141.372	1590.43	**50**	157.080	1963.50	**55**	172.788	2375.83
1/8	141.764	1599.28	1/8	157.472	1973.33	1/8	173.180	2386.64
1/4	142.157	1608.15	1/4	157.865	1983.18	1/4	173.573	2397.48
3/8	142.550	1617.05	3/8	158.258	1993.06	3/8	173.966	2408.34
1/2	142.942	1625.97	1/2	158.650	2002.96	1/2	174.358	2419.22
5/8	143.335	1634.92	5/8	159.043	2012.89	5/8	174.751	2430.13
3/4	143.728	1643.89	3/4	159.436	2022.84	3/4	175.144	2441.07
7/8	144.121	1652.88	7/8	159.828	2032.82	7/8	175.536	2452.03
46	144.513	1661.90	**51**	160.221	2042.82	**56**	175.929	2463.01
1/8	144.906	1670.95	1/8	160.614	2052.85	1/8	176.322	2474.02
1/4	145.299	1680.02	1/4	161.007	2062.90	1/4	176.715	2485.05
3/8	145.691	1689.11	3/8	161.399	2072.97	3/8	177.107	2496.11
1/2	146.084	1698.23	1/2	161.792	2083.07	1/2	177.500	2507.19
5/8	146.477	1707.37	5/8	162.185	2093.20	5/8	177.893	2518.29
3/4	146.870	1716.54	3/4	162.577	2103.35	3/4	178.285	2529.42
7/8	147.262	1725.73	7/8	162.970	2113.52	7/8	178.678	2540.58
47	147.655	1734.94	**52**	163.363	2123.72	**57**	179.071	2551.76
1/8	148.048	1744.19	1/8	163.756	2133.94	1/8	179.464	2562.96
1/4	148.440	1753.45	1/4	164.148	2144.19	1/4	179.856	2574.19
3/8	148.833	1762.74	3/8	164.541	2154.46	3/8	180.249	2585.45
1/2	149.226	1772.05	1/2	164.934	2164.75	1/2	180.642	2596.73
5/8	149.618	1781.39	5/8	165.326	2175.08	5/8	181.034	2608.03
3/4	150.011	1790.76	3/4	165.719	2185.42	3/4	181.427	2619.35
7/8	150.404	1800.14	7/8	166.112	2195.79	7/8	181.820	2630.70
48	150.796	1809.56	**53**	166.504	2206.18	**58**	182.212	2642.08
1/8	151.189	1818.99	1/8	166.897	2216.60	1/8	182.605	2653.48
1/4	151.582	1828.46	1/4	167.290	2227.05	1/4	182.998	2664.91
3/8	151.974	1837.94	3/8	167.682	2237.52	3/8	183.390	2676.36
1/2	152.367	1847.45	1/2	168.075	2248.01	1/2	183.783	2687.83
5/8	152.760	1856.99	5/8	168.468	2258.53	5/8	184.176	2699.33
3/4	153.153	1866.55	3/4	168.861	2269.07	3/4	184.569	2710.85
7/8	153.545	1876.13	7/8	169.253	2279.63	7/8	184.961	2722.40
49	153.938	1885.74	**54**	169.646	2290.22	**59**	185.354	2733.97
1/8	154.331	1895.37	1/8	170.039	2300.84	1/8	185.747	2745.57
1/4	154.723	1905.03	1/4	170.431	2311.48	1/4	186.139	2757.19
3/8	155.116	1914.72	3/8	170.824	2322.14	3/8	186.532	2768.84
1/2	155.509	1924.42	1/2	171.217	2332.83	1/2	186.925	2780.51
5/8	155.902	1934.15	5/8	171.610	2343.54	5/8	187.318	2792.20
3/4	156.294	1943.91	3/4	172.002	2354.28	3/4	187.710	2803.92
7/8	156.687	1953.69	7/8	172.395	2365.04	7/8	188.103	2815.67
50	157.080	1963.50	**55**	172.788	2375.83	**60**	188.496	2827.43

Circumferences and Areas of Circles.

Diameter.	Circum-ference.	Area.	Diameter.	Circum-ference.	Area.	Diameter.	Circum-ference.	Area.
60	188.496	2827.43	**65**	204.204	3318.31	**70**	219.911	3848.45
1/8	188.888	2839.23	1/8	204.596	3331.08	1/8	220.304	3862.21
1/4	189.281	2851.04	1/4	204.989	3343.88	1/4	220.697	3875.99
3/8	189.674	2862.89	3/8	205.382	3356.71	3/8	221.090	3889.80
1/2	190.066	2874.75	1/2	205.774	3369.55	1/2	221.482	3903.63
5/8	190.459	2886.65	5/8	206.167	3382.43	5/8	221.875	3917.48
3/4	190.852	2898.56	3/4	206.560	3395.33	3/4	222.268	3931.36
7/8	191.244	2910.50	7/8	206.952	3408.25	7/8	222.660	3945.26
61	191.637	2922.47	**66**	207.345	3421.19	**71**	223.053	3959.19
1/8	192.030	2934.46	1/8	207.738	3434.17	1/8	223.446	3973.15
1/4	192.423	2946 47	1/4	208.130	3447.17	1/4	223.838	3987.12
3/8	192.815	2958.51	3/8	208.523	3460.18	3/8	224.231	4001.13
1/2	193.208	2970.57	1/2	208.916	3473.23	1/2	224.624	4015.15
5/8	193.601	2982.66	5/8	209.309	3486.30	5/8	225.017	4029.20
3/4	193.993	2994.77	3/4	209.701	3499.39	3/4	225.409	4043.28
7/8	194.386	3006.91	7/8	210.094	3512.51	7/8	225.802	4057.38
62	194.779	3019.07	**67**	210.487	3525.65	**72**	226.195	4071.50
1/8	195.172	3031.26	1/8	210.879	3538.82	1/8	226.587	4085.65
1/4	195.564	3043.47	1/4	211.272	3552.01	1/4	226.980	4099.83
3/8	195.957	3055.70	3/8	211.665	3565.23	3/8	227.373	4114.03
1/2	196.350	3067.96	1/2	212.058	3578.47	1/2	227.766	4128.25
5/8	196.742	3080.25	5/8	212.450	3591.74	5/8	228.158	4142.50
3/4	197.135	3092.56	3/4	212.843	3605.03	3/4	228.551	4156.77
7/8	197.528	3104.89	7/8	213.236	3618.34	7/8	228.944	4171.07
63	197.920	3117.25	**68**	213.628	3631.68	**73**	229.336	4185.39
1/8	198.313	3129.63	1/8	214.021	3645.05	1/8	229.729	4199.73
1/4	198.706	3142.03	1/4	214.414	3658.43	1/4	230.122	4214.10
3/8	199.098	3154.47	3/8	214.806	3671.85	3/8	230.514	4228.50
1/2	199.491	3166.92	1/2	215.199	3685.28	1/2	230.907	4242.92
5/8	199.884	3179.40	5/8	215.592	3698.75	5/8	231.300	4257.36
3/4	200.276	3191.91	3/4	215.984	3712.23	3/4	231.692	4271.83
7/8	200.669	3204.44	7/8	216.377	3725.75	7/8	232.085	4286.32
64	201.062	3216.99	**69**	216.770	3739.28	**74**	232.478	4300.84
1/8	201.455	3229.57	1/8	217.163	3752.84	1/8	232.871	4315.38
1/4	201.847	3242.17	1/4	217.555	3766.43	1/4	233.263	4329.95
3/8	202.240	3254.80	3/8	217.948	3780.04	3/8	233.656	4244.54
1/2	202.633	3267.45	1/2	218.341	3793.67	1/2	234.049	4359.16
5/8	203.025	3280.13	5/8	218.733	3807.33	5/8	234.441	4373.80
3/4	203.418	3292.83	3/4	219.126	3821.01	3/4	234.834	4388.46
7/8	203.811	3305.56	7/8	219.519	3834.72	7/8	235.227	4403.15
65	204.204	3318.31	**70**	219.911	3848.45	**75**	235.619	4417.86

Circumferences and Areas of Circles.

Diameter.	Circum-ference.	Area.	Diameter.	Circum-ference.	Area.	Diameter.	Circum-ference.	Area.
75	235.619	4417.86	**80**	251.327	5026.55	**85**	267.035	5674.50
1/8	236.012	4432.60	1/8	251.720	5042.27	1/8	267.428	5691.20
1/4	236.405	4447.37	1/4	252.113	5058.01	1/4	267.821	5707.93
3/8	236.798	4462.15	3/8	252.506	5073.78	3/8	268.214	5724.68
1/2	237.190	4476.97	1/2	252.898	5089.58	1/2	268.606	5741.46
5/8	237.583	4491.80	5/8	253.291	5105.39	5/8	268.999	5758.26
3/4	237.976	4506.66	3/4	253.684	5121.24	3/4	269.392	5775.08
7/8	238.368	4521.55	7/8	254.076	5137.10	7/8	269.784	5791.93
76	238.761	4536.46	**81**	254.469	5153.00	**86**	270.177	5808.80
1/8	239.154	4551.39	1/8	254.862	5168.91	1/8	270.570	5825.70
1/4	239.546	4566.35	1/4	255.254	5184.85	1/4	270.962	5842.63
3/8	239.939	4581.34	3/8	255.647	5200.82	3/8	271.355	5859.57
1/2	240.332	4596.35	1/2	256.040	5216.81	1/2	271.748	5876.55
5/8	240.724	4611.38	5/8	256.432	5232.83	5/8	272.140	5893.54
3/4	241.117	4626.44	3/4	256.825	5248.86	3/4	272.533	5910.56
7/8	241.510	4641.52	7/8	257.218	5264.93	7/8	272.926	5927.61
77	241.903	4656.63	**82**	257.611	5281.02	**87**	273.319	5944.68
1/8	242.295	4671.76	1/8	258.003	5297.13	1/8	273.711	5961.77
1/4	242.688	4686.91	1/4	258.396	5313.27	1/4	274.104	5978.89
3/8	243.081	4702.09	3/8	258.789	5329.43	3/8	274.497	5996.04
1/2	243.473	4717.30	1/2	259.181	5345.62	1/2	274.889	6013.20
5/8	243.866	4732.53	5/8	259.574	5361.83	5/8	275.282	6030.40
3/4	244.259	4747.78	3/4	259.967	5378.06	3/4	275.675	6047.62
7/8	244.652	4763.06	7/8	260.360	5394.32	7/8	276.068	6064.86
78	245.044	4778.36	**83**	260.752	5410.61	**88**	276.460	6082.12
1/8	245.437	4793.69	1/8	261.145	5426.92	1/8	276.853	6099.41
1/4	245.830	4809.04	1/4	261.538	5443.25	1/4	277.246	6116.73
3/8	246.222	4824.42	3/8	261.930	5459.61	3/8	277.638	6134.07
1/2	246.615	4839.82	1/2	262.323	5475.99	1/2	278.031	6151.44
5/8	247.008	4855.25	5/8	262.716	5492.40	5/8	278.424	6168.82
3/4	247.400	4870.70	3/4	263.108	5508.83	3/4	278.816	6186.24
7/8	247.793	4886.17	7/8	263.501	5525.29	7/8	279.209	6203.68
79	248.186	4901.67	**84**	263.894	5541.77	**89**	279.602	6221.14
1/8	248.579	4917.19	1/8	264.286	5558.28	1/8	279.994	6238.63
1/4	248.971	4932.74	1/4	264.679	5574.81	1/4	280.387	6256.14
3/8	249.364	4948.32	3/8	265.072	5591.36	3/8	280.780	6273.67
1/2	249.757	4963.91	1/2	265.465	5607.94	1/2	281.172	6291.24
5/8	250.149	4979.54	5/8	265.857	5624.54	5/8	281.565	6308.82
3/4	250.542	4995.18	3/4	266.250	5641.17	3/4	281.958	6326.43
7/8	250.935	5010.85	7/8	266.643	5657.82	7/8	282.351	6344.07
80	251.327	5026.55	**85**	267.035	5674.50	**90**	282.743	6361.73

Circumferences and Areas of Circles.

Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.	Diameter.	Circumference.	Area.
90	282.743	6361.73	**95**	298.451	7088.22	**100**	314.159	7853.98
1/8	283.136	6379.41	1/8	298.844	7106.88	1/8	314.552	7873.63
1/4	283.529	6397.12	1/4	299.237	7125.57	1/4	314.945	7893.30
3/8	283.921	6414.85	3/8	299.629	7144.29	3/8	315.337	7913.00
1/2	284.314	6432.61	1/2	300.022	7163.03	1/2	315.730	7932.72
5/8	284.707	6450.39	5/8	300.415	7181.79	5/8	316.123	7952.46
3/4	285.100	6468.20	3/4	300.808	7200.58	3/4	316.516	7972.23
7/8	285.492	6486.03	7/8	301.200	7219.39	7/8	316.908	7992.03
91	285.885	6503.88	**96**	301.593	7238.23	**101**	317.301	8011.85
1/8	286.278	6521.76	1/8	301.986	7257.09	1/8	317.694	8031.69
1/4	286.670	6539.67	1/4	302.378	7275.98	1/4	318.086	8051.56
3/8	287.063	6557.60	3/8	302.771	7294.89	3/8	318.479	8071.45
1/2	287.456	6575.55	1/2	303.164	7313.82	1/2	318.872	8091.37
5/8	287.848	6593.53	5/8	303.556	7332.78	5/8	319.264	8111.31
3/4	288.241	6611.53	3/4	303.949	7351.77	3/4	319.657	8131.28
7/8	288.634	6629.56	7/8	304.342	7370.78	7/8	320.050	8151.27
92	289.027	6647.61	**97**	304.734	7389.81	**102**	320.442	8171.28
1/8	289.419	6665.69	1/8	305.127	7408.87	1/8	320.835	8191.32
1/4	289.812	6683.79	1/4	305.520	7427.95	1/4	321.228	8211.39
3/8	290.205	6701.91	3/8	305.913	7447.06	3/8	321.620	8231.48
1/2	290.597	6720.06	1/2	306.305	7466.19	1/2	322.013	8251.59
5/8	290.990	6738.24	5/8	306.698	7485.35	5/8	322.406	8271.73
3/4	291.383	6756.44	3/4	307.091	7504.53	3/4	322.799	8291.89
7/8	291.775	6774.66	7/8	307.483	7523.73	7/8	323.191	8312.08
93	292.168	6792.91	**98**	307.876	7542.96	**103**	323.584	8332.29
1/8	292.561	6811.18	1/8	308.269	7562.22	1/8	323.977	8352.53
1/4	292.954	6829.48	1/4	308.662	7581.50	1/4	324.369	8372.79
3/8	293.346	6847.80	3/8	309.054	7600.80	3/8	324.762	8393.07
1/2	293.739	6866.15	1/2	309.447	7620.13	1/2	325.155	8413.38
5/8	294.132	6884.52	5/8	309.840	7639.48	5/8	325.548	8433.72
3/4	294.524	6902.91	3/4	310.232	7658.86	3/4	325.940	8454.08
7/8	294.917	6921.33	7/8	310.625	7678.26	7/8	326.333	8474.46
94	295.310	6939.78	**99**	311.018	7697.69	**104**	326.726	8494.87
1/8	295.702	6958.25	1/8	311.410	7717.14	1/8	327.118	8515.30
1/4	296.095	6976.74	1/4	311.803	7736.61	1/4	327.511	8535.76
3/8	296.488	6995.26	3/8	312.196	7756.11	3/8	327.904	8556.24
1/2	296.880	7013.80	1/2	312.588	7775.64	1/2	328.296	8576.74
5/8	297.273	7032.37	5/8	312.981	7795.19	5/8	328.689	8597.28
3/4	297.666	7050.96	3/4	313.374	7814.76	3/4	329.082	8617.83
7/8	298.059	7069.58	7/8	313.767	7834.36	7/8	329.474	8638.41
95	298.451	7088.22	**100**	314.159	7853.98	**105**	329.867	8659.01

The Locomotive

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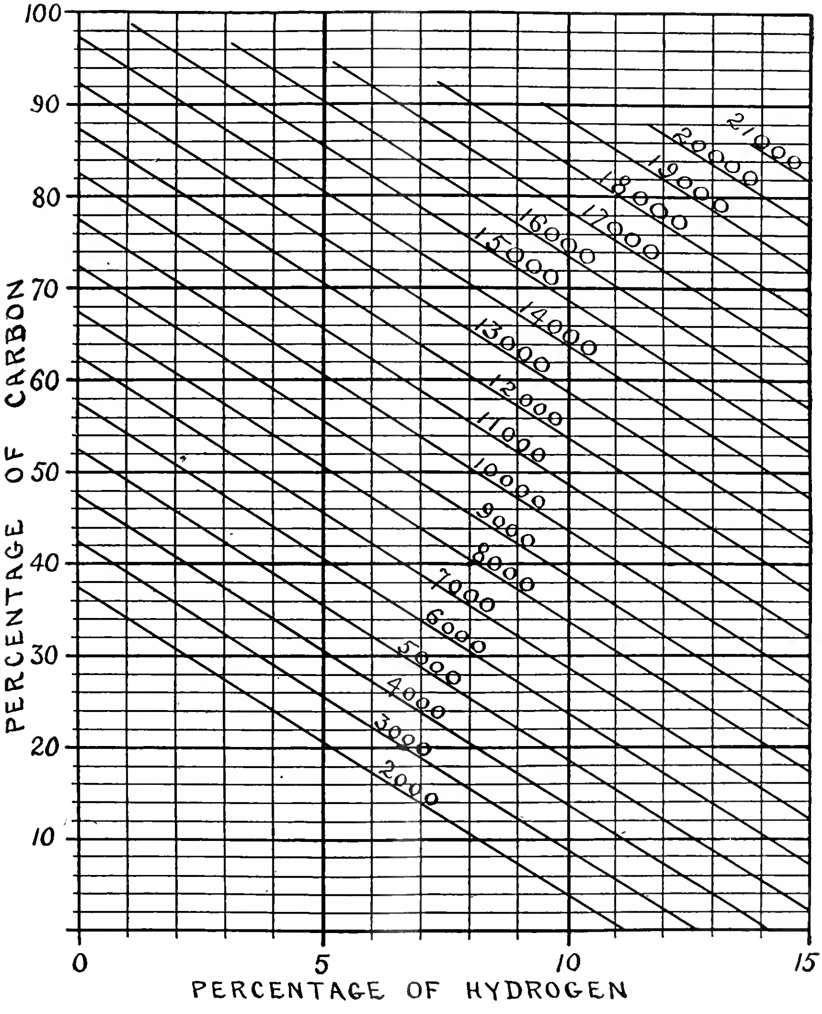
Diagram for Use with Fuel Formula.



On Fuel Formulas.

When a given kind of fuel is under consideration, and we wish to know how many units of heat may be obtained by the combustion of one pound of it, the only accurate way to proceed is to make a careful calorimetric test upon a fair sample of the fuel, so as to learn its heat value by direct observation. It sometimes happens, however, that such a test is impracticable, either because the necessary apparatus is not at hand, or for some other reason. It is desirable, therefore, to have some other alternative method of determining the heat-value of a fuel, — some method which, though it may not be particularly accurate, will yet be serviceable for rough purposes.

Numerous formulas have been proposed for calculating the heat-value of a fuel whose chemical composition is known; and although the results that such formulas yield are always distinctly inferior to those obtained by the direct application of the calorimeter, they are nevertheless useful under certain conditions.

The oldest and best known formula of this kind is that of Dulong, which has been much used among engineers. Dulong's formula, however, is somewhat complicated, and it requires a rather refined knowledge of the composition of a fuel. The constants that it contains may be determined, however, so that the formula will give very consistent and valuable results, when it is applied to the coals, for example, from any one general region; but it does not appear to be possible to determine its constants, once for all, so that the formula shall give equally satisfactory results when applied to fuel of all kinds and from all places. This being the case, and it being also admitted that the method by calculation can never be regarded otherwise than as an inferior and comparatively inaccurate substitute for the calorimetric method, the refinement that characterizes Dulong's general formula appears to be of doubtful utility. In the present article we shall, therefore, confine our attention to a simpler formula that was proposed by Mahler, which is probably exact enough for most of the rough purposes for which a formula is wanted.

Let us conceive of a fuel consisting solely of hydrogen, carbon, moisture, and inert substances such as silica and alumina. In W pounds of the fuel, let there be C pounds of carbon, and H pounds of hydrogen. Then, for the purpose of developing a formula to be subsequently tested by experiment, we may assume that the total heat developed by the combustion of the W pounds of actual fuel is the same as that which would be developed by the combustion if C pounds of carbon and H pounds of hydrogen were burned separately. This assumption is undoubtedly more or less inaccurate, because in a solid or liquid fuel the hydrogen must be present in the combined state, and in a gaseous fuel the carbon must be present in the combined state; and it is not at all likely that the heat developed by the combustion of any substance is the same when that substance is free, as when it is combined with something else. Nevertheless, we will proceed as indicated, and then examine the formula that results.

One pound of carbon, in burning to carbon dioxide gas, gives off about 14,550 heat units, and one pound of hydrogen gives off about 62,100 heat units. Hence the assumed mixture of C pounds of carbon and H pounds of hydrogen would give off $14{,}550C + 62{,}100H$ heat units. If C and H are expressed as hundredths of the total weight, W, of the fuel, and W is taken as one pound, then we have, as the formula for the heat given off by one pound of the fuel,

$$145.5C + 62.1H = \textit{heat units per pound of actual fuel.}$$

This formula is absolutely correct when the combustible portion of the fuel is all free carbon, or all free hydrogen; but it will be found to be unsatisfactory when applied to fuels which contain *both* of these elements in relatively important amounts. The problem therefore arises, as to how we can generalize it so that it will still hold true when the combustible is all carbon or all hydrogen, and will also apply to mixtures of the two. The generalization may be effected in a great variety of ways; but since it is desirable, for the purposes of practical calculation, to keep it *linear* (that is, to restrict it so that it shall contain only the first powers of C and H), we are led to consider the very simple generalization in which the formula is written in the form

$$xC + yH + z = \textit{heat units per pound of actual fuel,}$$

where x, y, and z are constants whose values are to be determined by comparing the formula with the results of experiment. This formula differs from the foregoing one, it will be seen, simply by containing the additional constant term z. It is evident that cases can be imagined, in which this last formula would give absurd results. For example, it indicates that a substance which contains no carbon and no hydrogen, would nevertheless give out z units of heat per pound. This particular extreme case will not arise in practice, however, because every form of fuel that is of any value, and to which the formula is likely to be applied, contains at least 40 (or more) parts of carbon per hundred.

In determining the values of the constants, x, y, and z, we may proceed somewhat as we did in the first case. For example, if the fuel is pure carbon, we have $C = 100$, and $H = 0$; and in this case we know that the heat developed is 14,550 heat units. Hence we have the relation

$$100x + z = 14{,}550,$$

$$\text{or } z = 14{,}550 - 100x.$$

Substituting $14{,}550 - 100x$ for z in the general equation, that equation becomes

$$xC + yH + 14{,}550 - 100x = \textit{heat units per pound of fuel.}$$

If the fuel is entirely hydrogen, then $C = 0$ and $H = 100$, and the total number of heat units developed is 62,100. Hence the last equation becomes

$$100y + 14{,}550 - 100x = 62{,}100;$$

and this may be written in the form

$$y = x + 475.5.$$

If we replace y by $x + 475.5$, the general equation becomes further reduced to the form

$$xC + (x + 475.5)H + 14{,}550 - 100x = \textit{heat units per pound of fuel.}$$

Tests with the calorimeter have shown that a pound of pure cellulose develops 7,560 heat units upon being burned; and since chemical analysis shows that cellulose contains 44.44 per cent. of carbon and 6.17 per cent. of hydrogen, the last equation, when applied to cellulose, takes the form:

$$44.44x + 6.17(x + 475.5) + 14{,}550 - 100x = 7{,}560,$$

from which we easily find that

$$49.39x = 9{,}924, \text{ or } x = 200.9.$$

Then, since we know that $y = x + 475.5$, we have $y = 676.4$; and finally, since $z = 14{,}550 - 100x$, we find that $z = -5{,}540$.

The complete general equation for the quantity of heat developed by the combustion of a pound of fuel therefore takes the form

$$200.9C + 676.4H - 5{,}540 = \textit{heat units per pound of fuel;}$$

or, more briefly (and yet with sufficient accuracy),

$$201C + 676H - 5{,}540 = \textit{heat units per pound of fuel.}$$

This is the equation which we shall adopt as final, if it proves to correspond well enough with the facts of calorimetry, as applied to fuels of various kinds.

To test the equation

$$201C + 676H - 5{,}540 = \textit{heat units per pound of fuel,}$$

we will compare it with actual calorimetric tests of several widely different kinds of fuel, selecting, for this purpose, bituminous, semi-bituminous, and anthracite coal, pine and ash wood, Irish peat, and Pennsylvania petroleum. The data for the comparison are given in the accompanying table; the analyses and the calorimetric results in which are taken from Mr. Herman Poole's *Calorific Power of Fuels.*

COMPARISON OF FORMULA WITH CALORIMETER.

FUEL	Total carbon	Total hydrogen	Hygroscopic moisture	Ash	HEAT UNITS FROM 1 LB. FUEL		Per cent. of error
					Actual	By formula	
Blue Creek, Ala., bituminous coal,	72.34	4.45	......	10.16	11,930	12,008	0.6
Beaver Creek, Pa., bituminous coal,	74.60	4.89	1.50	8.75	13,250	12,760	3.7
Pocahontas, W.Va., semi-bitumin's coal,	83.75	4.13	0.80	7.25	14,420	14,086	2.3
Treverton, Pa., anthracite coal,	90.66	1.73	0.84	6.83	14,030	13,851	1.3
Ash wood, . .	49.18	6.27	......	0.57	8,430	8,584	1.8
Norway pine, . .	47.37	5.58	6.94	0.34	8,057	7,753	3.8
Irish peat, thoroughly dried,	59.0	6.0	......	4.0	10,260	10,375	1.1
Heavy petroleum, Pennsylvania,	84.9	13.7	......	......	19,210	20,786	8.2

The quantities of carbon and hydrogen are expressed, here as in the formula, as hundredths of the total weight of the fuel, and no separate account is taken (as will be observed), either of the ash or of the moisture. The ash is treated as so much inert matter, which detracts from the heat-value of the fuel merely by diminishing the number of hundredths of it which are combustible; and in this sense it has already been taken into account, when the percentage of carbon and hydrogen in the original fuel have been stated. The same may be said of the moisture that is present in the fuel; except that the moisture that is present further detracts from the *available* heat developed by the fuel, by the amount which is required to effect its evaporation. In accurate tests of fuel, the heat required to evaporate the moisture in the fuel should, of course, be carefully estimated, and proper allowance made for it; but the error due to the total neglect of the heat expended in evaporating the moisture in the fuel will almost invariably be much smaller than the uncertainty of the formula itself; so that we need not take account of it, under ordinary circumstances, when calculating the heat-value of a fuel by the method here explained. The correspondence between the calculated and observed values of the heat given out by the combustion of these very various kinds of fuel is as good as could be expected, and it appears to indicate that the formula, for rough purposes, is worth consideration. It would doubtless be easy to cite cases of fuels which do not conform to it; but that could be said of any formula whatever, and hence it does not constitute a valid objection to this one.

To facilitate the application of the foregoing formula to actual fuels whose compositions are known, we have prepared the diagram that accompanies this article. The scale at the bottom of the diagram corresponds to the *total* hydrogen present in the fuel, whether it is free or combined; and the scale at the left corresponds, similarly, to the *total* carbon present, whether free or combined. The oblique lines correspond to the quantities of heat liberated by the combustion of a pound of the fuel. Suppose, for example, that we desired to know the heat-value of a pound of fuel which contains 5 per cent. of hydrogen and 90 per cent. of carbon, the remainder consisting of ash, moisture, or other negligible material. We first seek "5" on the hydrogen scale at the bottom, and we pass vertically upwards from the point so found, until we meet the horizontal line that passes through "90" on the carbon scale. The intersection corresponds to the heat-value of the fuel in question; and since we see that the oblique line marked "16,000" passes through this point, we conclude that one pound of such a fuel as we have described would, in burning, give out 16,000 units of heat. As a further example, consider the case of the peat, for which data are given in the table. We first find "6" on the hydrogen scale at the bottom, and we pass up the vertical line through this point until we meet the horizontal line through "59" on the carbon scale. (It will be observed that on the vertical scale, each space corresponds to *two* per cent.; so that the point corresponding to "59" comes half way between two successive horizontal lines.) The intersection of the vertical line through "6" with the horizontal line through "59" gives the point that represents the heat-value of the peat. On the diagram this intersection comes between the oblique lines "10,000" and "11,000." Judging by the eye, it is about one-third of the way from the "10,000" line to the "11,000" line; and hence we conclude that the heat-value of the peat is approximately 10,300 heat units per pound.

Boiler Explosions.

June, 1903.

(151.) — On June 1st a boiler exploded at the Victoria Rice and Irrigation Company's plant, at Victoria, Tex. Assistant engineer Howe was killed, and chief engineer Hurley was injured.

(152.) — A boiler exploded, on June 1st, in the East End plant of the Montreal Light, Heat, and Power Company, Montreal, Can. Napoleon Marion was scalded so badly that he died within a few hours. John Schwab was also injured seriously, but not fatally.

(153.) — Robert Wineland was fearfully scalded about the face and hands, on June 3d, by the explosion of a boiler in the Marion township oil field, near Marion, Ohio.

(154.) — A boiler exploded, on June 3d, in the Wilcox sawmill, near Spencer, Md. Fireman Edward Mann was injured severely, but not fatally. This is the third boiler explosion that Mr. Wilcox has been through, in the course of his experience in the sawmill business. In the last one before this he was himself injured, and three of his men were killed.

(155.) — A boiler belonging to the Smith Construction Company exploded, on June 3d, at Ridley Creek, near Chester, Pa. The explosion was very violent, but nobody was injured.

(156.) — On June 4th a boiler exploded at a coal mine in Buxton, Clinton county, near Centralia, Ill. August and Louis Beckmeyer were killed.

(157.) — On June 4th two boilers exploded in Shelley Robinson's stave mill, at Sunfield, Mich. The machinery and the boiler house were totally destroyed, but nobody was injured. The explosion occurred in the early morning, while the fireman was gone to breakfast.

(158.) — On June 4th an accident occurred in the plant of the New York Glucose Works, at Shady Side, N. J. It is reported that it consisted in the bursting of a fly-wheel, together with the practically simultaneous explosion of a boiler. Michael Colon was seriously injured, and the total property loss was estimated at $100,000.

(159.) — A slight boiler explosion is reported to have occurred, on June 9th, in the Doniphan Roller Mill, at Bowling Green, Ohio. Nobody was injured, and the property loss was small.

(160.) — The boiler of Southern Pacific freight locomotive No. 2626 exploded, on June 11th, at Rowan, near Bakersfield, Cal. Fireman Laidley was instantly killed, and engineeer D. J. Daze was badly injured.

(161.) — A boiler exploded, on June 12th, in the custom mills at Paris, Mo., wrecking the plant and demolishing a drug store across the street. Nobody was injured.

(162.) — On June 12th the boiler of locomotive No. 1674 of the Southern Pacific railroad exploded in the roundhouse at San Pedro, near Los Angeles, Cal. John Steen was injured so badly that he died a few days later. The roundhouse was badly damaged and the locomotive was demolished.

(163.) — The boiler of a hoisting engine exploded, on June 14th, at the Crum Creek bridge on the Pennsylvania railroad, near Chester, Pa. Samuel Gilbert, the night fireman, was instantly killed, and David Watt was seriously scalded. Fireman Gilbert apparently had had some intimation of the impending trouble, as he was in the act of hauling the fire when the explosion occurred.

(164.) — Assistant engineer George Conklin was scalded to death, on June 18th, by the failure of a boiler tube on the suction dredger *Olympia,* which was engaged in deepening a portion of the harbor at San Pedro, Cal.

(165.) — The boiler of a portable sawmill exploded, on June 18th, in the town of Ward, N. Y. Llewellyn Sprague was killed almost instantly, and another man was slightly injured. The firebox end of the boiler was thrown into the air to an estimated height of 500 feet, finally landing some 800 feet from its initial position.

(166.) — On June 18th a boiler exploded in a machine shop connected with the Lackawanna steel plant at Stony Point, near Buffalo, N. Y. The boiler house was partially wrecked, and a Polish laborer, whose name we have not learned, was badly scalded.

(167.) — A slight boiler explosion occurred, on June 21st, in the Wellington

Hotel, at Chicago, Ill., instantly killing fireman Jacob Newman, and causing a panic among the guests.

(168.) — On June 21st a slight explosion occurred in the electric light plant at Lima, Ohio, fatally injuring fireman Lee Glenn.

(169.) — On June 22d a flue failed in a boiler at Bancroft, near Vernon, Mich. Nobody was injured, but the accident caused the temporary closing of the factory in which it occurred.

(170.) — A boiler exploded, on June 22d, in the R. W. Hinton Company's planing mill, at Lumberton, Miss., killing fireman Primus Snow and slightly injuring several others. The property loss was estimated at about $3,000.

(171.) — The C. P. Orr sawmill, at Huntsville, near Bellefontaine, Ohio, was wrecked by a boiler explosion on June 22d, but fortunately nobody was injured.

(172.) — On or about June 25th a boiler exploded in B. F. Mathews' mill, near Barkers, ten miles north of Westville, Fla. Marcus Mathews, a son of the proprietor, was instantly killed. Two other sons of the proprietor and a young man named Wade were likewise seriously injured. The building was completely wrecked.

(173.) — A boiler exploded, on June 29th, in the Wild Rose mill, near Galena, Mo. John W. Burns was seriously injured, and John Cope was injured slightly.

(174.) — The boiler of W. B. Porter's threshing machine outfit exploded, on June 30th, near Collinsville, in the southwestern part of Grayson county, Tex. Julius Porter, who was standing near the boiler at the time, was fatally injured.

July, 1903.

(175.) — On July 5th a locomotive boiler exploded on the Grand Trunk railroad, at Stirling, Ont. Engineer Robert McAuliffe was injured so badly that he died later in the day. Fireman Porter was also injured seriously.

(176.) — A boiler exploded, on July 5th, at the New London Copper Mines, New London, Frederick county, Md. Superintendent W. Johnson, engineer Abraham Dorsey, and Howard Murdock, were slightly injured. The building in which the boiler stood was wrecked.

(177.) — On July 9th a boiler exploded on the pleasure yacht *Felicia*, near Rose's Grove, L. I. Alfred J. Whewell was fatally injured, and William A. Kruger was injured to a lesser extent. The yacht was not disabled, but proceeded to Rose's Grove under her own steam. The *Felicia* is owned by E. W. Bliss, but was chartered for the season by Charles Steele.

(178.) — A boiler exploded, on July 10th, in Henry P. Simon's weiss beer factory, Jersey City, N. J. The two-story building in which the boiler stood was badly wrecked, but nobody was injured, as the employees were not present at the time of the accident.

(179.) — A slight boiler explosion occurred, on July 11th, in the Stearns silk mill, at Elmira, N. Y. Nobody was injured, and the property loss was small.

(180.) — The boiler of locomotive No. 1512 of the Union Pacific railroad exploded, on July 12th, at Colores, near Laramie, Wyo. Engineer Michael Lyons was instantly killed, and fireman Alfred Hansen was seriously scalded and otherwise injured. The locomotive was completely wrecked.

(181.) — A boiler exploded, on July 14th, at the Horn Superior coal mine, two miles west of Belleville, Ill. Engineer Jacob Ackermann and pit boss Adolph Laesser were seriously injured, and the boiler house was completely wrecked.

(182.) — The boiler of a locomotive exploded, on July 15th, at Alameda, Cal., on the South Shore local broad-gauge line. Engineer Willis R. Duncan, fireman Edward Gale, and another employee of the railroad, named C. Hansen, were injured painfully but not fatally, and several buildings in the vicinity were more or less damaged.

(183.) — The boiler of freight locomotive No. 1516 of the Union Pacific railroad exploded, on July 15th, at Otto, some fifteen miles west of Cheyenne, Wyo. Fireman Carl Carlson was fatally hurt, and engineer D. D. Sweeney and brakeman J. H. Whaley were injured seriously. The locomotive was demolished, and a "helper" was also badly damaged. Locomotive No. 1516 was of the same type as No. 1512, which exploded three days earlier. (See explosion No. 180, above.)

(184.) — On July 16th the boiler of a channeling machine exploded in the Perry, Matthews & Buskirk quarry, at Bloomington, Ind. Engineer William Payne was seriously injured.

(185.) — A boiler exploded, on July 16th, at the shaft of the Avoca Coal Company, in Avoca, near Scranton, Pa., instantly killing fireman Malachi Cavanaugh and wrecking the boiler house. One large fragment of the boiler was thrown to a distance of 500 feet.

(186.) — A locomotive boiler exploded, on July 18th, in the Pennsylvania railroad shops, at Olean, N. Y. Archibald Battles, Herman Houseknecht, John Jonak, and Andrew Ritter were severely injured.

(187.) — The boiler of a threshing machine outfit exploded, on July 20th, at Britton, near Tecumseh, Mich. Leonard Rodney and H. M. Tucker were badly scalded and bruised.

(188.) — A boiler exploded, on July 22d, in the Chesterfield apartment house, at Richmond, Va. W. Spauls was injured very seriously.

(189.) — On July 22d a small boiler exploded in David Greenbaum's hat factory, at Newark, N. J. The building in which it stood was wrecked, but nobody was injured.

(190.) — A boiler used by John Muirhead & Co., artesian well sinkers, exploded on July 22d near the Lackawanna Avenue bridge, at Scranton, Pa. Nobody was injured. The small building in which the boiler stood was demolished, and the boiler itself was thrown to a distance of 500 feet.

(191.) — A locomotive boiler exploded, on or about July 23d, at Colbert, near Fort Smith, Ark. Fireman G. Rusker was severely scalded.

(192.) — A boiler exploded, on July 25th, in the Bulbeggar barrel factory, at Laurel, Del. Foreman William Martin was instantly killed, and his son, William, was injured so badly that he died an hour later.

(193.) — On July 26th a boiler tube failed on the steamboat *Waiontha,* on the Connecticut River, off Rocky Hill, near Hartford, Conn. Engineer Charles Bosworth was terribly scalded about the chest and arms.

(194.) — A boiler exploded, on July 27th, in S. J. Walters' sawmill, at Grand Bay station, near Mobile, Ala. Alfred Washington, William Carter, and Louis Johnson were instantly killed, and Robert Tate and Calvin Fort were fatally injured. It is said that the accident was primarily due to the fact that the mill was struck by lightning, but we have been unable to verify this report.

(195.) — On July 28th a boiler exploded in Josiah Bishop & Son's sawmill, at Rushville, near Madison, Ind. Nobody was injured, but the plant was wrecked.

(196.) — On July 28th a boiler exploded in the Mountain State Brick and Tile Company's plant, at Point Pleasant, W. Va. Superintendent C. Fritz Hess and one fireman were seriously injured and several others received minor injuries. The building in which the boiler stood was destroyed.

(197.) — A slight explosion occurred, on July 29th, at the American Woolen Company's plant, at Gardiner, Me. Fireman John Riley was painfully but not fatally burned.

(198.) — The mud drum of a boiler exploded, on July 29th, in the Dayton Cereal Company's plant, at Dayton, Ohio. Nobody was injured, and the property loss was small.

(199.) — A boiler exploded, on July 29th, in a cold storage plant at Pueblo, Colo. H. T. Winn was killed.

(200.) — A boiler exploded, on July 30th, in a creamery at Battle Creek, Mich. We have not learned of any personal injuries, and the property loss was small.

August, 1903.

(201.) — On August 4th the boiler of Guy Sevier's threshing outfit exploded at Beaver City, Neb. Mr. Sevier was fatally scalded.

(202.) — The boiler of locomotive No. 4026 of the Northern Central railroad exploded, on August 4th, about half a mile from Timonium, near Baltimore, Md. Engineer John H. Baer was injured so badly that he died within an hour, and fireman William G. Chenowith also received very severe injuries. Chenowith's skull was fractured, and at last accounts it was doubtful if he could recover. Portions of the exploded boiler were hurled to a distance of 1,000 yards.

(203.) — On August 5th a boiler exploded in the plant of the Tuscaloosa Light and Power Company, at Tuscaloosa, Ala. Adolph Johnson and Nathan D. Johnson were instantly killed, and A. M. McGhee, Crawford McCloskey, and E. W. Housman received minor injuries. The plant in which the boiler stood was demolished and considerable damage was also done to other buildings in the vicinity. The total property loss was estimated at $25,000.

(204.) — A boiler exploded, on August 5th, at the Black Hawk Oil Company's plant, on Spindle Top Heights, near Beaumont, Texas. A tube from the boiler was blown into the residence of Mr. E. D. Lord, near by, and Mr. Lord, who was eating his dinner at the time, was almost instantly killed. A second projectile struck a laundress and injured her so badly that it was thought for a time she could not recover. Later advices indicate that she did recover, however. The fireman at the plant where the boiler exploded was thrown to a considerable distance and seriously injured.

(205.) — The boiler of a threshing machine outfit exploded, on August 7th, at Freeport, Kans. J. A. Doane was instantly killed.

(206.) — A heating boiler exploded, on August 7th, in the Elks' building at Ottumwa, Iowa. Nobody was injured, and the property loss was small.

(207.) — On August 8th a boiler exploded in the Minnesota Lumber Company's plant, at Cutting, some thirty miles east of Valdosta, Ga. A man named Grace was killed, another man had his arm broken in two places, and a boy was scalded. We have seen no definite estimate of the property loss, but we understand that it was considerable.

(208.) — A boiler exploded, on August 8th, in the Cœur d'Alene Lumber Company's plant, at Cœur d'Alene, Idaho. A fragment of the boiler struck a man named A. Bartlett, cutting his left leg off below the knee. The explosion was preceded or followed by a disastrous fire, which caused a loss of from $40,000 to $75,000; but we do not know whether the explosion was the cause of the fire, or its result.

(209.) — On August 10th a boiler exploded in the Humphrey & Holt crate factory, at Rutland, near Pomeroy, Ohio. Gardiner Near, Dale Rawlings, and Don Mutchler were killed, and Albert Brackstole, Webber Holt, and Dennis Holt were seriously injured.

(210.) — The boiler of a locomotive exploded, on August 10th, at the Ozark Mill Switch, near Charlotte, N. C. Engineer Zebulon Black and fireman Edward Earle were injured very seriously, and O. H. Burchfield, W. A. Sharpe, Robert M. Cobb, and three passengers whose names we have not learned were injured to a lesser degree. The property loss due to the explosion and the accompanying wreck were estimated at from $50,000 to $75,000.

(211.) — A boiler exploded, on August 11th, in a fruit cannery at Visalia, Cal. Nobody was injured, and the property loss was confined to the building in which the boiler was located.

(212.) — The boiler of Union Pacific locomotive No. 1515 exploded, on August 14th, at Colores Station, on Sherman Mountain, near Cheyenne, Wyo. Engineer Michael Lyons was killed and fireman Albert Hansen was fatally injured.

(213.) — On August 14th a boiler exploded in McMillan's sawmill, about eight miles south of Knoxville, Tenn. Jefferson McMillan, Sr., Jefferson McMillan, Jr., William Ginn, and W. B. Wagoner were seriously injured. The machinery was totally wrecked, the boiler being thrown 150 yards.

(214.) — The boiler of a pumping outfit, used by Arbogast Bros. in prospecting for coal, exploded, on August 15th, about two miles southeast of Barnesville, Minn. The engineer was fatally scalded, and several other men were injured to a lesser extent.

(215.) — A small boiler exploded, on August 16th, in the Beverly Steam Mills, at Beverly, Ohio. Nobody was injured, and the property loss was small.

(216.) — On August 18th the boiler of the locomotive hauling the Santa Fé Limited exploded near Kingman, Ariz. Engineer Fitch was killed, and fireman J. H. Bland was injured so badly that he died two days later. The boiler was thrown clear of the trucks, and landed 300 feet away. That part of the Santa Fé which lies between Needles, Cal., and Kingman, Ariz., is known among railroad men as "Dead Mans' Stretch," on account of the numerous accidents that have happened there.

(217.) — On August 18th the boiler of a threshing machine outfit exploded at Adams' Mills, near Zanesville, Ohio. Charles Hahn was instantly killed, and John Hawk, Frank Strong, and Elbert Jones were terribly scalded.

(218.) — The boiler of a locomotive drawing an excursion train on the Northern Pacific railroad exploded, on August 22d, at Chehalis, near Olympia, Wash. The explosion occurred on a curve, and the train left the track and plunged down a thirty-foot embankment. Charles Farleman and Frank Gales were killed instantly, and Mrs. C. B. Brown was injured so badly that she died later in the day. About thirty others were also more or less seriously injured, probably by the plunge of the train over the embankment.

(219.) — On August 25th the crown sheet of a Lake Shore locomotive blew out two miles west of Girard, near Erie, Pa. Engineer Charles Albright and fireman J. W. Burns were fatally scalded, and brakeman Ralph Clary received serious injuries.

(220.) — A boiler exploded, on August 25th, in E. L. Brown's sawmill, at Creighton's Siding, near Oak Hill, on the Florida East Coast railroad, in Volusia county, Fla. Fireman Edward Small and a workman named Cowart were painfully burned.

(221.) — On August 26th a boiler exploded in the Lindsey Fertilizer Company's plant, some three miles north of Circleville, Ohio. Wayne Lindsey, Jr., was injured very seriously and perhaps fatally, and John Lindsey and George B. Ritt were badly cut and bruised. The entire building was wrecked.

(222.) — A locomotive boiler exploded, on August 27th, in the roundhouse of the Southern Pacific railroad, at Tucson, Ariz. Fireman G. C. Mayfield was hurled to a distance of 300 feet and instantly killed. The force of the explosion was terrific, and the buildings were badly wrecked. The property loss was estimated at $50,000.

(223.) — A boiler used for pumping out a cofferdam exploded, on August 28th, on the Scioto River, near Columbus, Ohio. The cofferdam was opposite the Casparis quarries, about a thousand feet above the wooden bridge at Arlington. John H. Carey, a lime burner, was fearfully scalded, and John Patterson, the fireman of the boiler, was badly cut about the head.

(224.) — The boiler of a compound freight locomotive belonging to the Oregon Railway and Navigation Company exploded, on August 28th, at Weatherby, Oregon. Fireman Faust was killed instantly, and engineer Gilman was injured so badly that at last accounts it was believed that he could not recover. The locomotive was wrecked.

(225.) — The boiler of Barnes Bros.' threshing machine outfit exploded, on August 31st, at Milroy, Minn. Walter Abel and Thomas Finnell were seriously but not fatally injured.

The Locomotive.

HARTFORD, NOVEMBER 15, 1903.

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

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Obituary.

DR. ROBERT HENRY THURSTON.

It is with profound sorrow that we record the death of Dr. Robert Henry Thurston, who passed away on October 25th, in the library of his residence at Ithaca, N. Y. He was born at Providence, R. I., on October 25, 1839, and was therefore sixty-five years of age to a day. Mr. William Kent, whose acquaintance with Dr. Thurston was long and intimate, contributes an appreciative biographical notice of him to the *Sibley Journal of Mechanical Engineering*, to which we are indebted for many of the facts that are here presented.

Dr. Thurston inherited from his father an extraordinary talent for mechanical engineering, and much of his childhood and early youth was spent in his father's shop. He was graduated at Brown University in 1859 with the degrees of bachelor of philosophy and civil engineer, receiving the degree of master of arts in 1869 and doctor of laws in 1889. During the two years that followed his graduation he was engaged with the firm of which his father was senior partner. He joined the engineer corps of the United States Navy in 1861, serving in Dupont's and Dahlgren's fleets throughout the war. He was made engineer-in-charge of the *Chippewa* in 1863, while he was a second assistant engineer; and he was later transferred to the *Dictator*, and commissioned first assistant in 1864. He was present at the battle of Port Royal and at the siege of Charleston. At the close of 1865 he was detailed to do duty in the department of natural and experimental philosophy at the United States Naval Academy at Annapolis, and upon the death of the professor of the department he was placed in charge of it, *ad interim*, under Admiral David D. Porter, superintendent of the academy. In 1870 he was invited by President Henry Morton to take part in the organization of the Stevens Institute of Technology, and to occupy the chair of mechanical engineering, a position which he held until 1885.

Since that time Dr. Thurston has been extraordinarily active in mechanical engineering, so that his name has become familiar as that of an expert (especially in steam engineering and in the strength of materials) throughout the civilized world. At the Stevens Institute he organized the department of mechanical engineering, and started an engineering laboratory. He served as a member of a United States commission on boiler tests, and was United States commissioner (and also a juror) at the Vienna Exposition of 1873. He edited the *Reports* to the United States government on that exposition, writing one of the four large volumes (on manufactures) himself, and passing the whole through the press in ten months. He was an active member of the American Society of Civil Engineers, to whom he frequently reported the results of his researches upon the strength of materials and other matters.

The first laboratory of mechanical engineering in the United States was that established by Dr. Thurston when the Stevens Institute was organized in 1871. His ideas on the subject of a laboratory of this character were first published in July, 1871, and these were later amplified in a paper entitled "On the Necessity of a Mechanical Laboratory," which was published in 1875 in the *Journal* of the Franklin Institute. Work along this line had been done in Europe only a little earlier. King's College, London, the University of Edinburgh, and the Polytechnic at Zurich introduced machinery of investigation in 1870, and the Munich laboratory was planned by Prof. Linde in 1871. The unremitting labors of Dr. Thurston, exerted for the advancement of mechanical engineering in general as well as for that of the Stevens Institute in particular, resulted very seriously, inasmuch as they nearly ruined his constitution.

From the last of April to the first of October, 1876, he was seriously ill with nervous prostration. During this illness, however, he conceived the idea of his famous "topographical triangle," by means of which he contrived to represent the tensile strengths of all the triple alloys of copper, zinc, and tin upon one model. His health improved afterwards, and he was able to continue his work for about two years, but at the end of this time he found himself in a still worse plight, and on May 22, 1879, he was forced to retire to the well-known sanitarium at Dansville, N. Y., for systematic treatment. He remained in the sanitarium until August 4, 1880, when he left it for good, completely cured.

In 1885 Dr. Thurston accepted the appointment of director of the Sibley College of Mechanic Arts at Cornell University, a place which he filled with distinction up to the time of his death. He reorganized Sibley College, and his work was so successful and so stimulating that the attendance at the institution increased from an insignificant figure up to a present student roll of about 900, and the standing of Sibley College has been raised simultaneously and in a corresponding measure, very largely indeed through Dr. Thurston's efforts.

Dr. Thurston was a member of a multitude of American and foreign societies for the advancement of engineering and of science, and he was also a voluminous writer, his articles and books always being received by the world as highly authoritative. Personally, Dr. Thurston was a man whose earnestness, uprightness, geniality, sincerity, helpfulness to his fellow man, and general nobility of character it is impossible to describe. He was a devout Christian and an earnest seeker after truth, wherever it might lie. His motto was, in his own words, "When a man seeks Truth, Consistency must be left to take care of herself — and may usually be trusted to do so. No scientific man cares particularly what the truth may prove to be. His business and his desire are simply to find it, *whatever* it proves to be."

Dr. Thurston was an intimate friend of the officers of this company, and we all desire to record, in this formal manner, our earnest and sorrowful sense of the loss that we have sustained in his death. His direct services to engineering were indeed great; but who shall say that they were greater than those equally positive though less visible services that he has done to the world at large, by the stimulating and irresistible influence for good that his own personality has had upon the two thousand students now living, whose intellectual powers were developed under his tutelage?

The Heat Treatment of Steel.

There is probably no one material of construction concerning which our notions have undergone more radical changes during the past few years than that most important substance known as steel. It is not so very long ago that the question was asked, "What is steel?" and even yet that question is but imperfectly answered At least we know that it is a material of very varying properties, and that those properties by no means depend upon chemical composition alone, but that the physical structure may and does vary to a marked degree according to the heat treatment that the piece has undergone; and that the strength, toughness, and general usefulness of a structural member of steel may be largely controlled by the way in which it is subjected to the action of heat.

Formerly it was assumed that phosphorus gives brittleness, that sulphur makes the metal red-short, and that the other properties are almost entirely dependent upon the percentage of carbon present. With the introduction of the microscope and the use of the methods of metallography in the study of steel and other alloys, it has been found that the structure and the properties of the material may be largely modified without any change whatever in the chemical composition, and as a consequence some very practical lessons have been learned

In a paper presented before the recent meeting of the Iron and Steel Institute by Messrs. J. E. Stead and Arthur W. Richards, the great practical value of the study of the effects of heat treatment upon steel is shown, especially in connection with the restoration of toughness and strength to steel which has been rendered crystalline by overheating or other improper treatment. It has been completely demonstrated by the researches of Brinell, Tschernoff, Le Chatelier, Heyn, Ridsdale, Stead, and many others, that when steel of a coarse structure, but not necessarily brittle, is heated to a certain temperature and is then allowed to cool in air, or is quenched in oil or in water, the original structure is destroyed, and is replaced by one of a very fine-grained character. As recently as 1898 Mr. Stead showed that pure iron, when so coarsely crystalline as to resemble cast zinc, may be restored to excellent qualities by simply heating it to a certain temperature (known as the "critical point"); its subsequent structure resembling that which it possessed when it originally left the rolls.

Steel which is to be used in important structures, such as bridges and large buildings, must contain the best possible material, and it must also be in the best possible physical condition. The unfitness of crystalline steel for these purposes is admitted by everybody. For several years Messrs. Stead and Richards have devoted much time and attention to the study of the effects of heat upon the mechanical properties of steel, and have repeatedly succeeded in restoring dangerously crystalline steel in large pieces, by simple heat treatment, transforming it in this manner into material which would be accepted by any engineer as excellent. In view of the success of these experiments, the account which has been given in the paper referred to is of especial value and interest, and some abstract of the method is given below.

Dangerously crystalline steel may be divided into three classes. "The first class occurs only in pure iron, and in mild steel very low in carbon; and in it the crystallization is caused by annealing for a long period at too low a temperature in a slightly oxidizing atmosphere. The second class, which is very common, and in which the crystallization is equally dangerous, owes its state to long continued heating at high temperatures. The third variety occasionally met with is produced by heating the steel until it is practically burned; in other words, by heating it to a point so near fusion that an evolution of gas occurs in the interior of the steel, the gas separating the crystals from one another, and thus breaking up the whole mass, so as to make it more or less discontinuous. Steel in this third class can be greatly improved by heat treatment, but its original structure can never be entirely restored in that way. Steel in the first or second class can, by proper heat treatment, be made equal and often superior to normal or forged steel which has been worked and finished at proper temperatures."

The experiments which are examined in detail in the paper from which we quote were made upon steel rails of various sections; portions of the same rail being tested in the normal condition, after overheating, after restoring, and after a still higher heating. The temperatures were in all cases carefully taken by pyrometer, and the material was also analyzed and subjected to microscopic examination. The tests to which the material was subjected included the impact or drop test, tensile test, Brinell impression test, and vibratory-stress test; and the records of these examinations, both for the specimens taken from rails and for those from large ingots, are given in detail in the paper. The results fully bear out the theory, and show that when the material was originally of good quality, it was fully restored by proper heat treatment.

The most essential feature which appears about the method is the demonstration of the fact that it is the *temperature* to which the steel is exposed that is the crucial factor in the improvement, and not the *duration* of that temperature. The old idea of the process of annealing was to reheat the material to a high temperature, and then to hold it for a time at that temperature, and subsequently to cause it to cool very slowly; but the researches of Messrs. Stead and Richards show that the temperature of reheating must not exceed 1650° Fahr., and that the time of cooling has little or no influence upon the result. It is altogether unnecessary to reheat and reforge the specimen, and, in fact, the material is apt to be still further injured by such a process. Since almost any piece of structural steel is liable to be rendered more or less crystalline during the operations through which it is necessarily passed, it is most desirable that the process of restoration be made a regular portion of the routine of manufacture. To permit this it is only necessary that proper furnaces be designed to admit the large pieces, and to permit a uniform temperature to be maintained in all parts, reliable pyrometers being of course provided so that the correct temperature may be maintained. The operation may then be performed upon every piece as the final stage in its manufacture. The result would be the complete elimination of danger of accident from weakness by crystallization, according to the views of the experimenters; and if this is substantiated by further work along the same lines, it is evident that the discovery is of the first importance.

The following facts appear to have been fully established by the researches of Messrs. Stead and Richards:

"The microscope, in each experimental series, indicates the same result, namely, that heating at high temperatures causes a great development in the size of the crystalline grains, and that reheating to about 1600° Fahr. restores the original structure, or yields an even better one. A structural steel, although good in its normal rolled or forged condition, may easily deteriorate by being heated to a temperature a little above that to which steel is most commonly heated previously to being rolled or forged. Steel that is made brittle by such heating, or dangerously brittle by exposure to considerably higher temperatures, can be completely restored to the best possible condition without remelting and without forging down to a smaller size. Practically all of the experimental results show not only that the original good qualities of normally rolled steel can be restored after the material has been made brittle by the exceedingly simple expedient of heating to about 1600° Fahr. for a very short time, but also that the steel may even be made better than it was originally." — *Engineering Magazine.*

The Locomotive

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FIG. 1. — SHOWING THE OPENING IN THE OUTER WALL OF THE BUILDING.

Explosion of a Hot-Water Boiler.

It is generally believed that boiler explosions of a destructive character never occur except in connection with high pressure boilers, which are used for power purposes. A perusal of the lists of boiler explosions in the United States, as printed each month in THE LOCOMOTIVE, will show, however, that heating boilers, in which the pressure is not intended to exceed four or five pounds per square inch, not infrequently explode in such a manner as to cause a destruction of property which appears, to those who have not computed the enormous heat-energy stored up in hot water, to be entirely disproportionate to the cause that gives rise to it. Even kitchen hot-water boilers explode in this manner from time to time, with disastrous consequences.

Our illustrations, in this issue, relate to an explosion which occurred some time ago in a prominent club house not many miles from the home office of the Hartford Steam Boiler Inspection and Insurance Company, and they should be sufficient, in our opinion, to establish the necessity of attending most carefully to the conditions under which the simplest and apparently most innocent types of boiler are operated. The boiler which exploded in this case was situated in the kitchen, in the basement of the building. There was no fire under it, the water that it contained being heated in the usual manner by a water-front in the kitchen range. It consisted of an ordinary upright cylindrical copper tank, and differed from the tanks that are found in nearly every household solely by reason of its greater size, its cubical capacity being about 300 gallons.

On the evening of the explosion the kitchen was unusually busy, and the fires in the range were correspondingly active. At about ten o'clock, and with no previous warning, the boiler suddenly gave way, with the results shown in the engravings. The entire building was shaken, the floors being apparently lifted bodily to a greater or lesser extent, so that every person who was in the same general part of the building as the boiler experienced a violent vertical shock. In the grill-room, which is shown in one of the engravings, and which was situated directly over the boiler, the destruction was greatest; but in other parts of the building the damage was not inconsiderable. A large opening was also blown through the heavy, solid exterior wall of the building, as is plainly indicated in Fig. 1, which is from a photograph that was taken on the morning after the accident. We are glad to be able to state that there were no personal injuries of any consequence. It will be evident from the illustrations that there were generous possibilities of serious injury and even death; and the members of the club are to be congratulated upon their fortunate escape. The damage to property is said to have been about $2,500.

Passing now to the cause of the explosion, we find here a very instructive lesson. We have drawn attention to this matter in previous issues of THE LOCOMOTIVE; but the present explosion will serve as an excellent text for a new sermon on the subject. The boiler was not supposed to be subjected to any pressure whatsoever, save that prevailing at all times in the city water mains, namely, about sixty-five pounds per square inch. There could be no doubt but that the boiler was perfectly safe at this pressure; and hence it became evident that some cause was operative, which permitted the actual pressure to exceed the normal pressure in the city mains by a very substantial amount. Investigation revealed the following facts: Upon the supply pipe which entered the club-house from the street there was a water-meter; and on several occasions the fires in the range had been pushed to the point of generating steam in the water-front.

so that some of the water in the boiler had been forced back towards the street mains. The water thus caused to "back up," being hot, did more or less damage to the meter, through which it had to pass in order to leave the boiler, and after this had happened several times, orders were given that a check valve should be placed in the supply pipe, to prevent further damage of this sort.

Now there should never be a check valve in the pipe between a kitchen boiler and the water main which supplies it; for when the fires are run hard enough to generate steam in the water-front, it is evident that one of two things must happen. Either (1) a portion of the water must escape from the tank and piping in some manner, or (2) the pressure in the system will rise to an intensity which may be great enough to disrupt the boiler or the piping. If the boiler is always in free

Fig. 2. — The Wrecked Grill Room.

communication with the city main, it is plain that the pressure can never exceed that of the city supply; but when there is a check valve in the supply pipe, it is not possible for the boiler to relieve itself by discharging a portion of its contents back through that pipe, for the first tendency towards such an efflux causes the check valve to close, and thereafter the boiler must be regarded as a sealed vessel, the pressure in which may rise to a point which is determined only by the strength of the boiler and by the intensity of the fire in the range. The man who ordered the check valve put in was thinking solely of the damage that the hot water might do to the meter; and he did not give proper consideration to the consequences of such a valve, so far as the pressure within the boiler is concerned.

Of course an accident of this kind could be prevented by providing the hot-water boiler with a suitable safety-valve; and if such a valve were placed upon it, the objection to the check valve would be far less serious. Safety-valves are seldom placed upon kitchen boilers in the United States, however, though in England they are quite common; "dead weight" valves having the preference for this purpose over those of other types, on account of their simplicity and reliability. It does not appear that any safety-valve had been provided in the case of the boiler whose explosion is here illustrated; and even if there were such a valve, it certainly was not operative. We should not regard a kitchen boiler as dangerous, if it were provided with a check valve in the supply pipe, and *also* with a safety-valve of some approved type, suitably located and properly cared for. It should be remembered, however, that safety-valves are likely to corrode and stick; and if they leak a little, they may become such a source of annoyance as to tempt the queen of the kitchen (or the chef, it may be) to deposit a few bricks or flatirons, or other portable miscellany, upon them, to keep them tight. On the whole, therefore, we counsel the omission of the check valve altogether; and if there is any trouble, either to the meter or to any other appliance, from the "backing up" of hot water towards the city main, we advise placing a second tank of suitable capacity upon the supply pipe, between the kitchen boiler and the meter. Such a tank can be easily arranged so as to receive the hot water from the boiler in its upper part, while discharging an equal quantity of cold water from a connection at the bottom, back through the meter.

We do not wish to be understood as opposed to the use of a safety-valve upon a kitchen boiler, for we believe that such a safeguard is a most excellent thing; but we do believe that it is bad practice to put in a check valve, even when a safety-valve is present; for by doing so we are forced to rely altogether upon the continued good condition of the safety-valve, and experience indicates that the mechanical instincts and training of kitchen help in general cannot be relied upon to see that a safety-valve is always in good order. As an additional safeguard, the safety-valve is a good thing, and it is especially to be recommended in the colder latitudes, where the supply pipe may freeze in the winter, and hence prevent the boiler from relieving itself by the "backing out" process.

It is practically a necessity to have a *stop-valve* somewhere upon the supply pipe of a kitchen boiler, but we always counsel placing this in such a position that it cannot be confused with any other valve, and hence cannot be closed through mistake. It is a good plan to secure this valve, when open, with a wire, for this lessens the likelihood of its being closed accidentally, and it is no trouble to break the wire which fastens it, in case of emergency.

Boiler Explosions.

SEPTEMBER, 1903.

(226.) — The boiler of a donkey engine in use for grading purposes exploded, on September 1st, at Carville, near San Francisco, Cal. Engineer Wesley Heflinger, contractor Edward Kreisel, and a small boy named Clarence Cole were seriously burned and scalded.

(227.) — A boiler exploded, on September 1st, in Priest Bros.' stave mill, near Huntingdon, Tenn. A number of workmen were near by, but nobody was hurt.

(228.) — The boiler of a threshing machine outfit exploded, on September 2d, on a farm owned by Otto Gard, near Geneva, Ill. John Stevens was instantly killed, Frank Updyke was fatally injured, and Jacob Kautz, Frederick Kautz, Otto Gard, Edward Kautz, and Edward Gard were seriously scalded and bruised. Several others also received minor injuries from flying débris.

(229.) — On September 2d a boiler exploded in a sawmill at Ralston, Miss., on the Mobile, Jackson & Kansas City railroad. Two firemen were killed, and the engineer and several other employees were injured. The mill was destroyed and most of the machinery was wrecked.

(230.) — A boiler exploded, on September 3d, in the electric light plant at Lancaster, Pa. The engineer was not present at the time and nobody was injured.

(231.) — A boiler exploded, on September 3d, in the wholesale chemical house of Hanson & Van Winkle, at Newark, N. J. William Winters and John Henretti were injured very seriously and Charles Connelly, Howard Oliver, Bernard Bugelmann, Otto Musselıl, and Herman Arndt received lesser injuries. The building in which the boiler stood was wrecked, and the property loss was estimated at $10,000.

(232.) — On September 4th a boiler exploded in Irving Forbes' portable sawmill, about two miles southwest of Coleman, Mich. Mr. Forbes and his assistant, Charles Freeman, were killed, and one other man was slightly injured.

(233.) — On September 5th a boiler exploded at the Wabash railroad camp, on McIntyre Creek, near Steubenville, Ohio. Jacob Brown was severely burned and lacerated.

(234.) — A boiler exploded, on September 5th, in W. D. Young & Co.'s mill, at Bay City, Mich. The boiler house was considerably damaged, but nobody was injured.

(235.) — A tube failed, on September 6th, in a boiler in the Jacob Ruppert Brewing Company's ice plant, in New York city. Joseph Dilley and Frederick Dosso were severely injured.

(236.) — The boiler of locomotive No. 341 of the Chicago & Alton railroad exploded, on September 6th, at Tice's Crossing, one or two miles west of Greenview, Ill. Engineer Frank J. Upton and fireman Chester C. Keltner were killed, and brakeman J. A. Montgomery was severely injured. The locomotive was attached to a freight train, and at the time of the accident the train was descending a grade at the rate of perhaps twelve or fifteen miles an hour. Ten cars were wrecked and their ruins were piled up on the tracks.

(237.) — A slight boiler explosion occurred, on September 7th, in the office of the Cresson *Record,* at Cresson, Pa. Nobody was injured, and the property loss was small.

(238.) — On September 8th a slight boiler explosion occurred on the narrow-gauge local line of the Southern Pacific railroad company, at Alameda, Cal. Engineer Frank Rodige was fatally scalded and burned. It is said that engineer Rodige was attempting to repair a leak in the boiler at the time. If this rumor is correct, the case affords one more example of the exceeding danger of attempting to make repairs of any kind while a boiler is under pressure.

(239.) — A boiler exploded, on September 8th, in the B. F. Thomas cannery, operated by W. Scott Hamby, at North East, near Elkton, Md. Engineer Earl Gatchell was fatally scalded and burned, and William Bryson was also injured to a lesser extent. The boiler room was wrecked.

(240.) — On September 9th a small boiler, used for pumping purposes, exploded at Seneca Falls, N. Y. Nobody was injured, and the damage was mostly confined to the boiler and its attachments.

(241.) — The boiler of a threshing machine outfit exploded, on September 10th, on William Brickman's farm, near McComb, Ohio. Nobody was injured, as the explosion occurred at about one o'clock at night. The early hour at which it took place led to various theories as to its cause, including the idea that it was struck by lightning, or blown up intentionally by dynamite; but there does not appear to be any good reason for doubting that the explosion was from ordinary causes, the fires, perhaps, not being sufficiently deadened for the night.

(242.) — A boiler exploded, on September 10th, in the electric lighting plant of the Sherman Oil & Cotton Company's plant, at Sherman, Tex. The roof of the building in which the boiler stood was somewhat damaged, but nobody was injured.

(243.) — On September 11th a boiler exploded in the Buchanan Lumber Company's plant, on the Murphy branch of the Southern railway, near Asheville, N. C. Two men were reported as being killed and five as injured.

(244.) — A boiler exploded, on September 12th, in the boiler house of the Heller flats, at East St. Louis, Mo. Nobody was injured. The explosion appears to have been due to the collapse of the boiler house, owing to the undermining of its walls by water. Arthur Lovell, the janitor, who slept in the boiler house, is said to have feared an accident of some sort to the building, and he furthermore states that the walls fell in before the explosion came.

(245.) — A boiler exploded, on September 17th, in W. O. Ferrall's cotton gin, at Millbrook, near Raleigh, N. C. The roof of the building was blown off, but nobody was injured, the employees being all away at dinner.

(246.) — On September 17th a boiler exploded on E. A. Braden's rice plantation, some ten miles south of Jennings, La. John Marshall was instantly killed, and Fred Brown was seriously injured.

(247.) — A boiler exploded, on September 18th, in Dubberly's mill, near Sterling, Glynn county, Ga. Augustus Humins was killed, and three other men were seriously injured.

(248.) — About September 18th, a locomotive boiler exploded at Birch Station, near Proctorknott, Minn. Samuel Nelson and George Wombacker were severely injured, but at last accounts they were on the road to recovery.

(249.) — A boiler exploded, on September 18th, in Simpson's sawmill, some seven miles from Liberty, Miss. Hugh Duck was so badly scalded and otherwise injured that he died on the following day.

(250.) — On September 18th a boiler exploded in Elihu Southerland's cotton gin, some two miles from Cookville, Titus county, Tex. The boiler was thrown several hundred yards, and the building in which it stood was considerably damaged. The explosion occurred during the noon hour, and nobody was injured.

(251.) — The boiler of H. L. Quinius' cotton gin exploded, on September 18th, at Robinson, six miles south of Waco, Tex. Engineer R. F. Williams was instantly killed. The proprietor and Jacob Moore were painfully injured, and several other persons received minor injuries. The explosion was very violent, and the gin house was destroyed.

(252.) — On September 20th a boiler exploded in a sawmill at Virginia City, Wise county, Va., instantly killing fireman Noah Buchanan, and injuring Albert Meade and Clarence Buchanan (father of the dead man) so badly that their recovery was considered doubtful.

(253.) — A boiler used for pumping purposes and belonging to the Corwin Oil Company, exploded, on September 21st, on the Maddox lease, near Dundee, Madison county, Ind. Samuel Sloan was fatally scalded, and the boiler house was wrecked.

(254.) — The boiler of a threshing machine outfit belonging to Scotton Bros. exploded, on September 22d, at Brown's Corners, near Huntington, Ind. Frederick Scotton was scalded so badly that he died before medical assistance could be had.

(255.) — On September 23d a boiler exploded in Biggio's quarry, at Ocean View, San Francisco, Cal. Engineer John Rayner was killed instantly, his body being thrown 200 feet. John and Daniel O'Brien were seriously injured, and Rico Biggio, a son of the owner of the quarry, received injuries of less importance. The shed in which the boiler stood was demolished.

(256.) — A boiler exploded, on September 24th, in James Wise's sawmill, three miles south of Nashville, Ind. Gilbert Sturgeon and Martin Frye were fatally injured, and Verna Wise, a daughter of the owner of the plant, was severely scalded. James Wise, Henry Rose, and William Ogle were also injured.

(257.) — On September 24th the boiler of a threshing machine outfit exploded at Bradley, twenty miles southwest of Webster, S. Dak. Martin Peterson was killed, and five other persons were seriously injured.

(258.) — The boiler of a threshing machine outfit belonging to Nicholas McCrea exploded, on September 25th, at Sharon, N. Dak. The machine was wrecked, but nobody was injured.

(259.) — On September 28th the boiler of Claude Giddings' threshing machine outfit exploded at Timnath, near Fort Collins, Colo. Charles Richie had one of his eyes destroyed by a fragment of the gauge glass.

(260.) — A boiler exploded, on September 28th, in L. M. Pilliod's planing mill, at Swanton, Ohio. Engineer Norman Hubbard was killed, and Burchard Read and Dr. W. A. Scott were seriously injured. The building in which the boiler stood was wrecked, and the ruins subsequently took fire. The property loss is estimated at $25,000.

(261.) — A boiler exploded, on September 29th, in a sorghum factory at Oakland, Ill. Andrew Hite was instantly killed, and Jefferson Hite, his nephew, was fatally injured.

(262.) — A boiler exploded, on September 30th, in H. McInnis' sawmill, near Hattiesburg, Miss. One man was instantly killed, and five others were more or less seriously injured.

THE Index and title-page to the twenty-fourth volume of THE LOCOMOTIVE can now be had by those desiring to preserve their copies for binding. The bound volumes for the year 1903 may also be had, at one dollar each.

The Locomotive.

HARTFORD, DECEMBER 15, 1903.

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

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Obituary.

WILLIAM G. LINEBURGH.

It again becomes our painful duty to record the decease of one who has for many years been a friend and a business associate of the officers of the Hartford Steam Boiler Inspection and Insurance Company. Mr. William G. Lineburgh, general agent of this company at Bridgeport, Connecticut, passed away at his home in that city on November 18th. He had been in ill health for some time, and for the past five years the active management of the firm of W. G. Lineburgh & Son, of which he was the founder, has devolved upon his son, W. G. Lineburgh, Jr.

Mr. Lineburgh was born in Norwich, Connecticut, but moved to Bridgeport in 1848, being first employed as a bookkeeper for C. Hart, a car builder of East Bridgeport, and subsequently becoming secretary and treasurer of the Sash, Blind & Planing Company. Later, and in company with Mr. Russell Tomlinson, he organized the Tomlinson Spring & Axle Company, of which he was secretary and general manager until 1871. He was also one of the organizers of the Tomlinson Spring Company of Newark, N. J., of which he was vice-president.

About 1871 Mr. Lineburgh went into the insurance business, being then appointed general agent of the Hartford Steam Boiler Inspection and Insurance Company, a position which he filled until his death. When he entered this field there was not a single insured boiler in Bridgeport, and Mr. Lineburgh was therefore the pioneer in steam boiler insurance, in the department that he has since controlled. In 1887 he took his son into partnership, and since that time the firm name has been W. G. Lineburgh & Son, with offices in the Sanford building.

Mr. Lineburgh had been president of the Mechanics & Farmers Savings bank, vice-president of the People's Savings bank, a director in the Pequonnock National bank, and a member of the board of aldermen of Bridgeport. At the time of his death he was a member of the Seaside Club, of the Board of Trade, and of the First Congregational Church. At the age of twenty-one he married Miss Eliza A. Cooley, who died on December 11, 1899.

He leaves three children, Mrs. Mary E. Gray of Newark, N. J., and Charles H. Lineburgh, and W. G. Lineburgh, Jr., of Bridgeport, Conn. He also leaves ten grandchildren and three great-grandchildren. He was widely known for the work that he did in the service of the church, and for many years he conducted the union daily prayer meeting, which was organized by Rev. B. Fay Mills and held in the North Church chapel every morning.

Mr. Lineburgh was greatly esteemed by his friends and associates. He was an important factor in the business circles of Bridgeport, in which he had moved for half a century, and his influence will be sorely missed for a long time to come.

Thermit.

It has been known for many years that metallic aluminum has the power of reducing the oxides of many of the other metals, and it has been employed for this purpose by many experimenters. The heat developed by the reaction is often very great, and Dr. Hans Goldschmidt, of Essen, Germany, has succeeded in making use of this heat for the successful welding of large masses of iron and steel, in a very convenient manner. The preparation which he uses, and which he calls "thermit," consists of a mixture of pulverized aluminum and oxide of iron. When this mixture is ignited by means of a small portion of metallic magnesium, which, in turn, is ignited by a match, a chemical reaction of tremendous energy spreads rapidly through the mass, the oxygen leaving the iron and combining with the aluminum, so that the final product is alumina and molten metallic iron. The temperature produced is incredibly high, some authorities estimating it to be equal to that of the electric arc; and the melted iron that is produced may be run into a chink between two masses of cold iron in such a way as to melt them superficially, and weld them together very solidly.

The thermit process of welding has been used to a considerable extent in Europe, and also (for repairing broken mining machinery) in the Transvaal; but it has not yet come into general use in the United States. To introduce the various applications of his process in this country, Dr. Goldschmidt delivered an experimental lecture on November 13th before the Columbia University Chemical Society and many invited guests in Havemeyer Hall, Columbia University, New York. The large lecture room was crowded, and the experiments that the lecturer showed were extremely successful. He first showed the ignition of a portion of the mixture in an ordinary crucible, which, when turned down for the audience to look into, showed a glowing mass so brilliant as to be painful to the eye, and which, when the crucible was turned about, threw a beam of light about the room which was fairly comparable to that from an electric search-light.

The application of this new source of intense concentrated heat are (as Dr. Goldschmidt explained) to both metallurgical and mechanical operations,— the latter being chiefly welding. The experiments that were shown related to the latter class of operations, and included the welding of rails and of pipes. The two sections to be joined were enclosed in suitable molds, while a crucible adapted to the work in hand, and provided with a hole in the bottom which was closed by a suitable plug, was supported immediately above the gate of the mold. A proper charge of thermit was placed in the crucible and ignited, and as soon as the reaction had spread through the mass the crucible was tapped. A stream of dazzling liquid iron shot into the mold and filled the space between the pieces to be welded, and in less time than it takes to read this description the operation was complete. In another experiment the fiery stream of liquid iron was allowed to fall upon a plate of iron an inch thick, through which it melted its way in the twinkling of an eye, the time consumed being, in fact, so short that the plate, as a whole, was still cold after the experiment. Indeed, this was true in all of the welding operations, a welded pipe two feet long being still cold at the ends when removed from the mold, although white hot at the center.

Dr. Goldschmidt showed, also, a great many lantern slides illustrative of welding operations as practically carried out in the field in Germany. The operations so illustrated included the welding of rails in position, and of broken stern frames of steamships, broken locomotive driving wheels, and broken connecting rods of large size. Great enthusiasm prevailed at his lecture, and the applause as the various experiments were performed was tumultuous. The experiment in which he welded two tubes together is described as "certainly one of the most beautiful ever shown in a scientific lecture."

[For the report of Dr. Goldschmidt's lecture we are indebted to the *American Machinist* and to the *Electrical World*. A fuller account is to be given in *Marine Engineering* for January, 1904; and an illustrated article on the same subject, by Emile Guarini, will be found in the *Engineering Magazine* for January, 1904.]

The Flying Machine.

A "flying machine," in the proper sense of the expression, would appear to mean a machine which is capable of supporting itself in the air by the mechanical action of wings, or fans, or some other equivalent device, and which does not depend in any way upon the use of a gas bag. Machines, like those of Santos-Dumont, which are supported partially or wholly by the use of gas reservoirs, and whose machinery is employed chiefly or exclusively for horizontal propulsion, appear to come more properly under the head of "dirigible balloons." The dirigible balloon is well worth exploiting, and it probably will prove itself useful in military engineering, and perhaps in other ways; but it necessarily exposes a very large surface to the wind, and hence it is not likely that the problem of mechanical flight will find its ultimate solution in this direction. Many experimenters have endeavored to construct flying machines that would sustain themselves without the use of gas, but it is only recently that any great hope of ultimate success has been aroused in the minds of disinterested observers. The following letter written by H. H. Clayton to *Science* may be of interest in this regard:

"The newspapers of December 18th," he says, "contain the announcement that Wilbur Wright had flown a distance of three miles with an aeroplane propelled by a 16-horse power, four-cylinder gasoline motor, the whole weighing more than 700 pounds. To the average newspaper reader this meant no more than similar statements previously made in the newspapers that men had flown in New York, or St. Louis, or San Francisco. But to the student of aeronautics, and particularly to those who had followed the careful scientific experiments with aeroplanes which were being made by Orville and Wilbur Wright, it meant an epoch in the progress of invention and achievement, perhaps as great as that when Stephenson first drove a locomotive along a railroad. It meant that after ages of endeavor man had at last been able to support himself in the air as does a bird, and to land in safety at a spot chosen in advance.

"The report from an authoritative source confirms the fact of this flight, but modifies the details somewhat from those given in the newspapers. It appears that four successful flights were made in a motor-driven aeroplane on December 17th, near Kitty Hawk, N. C. The wind was blowing about 21 miles an hour, and a speed relative to the wind of 31 miles an hour was attained by the aeroplane. This meant a speed of 10 miles an hour, relatively to the ground The aeroplane had a surface of 510 square feet, and in the longest flight it was in the air 57 seconds. The aeroplane is said to have risen from a level, and the reported distance of three miles was probably relative to the wind. [Assuming that 57 seconds was the duration of the longest flight, and that the maximum speed of 31 miles relatively to the wind was maintained for this entire time, the distance traversed relatively to the wind would be only about 3,000 feet. The report of "three miles" was therefore probably an error. — *Editor* THE LOCOMOTIVE.] The earlier work of the Wright brothers is described in the reports of the Western Society of Engineers, and in part republished in the annual report of the Smithsonian Institution for 1902. Their invention of a forward rudder has contributed to the final success.

"The modern success in aeronautics may be said to date, I think, from the feat of Otto Lilienthal, in 1891, in gliding down an incline in an aeroplane. These glides were repeated with much success, and with an improvised aeroplane, by Mr. Chanute and Mr. Herring in our own country. Mr. Herring even went so far as to carry with him 50 pounds of sand, which weight he computed would be that of an engine sufficient to support him. Mr. Pilcher, in England, repeated these experiments on a level, by rising into the air in his machine when drawn by a horse attached to a rope, the machine rising like a kite and then gliding forward. Mr. Whitehead is described in the *Scientific American* as having repeated this experiment recently in Connecticut, with a motor on board the aeroplane.

"In the meantime, in 1896, Dr. Langley had driven a model weighing about 25 pounds through the air with a small steam engine, and Sir Hiram Maxim had performed the wonderful feat of lifting 7,000 pounds into the air for a moment. This was done with an aeroplane having 5,000 square feet of surface, driven by fan propellers attached to a steam engine of 360 horse power, and of extraordinary lightness. But notwithstanding all these partial successes, there was, owing to the recently reported failure of Dr. Langley to lift a man, and to other causes, a wide skepticism as to the possibility of human flight.

"Mr. Wright's success in rising and landing safely with a motor-driven aeroplane is a crowning achievement, showing the possibility of human flight. Much yet remains to be done, but with the stimulus of this beginning progress will probably be rapid. In the progress now achieved, a great deal is due to Mr. Octave Chanute, an eminent American engineer, whose enthusiasm and great knowledge have stimulated the work of Herring, Hufaker, the Wrights, and many others, and whose advice and supervision were freely given in perfecting the machine which has finally succeeded."

Remarkable Run of the "Kearsarge" Across the Atlantic.

That the accredited trial speed of warships is fictitious, so far as that to be attained under service conditions, has more or less been generally assumed, but in the American navy some most brilliant exceptions to this statement have been made, such as the world-famous trip of the *Oregon*, to show that the trial speeds obtained on our ships are not only within the province of possibilities, but that they may be actually secured.

The most recent and, in a way, remarkable of the long fast runs of our warships was performed by the U. S. battleship *Kearsarge*. She left Portsmouth, England, on July 17th, passing The Needles, the point of departure, at 1.30 P. M., Greenwich time, and arrived at Frenchman's Bay, on the coast of Maine, at 12.45 P. M. on July 26th. The distance covered by the ship was 2,885 nautical miles, and the time, 219 hours 30 minutes, giving a corrected average speed of 13.1 knots for the total run. This run was made under natural draft, and accomplished in the face of head winds and head seas, icebergs, dense fog, and a gale. It is probable that, had the ship been going eastward under similar conditions, she would have averaged a speed of 14 knots, for by careful standardization of the screws the revolutions on this voyage should have given her a speed of 13.6 knots.

The only incident in the engine-room of any kind was that, shortly after leaving, the wrist pin on the high-pressure port engine became heated, owing to an oiling tube clogging up. The bearing was quickly cooled down, and no damage resulted. Head winds varying from 3 to 6 miles were encountered on seven of the days, and on another day a gale washed the seas over the forward 8-inch turrets, necessitating slowing down to about 10 knots for 4 hours. While off the Banks, on account of the presence of icebergs, the speed had to again be cut down to 10 knots for a period of 10½ hours. The presence of the bergs was detected by the drop in the temperature of the water when the weather was foggy, for it was impossible during a greater part of the time to see a ship's length ahead. After running out of the fog, strong adverse currents were encountered for most of the run, it being estimated that on one day this head current amounted to 23 miles.

In commenting upon the results of the run, it should be borne in mind that the *Kearsarge* had been in active service for 44 days previously, having steamed in this time 5,000 miles. Twenty-three days had been spent in steaming, four days were occupied by coaling, and the remaining days, while in port, the ship was practically open to inspection to all visitors, and the officers and men were offered entertainment by first the German and later the English navies. All spare moments were spent in making necessary repairs, aand when the *Kearsarge* sailed on her homeward voyage the *personnel* was not in the best of physical condition.

The *Kearsarge* is a battleship of 11,525 tons trial displacement. She has two sets of vertical, triple-expansion engines, the diameter of the cylinders being 33½, 51, and 78 inches, and the common stroke 48 inches. Steam is supplied by three double-end and two single-end cylindrical boilers, with a total grate surface of 685 square feet and a total heating surface of 22,104 square feet. On trial under forced draft the speed attained was 16.8 knots, and the horse power developed 10,000. The total weight of machinery is 1,195 tons.

When starting out from Portsmouth she had a displacement of 13,406 tons, and when she dropped anchor in Frenchman's Bay her displacement was but 11,995 tons, and the mean draft for the voyage was 25 feet 6¼ inches. Fifteen hundred tons of coal were stored in the bunkers and 125 in the superstructure on deck. Fifty-five thousand gallons of fresh water were carried for making up feed water, in the four double-bottom compartments under the boiler-rooms. Thus steam was saved which would otherwise have been required to run the evaporators.

The only overhauling of machinery made necessary at the end of this successful run was cleaning the furnaces and combustion chambers and repacking a few of the main valve stems and the high and intermediate piston rods. — *Marine Engineering.*

[The mean indicated horse power developed by the main engines of the *Kearsarge* during this run was 5,191, and that developed by the auxiliary engines was 184. The total coal consumption was 2.17 pounds per indicated horse power per hour for all purposes, and the average distance traversed, per ton of coal consumed, was 2.47 knots.]

Inspectors' Report.

APRIL, 1903.

During this month our inspectors made 12,593 inspection trips, visited 24,348 boilers, inspected 9,966 both internally and externally, and subjected 1,073 to hydrostatic pressure. The whole number of defects reported reached 12,250, of which 913 were considered dangerous; 75 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,307	92
Cases of incrustation and scale,	3,521	98
Cases of internal grooving,	190	19
Cases of internal corrosion,	939	52
Cases of external corrosion,	724	46
Broken or loose braces and stays,	138	20
Settings defective,	429	33
Furnaces out of shape,	513	13
Fractured plates,	371	48
Burned plates,	453	60
Blistered plates,	105	2
Cases of defective riveting,	238	102
Defective heads,	97	7
Serious leakage around tube ends,	1,545	78
Serious leakage at seams,	475	17
Defective water gauges,	312	65
Defective blow-offs,	259	71
Cases of deficiency of water,	10	4
Safety-valves overloaded,	57	19
Safety-valves defective in construction,	77	24
Pressure gauges defective,	482	35
Boilers without pressure gauges,	8	8
Unclassified defects,	0	0
Total,	12,250	913

MAY, 1903.

During this month our inspectors made 12,523 inspection trips, visited 23,995 boilers, inspected 10,482 both internally and externally, and subjected 1,047 to hydrostatic pressure. The whole number of defects reported reached 13,590, of which 1,014 were considered dangerous; 69 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,387	65
Cases of incrustation and scale,	3,988	95
Cases of internal grooving,	243	20
Cases of internal corrosion,	1,143	40
Cases of external corrosion,	780	41
Broken or loose braces and stays,	203	34
Settings defective,	488	47
Furnaces out of shape,	588	19

Nature of Defects.	Whole Number.	Dangerous.
Fractured plates,	340	51
Burned plates,	511	42
Blistered plates,	103	1
Cases of defective riveting,	341	101
Defective heads,	78	21
Serious leakage around tube ends,	1,570	130
Serious leakage at seams,	462	27
Defective water gauges,	291	54
Defective blow-offs,	330	93
Cases of deficiency of water,	7	3
Safety-valves overloaded,	126	30
Safety-valves defective in construction,	104	33
Pressure gauges defective,	447	30
Boilers without pressure gauges,	37	37
Unclassified defects,	23	0
Total,	13,590	1,014

JUNE, 1903.

During this month our inspectors made 12,323 inspection trips, visited 22,800 boilers, inspected 11,215 both internally and externally, and subjected 1,097 to hydrostatic pressure. The whole number of defects reported reached 13,918, of which 977 were considered dangerous; 131 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,363	64
Cases of incrustation and scale,	3,756	68
Cases of internal grooving,	253	17
Cases of internal corrosion,	1,443	69
Cases of external corrosion,	1,067	64
Broken or loose braces and stays,	167	28
Settings defective,	577	38
Furnaces out of shape,	583	24
Fractured plates,	287	31
Burned plates,	466	44
Blistered plates,	118	15
Cases of defective riveting,	228	33
Defective heads,	146	10
Serious leakage around tube ends,	1,576	153
Serious leakage at seams,	549	37
Defective water gauges,	392	80
Defective blow-offs,	315	100
Cases of deficiency of water,	18	12
Safety-valves overloaded,	79	25
Safety-valves defective in construction,	83	34
Pressure gauges defective,	447	26
Boilers without pressure gauges,	5	5
Unclassified defects,	0	0
Total,	13,918	977

Concerning Thermometers.

Thermometers of all grades may be bought in the market, ranging from those that are suitable for decorative purposes and whist favors to those that are used for accurate scientific purposes. In the present article we shall speak only of "ordinary" thermometers, such as may be bought for from twenty-five to fifty cents, and which serve as the bases of the familiar controversies that arise in unusually cold or hot weather, among amateur meteorological observers.

A thermometer consists of four distinct parts, — the stem, the bulb, the enclosed mercury (or other fluid), and the scale on which the degrees are marked. In the manufacture of the stem a quantity of glass about the size of a peach pit is taken upon the end of a glass worker's blow-pipe, and blown up until it is about 2½ inches in diameter and elliptical in form. This is dipped again into the glass crucible, so that it gathers more glass, and the blowing continues. After a time another workman attaches his blow-pipe to the bottom of the mass, and the two men, both blowing, move away from each other so as to draw the bulb out into a long, fine tube, which is frequently as much as three hundred feet in length. The capillary tube thus prepared is cut into lengths, and reheated in an annealing oven, so that it may be straightened and also relieved of the internal stresses due to its original cooling. When a considerable number of lengths have been accumulated in this way, the diameter of the bore is measured in each specimen by the aid of a microscope, and the tubes are sorted out accordingly.

In the manufacture of a thermometer, a piece of this capillary tubing of the proper length is first selected, and to one end of this a piece of semi-molten glass of a special kind is attached, air being then forced through the capillary tube until the glass so attached is blown out into a bulb of the proper size. While the bulb is still hot, and the air in it is therefore rarefied by expansion, the open end of the stem is dipped into mercury, and as the heated glass cools the mercury is drawn up through the stem until it partially fills the bulb. The bulb is then heated again, and the operation is repeated until both the bulb and stem are completely filled. The bulb is then heated to a temperature a few degrees above the highest temperature which the thermometer is intended to measure, and when the mercury ceases to overflow at the open end the capillary tube is sealed in the flame of a blow-pipe. The glass and mercury parts of the instrument are then complete, and it remains to attach a suitable scale.

The ideal way to graduate a thermometer scale is as follows: The thermometer is first placed in the steam arising from water that is boiling freely under normal atmospheric pressure, and the point to which the mercury rises is marked (for a Fahrenheit thermometer) "212°." The instrument is then placed in a mixture of water and pulverized ice, and the point to which the mercury sinks is marked "32°." The space between these two marks is then divided into 180 equal divisions, which are called degrees. If the thermometer is not intended to measure such a wide range of temperature, the same idea can be carried out by comparing the instrument, at any two convenient temperatures whatsoever, with a standard instrument which has been previously graduated in the manner described.

Now it will be obvious that all this trouble cannot be taken with a thermometer that is to be sold at retail for twenty-five cents, since the method of graduation that we have described necessitates the engraving of a special scale for each instrument. In making cheap thermometers it is therefore customary to stamp the scales out in large numbers from sheet metal, and to blow the bulb of the instrument to such a size that the scale will be as nearly as practicable adapted to the finished thermometer. This can be done, by an experienced glass-worker, with greater accuracy than might be supposed; but it is evident that no high degree of precision can be realized in this way. The scale and the rest of the thermometer being adapted to each other as nearly as is commercially practicable, the thermometer is then exposed to some known temperature (say 70°) in the vicinity of the temperatures at which it is most likely to be used, and the point on the stem to which the mercury rises is then adjusted so as to be opposite the correct part of the scale. Such a thermometer will give readings that are not greatly in error at temperatures near the one at which it is standardized; but at other temperatures any two such thermometers will necessarily diverge by an amount which depends upon the judgment and skill of the workmen who blew the bulbs, and who endeavored to give them capacities adapted to the sizes of the degrees upon their respective graduated scales.