The Locomotive.

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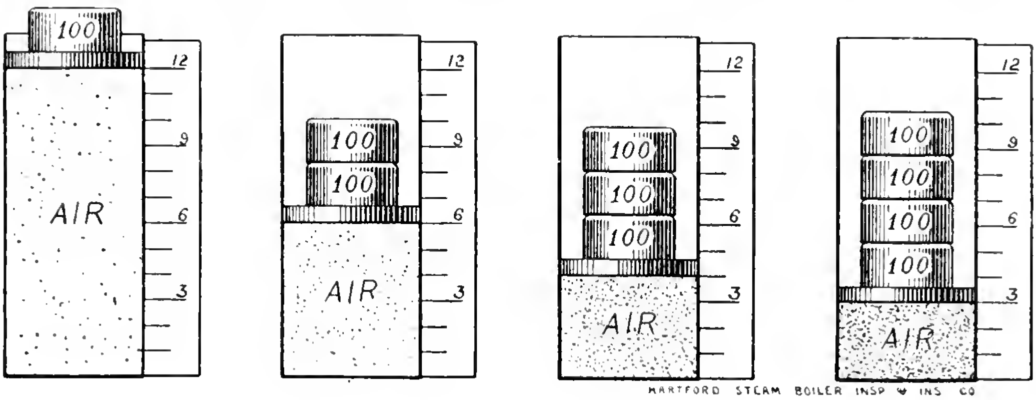
The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XXI. HARTFORD, CONN., JANUARY, 1900. No. 1.

The Weight of Air.

The properties of air and other gases are so different from the properties of the solids and liquids that we can see and measure and handle so readily, that it is not at all to be wondered at that the earlier men of science regarded gases as intrinsically different, in their very essence, from the more familiar and tangible things of our daily experience. The word "gas" was invented by a Belgian chemist named Van Helmont, in the first half of the seventeenth century, and while it is not definitely known where he obtained the suggestion from which the word took form, it is not at all unlikely that it came from the Dutch word "geest," which means "a spirit," and which is related to our common English word "ghost." Whatever the origin of the word, it is certain that the early philosophers considered gases to be essentially different from the other



Illustrating "Boyle's Law."

materials of which the world is composed. We do not need to discuss the views that they held about these things, beyond stating that until the year 1644 it does not appear to have occurred to anyone that gases (and, in particular, air) possess the property of *weight*. But in that year the Italian physicist Torricelli invented the barometer, and proved, by conclusive experiments, that *air*, at least, has weight, just as all the more substantial bodies have; and now, of course, we know that *every* mass of gas has a perfectly definite weight.

It is not essential to our present purpose to describe, in detail, the experimental methods by which the air has been weighed. It will be sufficient to say that the general process consists in weighing a balloon-shaped flask *twice* — the first weighing being performed with the flask full of air, while the second is performed after the air has been all pumped out. If air had no weight at all, these two experiments would give identical results; but it is found that, as a matter of fact, the flask is always sensibly heavier when it is full. By taking the differences of the two weighings, we therefore ascertain the weight of the quantity of air that is just sufficient to fill the flask. Knowing this, we next proceed, by means of a separate experiment, to find out the volume of the flask, in cubic inches; and when this has been done, we are in position to calculate the weight of a cubic inch of air, or of a cubic foot of it, or of any other quantity.

Measurements of this sort are exceedingly delicate, and they can be valuable only when performed by experienced men, with the aid of the finest apparatus that can be made. Regnault, whose skill cannot be doubted, and whose apparatus was beyond reproach, found that at the freezing point of water, a cubic centimeter of perfectly pure, dry air weighed 0.0012932 of a gramme, when the barometer stood at 76 centimeters, in his laboratory at Paris. To make this result available for practical work in this country, we have reduced these figures to their English equivalents; and we find that at ordinary atmospheric pressure, and at the temperature of melting ice (32° Fahr.), a cubic foot of air weighs 0.080681 of a pound.*

It will be observed that we have carefully specified the pressure and temperature of the air, in giving its weight. That is because the density of the air varies when these elements vary, unless certain conditions are fulfilled. If a given constant mass of air be compressed, or heated, or modified in any other way, its weight will remain unchanged, just as the weight of any other substance would remain unchanged under similar circumstances. The reason that the weight of a cubic foot of air varies so much under varying conditions of temperature and pressure is, that air is exceedingly expansible and compressible. Suppose, for example, that we had a light steel flask, with a capacity of precisely one cubic foot, and that we filled this box with air at the usual atmospheric pressure, and (say) at 70° temperature. The air so confined would have a certain definite weight. Suppose, next, that we pump *more* air into this flask, until there is perhaps three times as much air in it as there was before. In pumping in this extra air, we shall materially increase the pressure within the flask; but that does not concern us for the moment. The point that we wish to make is, that the air that was originally in the flask weighs just exactly the same as it did before — no more and no less; but the *total* weight of the air in the flask is now greater than it was before, because we have forced a good deal more air into this one cubic foot of space than there was in it in the first place; and that is the reason (and the only reason) why a cubic foot of air at a higher pressure weighs more than a cubic foot of air at a lower pressure. There is simply *more air crowded into this cubic foot*, at the higher pressure.

The first experimenter to investigate the behavior of air, under varying pressures, with anything like accuracy, was the English physicist, Robert Boyle, who discovered the fact of nature now known under the name of "Boyle's law." As this law is of constant use in connection with steam engineering and other allied branches, it will be worth our while to give some account of it. The law is very simple, and will be readily understood by referring to the illustrations which accompany this article. On the left we have endeavored to represent a metal cylinder, standing on end, in which a definite mass of air is confined by means of a weightless piston which fits the cylinder

* By "ordinary atmospheric pressure" we mean the pressure that would be exerted by a weight of 14.7 pounds, resting upon a base one inch square, at sea-level in the latitude of Washington; and throughout this article when we use the word "pound" it is to be understood that the data relate always to sea-level, at Washington. We make this explanation in order to guard against possible criticism; but for the purposes of engineering, no attention need be paid to this foot note, and the figures that we give may be used in any latitude, without fear of sensible error. The tables are supposed to be correct for Washington; and if the force of gravity were constant all over the United States, they would be equally exact for all places in the country. As a matter of fact, the earth attracts bodies a little more strongly as we go north, and a little less strongly as we go south; so that it is not possible to make a table that shall be strictly accurate for all places. The greatest amount by which the tables can be in error from this cause, however, when they are applied to any part of the United States north or south of the latitude of Washington, is only *one-ninth of one per cent.*,— this maximum error occurring at Key West.

perfectly, and yet without the least friction. We cannot realize, in practice, the condition of an air-tight piston which is at the same time perfectly frictionless; but our limitations in this regard need not prevent us from *imagining* such a thing, nor from learning something about what the behavior of air would be, if such a state of affairs *could* be realized. For the sake of further simplicity, we will also suppose that the external air does not press down upon the piston at all, but that the only force tending to confine the air is that due to the 100-pound weight which is represented in the engraving. This amounts to assuming that the whole experiment that we are about to describe is performed in a closed chamber from which the air has been removed by a suitable pump. In practice, such experiments are performed in the open air, and the effects of the external atmospheric pressure are allowed for in the calculations. We could pursue this latter course if we chose to, but as we are not going to actually *perform* the experiment, but only to *think* of its being performed, we might as well think of the external atmospheric pressure as being entirely done away with, by some such means as we have suggested; for this will save all complication, and enable us to give our undivided attention to the one thing that we wish to illustrate.

We have, then, a metal cylinder in which a certain definite amount of air is confined by means of a tight-fitting but frictionless piston; and the only force tending to hold this air confined is that exerted by the 100-pound weight which rests upon the piston. We will suppose that the quantity of air within the cylinder has been regulated so nicely that the weight is held by it at such a height that the bottom of the piston is precisely 12 inches from the bottom of the cylinder. If there is no leakage past the piston, and no change in the temperature of the air, the system will remain balanced in this precise condition forever (so far as we know).

Now, suppose that another 100-pound weight is placed upon the piston. The piston will be immediately forced downward by the additional weight, and the air under it will be compressed, and the pressure that the air exerts against each square inch of the cylinder and the piston will be greater than it was before. There will be various effects produced at the outset, besides the mere reduction of the air to a smaller volume. For example, small currents will be set up in the air, and the air will also become more or less heated. If we wait, however, until all these currents have died out, and the air has cooled again to its original temperature, we shall find that the piston comes finally to rest at a position such that its lower side is almost precisely *six* inches from the bottom of the cylinder instead of *twelve*, as it was originally. That is, by doubling the pressure upon the air, we have reduced the volume of the air to *one-half* of what it was at first — always understanding that the *temperature* of the air is precisely the same in both cases. If we had loaded the piston with *three* hundred pounds, we should have found that when the system finally came to rest, the volume of the enclosed air would be *one-third* of its original volume. If we had piled 400 pounds on the piston, we should find that the volume would be reduced to *one-fourth* of its original value, as shown on the extreme right of the engraving; and so on, for all ordinary pressures. This fact, that the volume of air (or of any other of the so-called "permanent gases") is halved by doubling the pressure, and so on, (*provided* the temperature of the air remains constant.) is known as "Boyle's law."

It will be plain, upon examining the engraving, why the weight of a cubic foot (or of a cubic inch) of air varies with the pressure; for under a load (or pressure) of 400 pounds, the same air is forced into a space only one-fourth as great as it occupied under a load of 100 pounds; and therefore its *density* (or, in other words, its weight per cubic foot, or per cubic inch,) is four times as great at the higher pressure.

We have referred, several times, to the necessity of keeping the *temperature* of the air constant during experiments of this kind, if "Boyle's law" is to be illustrated. We shall now explain, briefly, what happens when the temperature of the air is *not* kept constant; and we shall find that the effects of change of temperature are almost equally as simple as the effects of change of pressure. In the interest of simplicity it will be well to state, at the outset, that physicists are in the habit of reckoning temperatures,

TABLE I. — ABSOLUTE WEIGHT OF A CUBIC FOOT OF AIR, IN POUNDS.

Temp. of Air, on Fahrenheit Scale.	PRESSURE, IN POUNDS PER SQUARE INCH, ABOVE ATMOSPHERE.							
	0 lbs.	5 lbs.	10 lbs.	15 lbs.	20 lbs.	30 lbs.	40 lbs.	50 lbs.
0°	0.0863	0.1156	0.1450	0.1744	0.2037	0.2624	0.3211	0.3798
10	.0845	.1132	.1419	.1706	.1994	.2568	.3143	.3717
20	.0827	.1108	.1390	.1671	.1952	.2515	.3077	.3640
30	.0810	.1086	.1361	.1636	.1912	.2463	.3014	.3566
40	.0794	.1064	.1334	.1604	.1874	.2414	.2954	.3494
50	.0778	.1043	.1308	.1572	.1837	.2367	.2896	.3426
60	.0763	.1023	.1283	.1542	.1802	.2321	.2841	.3360
70	.0749	.1004	.1258	.1513	.1768	.2278	.2787	.3296
80	.0735	.0985	.1235	.1485	.1735	.2235	.2735	.3236
90	.0722	.0967	.1213	.1458	.1704	.2195	.2686	.3176
100	.0709	.0950	.1191	.1432	.1673	.2155	.2638	.3120
110	.0696	.0933	.1170	.1407	.1644	.2118	.2591	.3065
120	.0684	.0917	.1150	.1383	.1616	.2081	.2547	.3012
130	.0673	.0902	.1130	.1359	.1588	.2046	.2504	.2961
140	.0662	.0887	.1112	.1337	.1562	.2012	.2462	.2912
150	.0651	.0872	.1094	.1315	.1536	.1979	.2422	.2864
160	.0640	.0858	.1076	.1294	.1511	.1947	.2382	.2818
170	.0630	.0844	.1059	.1273	.1487	.1916	.2345	.2773
180	.0620	.0831	.1042	.1253	.1464	.1886	.2308	.2730
190	.0611	.0818	.1026	.1234	.1442	.1857	.2272	.2688
200	.0601	.0806	.1011	.1215	.1420	.1829	.2238	.2647
210	.0592	.0794	.0996	.1197	.1399	.1802	.2205	.2608
220	.0584	.0782	.0981	.1179	.1378	.1775	.2172	.2569
230	.0575	.0771	.0967	.1162	.1358	.1749	.2141	.2532
250	.0559	.0749	.0939	.1130	.1320	.1700	.2080	.2461
275	.0540	.0724	.0907	.1091	.1275	.1642	.2010	.2377
300	.0522	.0700	.0878	.1055	.1233	.1588	.1944	.2299
325	.0506	.0678	.0850	.1022	.1194	.1538	.1882	.2226
350	.0490	.0657	.0823	.0990	.1157	.1490	.1824	.2157

not from the arbitrary zero of the Fahrenheit scale, but from a point which is approximately 460 Fahrenheit degrees *below* this zero. The scientific starting point, or zero, so determined, is called the "absolute zero," because it is believed to be the temperature at which all bodies are totally destitute of heat; and temperatures reckoned from this "absolute zero" are called "absolute temperatures." To illustrate: The freezing point of water, on the ordinary Fahrenheit scale, is at 32°; and the "absolute temperature" of this point will therefore be 460°+32°=492°. Again, the boiling point of water, under one atmosphere pressure, is 212° on the ordinary Fahrenheit scale; and therefore the "absolute temperature" of this point is 460° + 212° = 672°.

With this much understood, we are now prepared to state what is known as "Gay Lussac's law" (or "Charles' law"); which is, that if the pressure exerted upon a given mass of air (or any other "permanent gas") be kept constant, the volume of the air (or gas) will vary proportionally to the "absolute temperature" of the gas. For example, consider the second of the engravings accompanying this article, where the air is confined by a total weight of 200 pounds. Let us suppose that this air, at the outset, is at the freezing point, or at 32° on the ordinary Fahrenheit scale; and let us imagine the air to be heated, in some way, until its temperature becomes 524° on this same scale, the load of 200 pounds being kept constant all the while. To find out how much the air will expand under these circumstances, we first convert the ordinary temperatures, given above, into "absolute temperatures," by adding 460° to each of them. We have

TABLE I. — ABSOLUTE WEIGHT OF A CUBIC FOOT OF AIR, IN POUNDS.

Temp. of Air, on Fahrenheit Scale.	Pressure, in Pounds per Square Inch, above Atmosphere.							
	60 lbs.	70 lbs.	80 lbs.	90 lbs.	100 lbs.	125 lbs.	150 lbs.	200 lbs.
0°	0.4385	0.4972	0.5559	0.6146	0.6733	0.8201	0.9669	1.2604
10	.4292	.4866	.5441	.6015	.6590	.8026	.9462	1.2335
20	.4202	.4765	.5328	.5890	.6453	.7859	.9265	1.2078
30	.4117	.4668	.5219	.5770	.6321	.7699	.9076	1.1832
40	.4034	.4574	.5114	.5654	.6195	.7545	.8895	1.1595
50	.3955	.4485	.5014	.5544	.6073	.7397	.8721	1.1368
60	.3879	.4398	.4918	.5437	.5956	.7254	.8553	1.1149
70	.3806	.4315	.4825	.5334	.5844	.7118	.8391	1.0939
80	.3736	.4236	.4736	.5236	.5736	.6986	.8236	1.0736
90	.3668	.4159	.4650	.5140	.5631	.6859	.8086	1.0541
100	.3602	.4084	.4566	.5049	.5531	.6736	.7942	1.0353
110	.3539	.4013	.4486	.4960	.5434	.6618	.7802	1.0171
120	.3478	.3943	.4409	.4875	.5340	.6504	.7668	0.9996
130	.3419	.3877	.4334	.4792	.5250	.6394	.7538	.9826
140	.3362	.3812	.4262	.4712	.5162	.6287	.7412	.9663
150	.3307	.3750	.4192	.4635	.5078	.6184	.7291	.9504
160	.3254	.3690	.4125	.4560	.4996	.6084	.7173	.9351
170	.3202	.3630	.4059	.4488	.4916	.5988	.7059	.9203
180	.3152	.3574	.3996	.4418	.4840	.5894	.6949	.9059
190	.3103	.3519	.3934	.4350	.4765	.5804	.6842	.8920
200	.3056	.3465	.3875	.4284	.4693	.5716	.6739	.8784
210	.3011	.3414	.3817	.4220	.4623	.5630	.6638	.8653
220	.2966	.3364	.3761	.4158	.4555	.5548	.6540	.8526
230	.2923	.3315	.3706	.4097	.4489	.5467	.6446	.8402
250	.2841	.3221	.3602	.3982	.4362	.5313	.6264	.8166
275	.2744	.3112	.3479	.3847	.4214	.5133	.6051	.7888
300	.2654	.3010	.3365	.3720	.4075	.4964	.5852	.7628
325	.2570	.2915	.3258	.3602	.3946	.4806	.5666	.7386
350	.2490	.2824	.3157	.3490	.3824	.4657	.5491	.7158

460°+32°=492°, and 460°+524°=984°. Now "Gay Lussac's law" states that so long as we keep the pressure constant, the volume will increase proportionally to the "absolute temperature": and since 984 is just twice as great as 492, it follows that the air will expand, under the stated conditions, until its volume is precisely double what it was at the beginning. That is, the mass of air shown in the second illustration will push up the load of 200 pounds until the piston comes into the position shown in the *first* of these illustrations.

By means of the laws of Boyle and Gay Lussac, we can calculate the way in which

TABLE II. — ABSOLUTE WEIGHT OF A CUBIC FOOT OF AIR, IN POUNDS, AT 32° AND 212°.

Pressure in pounds per square inch, above atmosphere.	Temperature (Fahr.).		Pressure in pounds per square inch, above atmosphere.	Temperature (Fahr.).	
	32°	212°		32°	212°
0	0.0807	0.0591	25	0.2179	0.1595
1	.0862	.0631	30	.2453	.1796
2	.0917	.0671	35	.2728	.1997
3	.0971	.0711	40	.3002	.2198
4	.1026	.0751	45	.3277	.2399
5	.1081	.0792	50	.3551	.2600
6	.1136	.0832	60	.4100	.3002
7	.1191	.0872	70	.4649	.3404
8	.1246	.0912	80	.5198	.3805
9	.1301	.0952	90	.5746	.4207
10	.1356	.0993	100	.6295	.4609
11	.1410	.1033	110	.6844	.5011
12	.1465	.1073	120	.7393	.5413
13	.1520	.1113	130	.7942	.5815
14	.1575	.1153	140	.8490	.6216
15	.1630	.1194	150	.9039	.6618
16	.1685	.1234	160	.9588	.7020
17	.1740	.1274	170	1.0137	.7422
18	.1795	.1314	180	1.0686	.7824
19	.1850	.1354	190	1.1235	.8226
20	.1904	.1394	200	1.1784	.8627

the volume of a given mass of air will vary under any imaginable circumstances of pressure and temperature, and hence we can calculate how much a cubic foot of air will weigh at any proposed temperature and pressure, when we once know, by experiment, how much such a volume of air will weigh under certain definite standard conditions — say at one atmosphere pressure, and at the temperature of freezing water. Regnault's labors, referred to earlier in this article, showed that a cubic foot of air exposed to a pressure of 14.7 pounds per square inch and a temperature of 32° Fahr., weighs .080681 of a pound (or 1.29 ounces); and from this as a starting point, we have calculated the appended tables by means of the two laws above described — namely, the laws of Boyle and of Gay Lussac.

The tables do not call for much explanation, except as to the precise meaning of the phrase "weight of a cubic foot of air." It is to be understood that the weights here given are the *absolute* weights of the various masses of air, no allowance being made for the buoyancy of the surrounding atmosphere. The atmosphere that surrounds us buoys up everything that is submerged in it, just as water does, only not to so great an extent. If a cannon ball is submerged in water, the water buoys it up by an amount which is precisely equal to the weight of a mass of water having identically the same size and shape as the cannon ball itself; and when the cannon ball is submerged in *air*, instead of in water, the surrounding *air* buoys up the ball by an amount which is precisely equal to the absolute weight of a mass of *air* having the identical size and shape of the cannon ball; and so on with any other fluid or gas, whether it is water or milk or mercury or carbonic acid gas or coal gas or anything else. If a cubic foot of air be enclosed in an air-tight case and then weighed in a vacuum, it will have the weight that is given in the table for its particular condition of temperature and pressure; but if it is weighed *in air* instead of in a vacuum, it will *appear* to weigh less by an amount equal to the tabular weight of an equal volume of air at atmospheric pressure. For example, it will be seen that the actual absolute weight of one cubic foot of air at a temperature of 70° Fahr. and a pressure of 80 pounds per square inch above the atmosphere, is 0.4825 lb.; but if this were weighed while surrounded by air at 70° and at ordinary atmospheric pressure, it would be buoyed up by an amount equal to the weight of an equal volume (that is, *one cubic foot* in the present case) of the surrounding air. Now, according to the tables, a cubic foot of the surrounding air weighs 0.0749 lb. under the conditions given; and hence the *apparent* weight of the given cubic foot of air will be only 0.4825 - 0.0749 = 0.4076 lb.

In all calculations concerning the heating and ventilating of buildings, the flow of air through pipes, the air required for combustion, and so on, it is necessary to use the *absolute* weight of the air considered; and that is why the absolute weight has been given in the tables. If the apparent weight should be wanted for any purpose (which is not likely), it can be obtained from the tables by making the proper allowance for buoyancy, as explained in the preceding paragraph; but for all the ordinary problems of engineering, the values as given directly by the tables should be used.

A special table has been given for the temperatures 32° Fahr. and 212° Fahr., as these temperatures occur in engineering calculations so frequently that separate tabulation appears to be desirable. This auxiliary table does not differ from the main one in its nature, and is to be regarded simply as supplementary to it.

Who Invented Steam Navigation?

One of the most interesting and scholarly books ever written is that by Thomas Ewbank upon hydraulics and mechanics The first edition appeared in 1841, and the book has since run through at least fifteen editions. We presume it is now out of print, but copies are to be found in many of the large libraries. It is largely historical, and treats exhaustively upon various branches of the development of mechanics. In discussing steam navigation it states that in 1543 a naval officer is said to have propelled a ship of two hundred tons by steam in the harbor of Barcelona, Spain. No account of the machinery exists, except that there was a large copper boiler, and that there were paddle-wheels at the sides of the vessel. Like all old inventors, this officer refused to explain his mechanism. The following account of the affair is said by Ewbank to be a copy of the official records contained in the Spanish Royal Archives:

"Blasco de Garay, a captain in the navy, proposed, in 1543, to the Emperor and King, Charles the Fifth, a machine to propel large boats and ships, even in calm weather, without oars or sails. In spite of the impediments and opposition which this project met with, the emperor ordered a trial to be made of it in the port of Barçelona, which trial took place on the 17th of the month of June, of the said year, 1543. Garay would not explain the particulars of his discovery; it was evident, however, during the experiment, that it consisted in a large copper of boiling water, and in moving wheels attached to either side of the ship. The experiment was tried on a ship of 200 tons called the *Trinity*, which came from Colibre to discharge a cargo of corn at Barcelona, of which Peter de Scarza was captain. By order of Charles V., Don Henry de Toledo, the governor, Don Pedro de Cordova, the treasurer Ravago, and the vice-chancellor and intendant of Catalonia, witnessed the experiment. In the report to the emperor and to the prince, this ingenious invention was generally approved, particularly on account of the promptness and facility with which the ship was made to go about. The treasurer Ravago, an enemy to the project, said that the vessel could be propelled two leagues in three hours — that the machine was complicated and expensive, and that there would be an exposure to danger in case the boiler should burst. The other commissioners affirmed that the vessel tacked with the same rapidity as a galley manœuvred in the ordinary way, and went at least a league an hour. As soon as the experiment was made Garay took away the whole machine with which he had furnished the vessel, leaving only the wooden part in the arsenal at Barcelona, and keeping all the rest for himself. In spite of Ravago's opposition, the invention was approved; and if the expedition in which Charles the Fifth was then engaged had not prevented, he would, no doubt, have encouraged it. Nevertheless, the emperor promoted the inventor one grade, made him a present of two hundred thousand maravedis, and ordered the expense to be paid out of the treasury, and granted him besides many other favors.

"This account is derived from the documents and original registers kept in the Royal Archives of Simuncas, among the commercial papers of Catalonia, and from those of the military and naval departments for the said year, 1543.

"Simuncas. August 27, 1825.

"THOMAS GONZALES."

Ewbank says, that so long as the authenticity of this document is admitted, it is difficult to perceive how other than Blasco de Garay can be accredited with the invention of steam navigation. It may appear singular that this specimen of mechanical ingenuity should have matured in Spain, but at that time Spain was, probably, the most promising scene for the display of such operations. Every one knows that half a century before, Columbus could find a patron nowhere else. Objections have been raised to the claim for Garay, and we give them as Ewbank presents them, together with his discussion regarding them. They make interesting reading, and we leave the reader to judge as to their value.

"The objections are: *1st.* Because the document was not printed in 1543; *2d.* It does not sufficiently prove that steam was the motive agent; *3d.* If Captain Garay really did employ a steam engine, it was according to all appearance the reacting eolipile of Hero, and, therefore, nothing new.

"To us there does not appear much force in these reasons. M. Arago observes: 'Manuscript documents cannot have any value with the public, because, generally, it has no means whatever of verifying the date assigned to them.' To a limited extent this may be admitted. Respecting private manuscript it may be true; but, surely, official and national records like those referred to by the Spanish secretary should be excepted. So far from rejecting such sources of information respecting the arts of former times, we should have supposed they were unexceptionable.

"But it is said, although a boiler is mentioned, that it is not sufficient proof that steam was the impelling agent, since there are various machines in which fire is used under a boiler, without that fluid having anything to do with the operations. Well, but the account states that which really appears conclusive on this point, *viz.*, that this vessel contained 'boiling water,' and that Ravago, the treasurer, opposed the scheme on the ground that there would be an exposure to danger 'in case the boiler should burst.' As this danger could not arise from the liquid contents merely, but from the accumulation of steam (the irresistible force of which was, as has been observed, well known from the employment of the eolipiles), it is obvious enough that this fluid performed an essential part in the operation — in other words, was the source of the motive power.

Had it not been necessary, Garay would never have furnished in it such a plausible pretext for opposition to his project. It has also been said that if Garay used steam at all, his engine was probably the whirling eolipile. There are, however, strong objections to such an opinion. That such an engine, acting on the same principle of recoil as Hero's eolipile, might have been made to propel a vessel of 200 tons is admitted; but from modern experiments with small engines of this description, we know: *first*, that in order to produce the reported result, the elasticity of the steam employed must have been equivalent to a pressure of several atmospheres; and *second*, that the enormous consumption of the fluid when used in one of these engines must have required either a number of boilers or one of extraordinary dimensions. Had Garay employed several boilers, the principal difficulty would be removed, as he might then have made them sufficiently strong to resist the pressure of the confined vapor; however, he used but one, and every person who has witnessed the operation of reacting engines will admit that a single boiler could hardly have been made to furnish the quantity of steam required at the requisite degree of tension.

"As the nature of this Spanish engine is not mentioned, every person is left to form his own opinion of it. We see no difficulty in admitting that he employed the elastic force of steam to push a piston to and fro — or that he formed a vacuum under a piston by condensing the vapor. Such applications of steam were likely to occur to a person deeply engaged in devising modes of employing it, in the sixteenth as well as in the seventeenth century, notwithstanding the objection so often reiterated that the arts were not sufficiently matured for the fabrication of a metallic cylinder and piston, and apparatus for transmitting the movements of a piston to revolving mechanism. The casting and boring of pieces of ordnance show that the construction of a steam cylinder was not beyond the arts of the sixteenth century, nor even of the two preceding ones; while the water works, consisting of forcing pumps worked by wheels, and also numerous other machines put in motion by cranks (and the irregularity of their movements being also regulated by fly-wheels), show that engineers at that time understood the means of converting rotary into rectilinear motions, and rectilinear into rotary ones.

"It need not excite surprise that Garay adopted paddle wheels as propellers, since they were well known before his time, being of very ancient date. Roman galleys were occasionally moved by them, and they had probably never been wholly laid aside in Europe since the fall of the empire."— *Steam Engineering.*

The Locomotive.

HARTFORD, JANUARY 15, 1900.

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

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Obituary.

MR. B. F. JOHNSON.

Death has laid his unsparing hand heavily upon the employes and friends of the Hartford Steam Boiler Inspection and Insurance Company during the past few months; and it again becomes our sad duty to announce the departure of one of our most faithful and respected servitors. Mr. B. F. Johnson, who for ten years has been Chief Inspector in our Southern Department, died at his home in Atlanta, Ga., on December 2d, after an illness of some considerable duration. Mr. Johnson was born at Blanford, Mass., on December 31, 1853, and was married, in 1873, to Miss Harriet E. McLaughlin of East Lee, Mass. He first entered the employ of the Hartford company, as an inspector, in 1884, being mainly connected with the Hartford office, although he was temporarily transferred, at times, to our Northeastern (or Boston) department. In the early part of 1889 he was made Chief Inspector in our Southern department, with headquarters at Atlanta. Mr. Johnson came north, a few months before his death, in the hope that his health might be improved by a visit to the Berkshire hills, in western Massachusetts. He received only temporary relief, however, and he returned once more to Atlanta, a short time before his death. He was a man of sterling qualities, with the interests of his employers always nearest to his heart; and the rapid growth of the Hartford company's business in the Southern department has been due, in no small measure, to his personal efforts and influence. He leaves a wife and three children.

Boiler Explosions.

AUGUST, 1899.

(211.) — On July 31st the boiler of a threshing-machine outfit exploded on the Haley farm, near Wenona, Ill. The crown-sheet of the boiler blew out. Fortunately nobody was injured.

(212.) — A boiler exploded, on August 1st, in L. Jackson's sawmill, near Sparta, Ga. Two workmen were fatally injured, and the proprietor himself was seriously scalded.

(213.) — The boiler of a road engine and stone crusher exploded, on August 1st, while it was being used on a road about a mile north of Voganville, near Lancaster, Pa. The machine was badly wrecked, and fragments of the boiler were thrown in all directions; but fortunately nobody was hurt.

(214.) — The boiler of Rose, Kennell & Wheeler's threshing outfit exploded, on August 2d, on Mr. Rose's farm, near Howe, Neb. Engineer John Riddle, who was at work about the machine at the time, was severely burned on both legs, from the knees down, by the escaping steam and water. He will recover. The engine and boiler were completely wrecked, and the loss will be about $1,200. The explosion tore up the ground so that the site of the boiler was marked by a hole three feet deep.

(215.) — On August 4th a boiler exploded at the Watts oil well, No. 3, near Corsicana, Tex. Engineer Metcalf, W. M. Tatum, and one other man whose name we do not know, were slightly injured. Considering the violence of the explosion, it is marvelous that the men were not killed.

(216.) — The boiler of a freight engine on the Pan Handle road exploded, on August 4th, while at the water tank at Winamac, Ind. Fireman Frank Soule was fatally injured, and died a few hours later. Engineer William Knight had his collar bone broken and was badly scalded. Brakeman P. J. Ruff was also severely scalded.

(217.) — A small hot-water boiler exploded, on August 5th, in New York city, in the basement of the building occupied by the Durand-Ruel Art Galleries, at Fifth avenue and Thirty-sixth street. Fortunately no picture of fame or great value was seriously damaged. The building itself, however, was well shaken up. Windows of quarter-inch plate glass were blown out into the street, and part of one of the basement walls was blown down.

(218.) — On August 5th a boiler exploded in the Twin City Ice and Cold Storage company's plant, at Champaign, Ill. The boiler house was completely disintegrated, not one brick being left standing on another. The front end of the boiler went south, into the engine room, and knocked a hole, 20 feet in diameter, through a brick wall 30 inches thick. The explosion occurred shortly after three o'clock in the morning, and nobody was injured. The engineer had just stepped out into the open air to cool off, and this action saved his life. One fragment of the boiler carried away a chicken coop filled with chickens, and a watch-dog chained to a block of wood. The accounts that we have received agree that the dog and the chickens were "annihilated." Some who viewed the ruins of the plant say that it suggested a cyclone. Others say that it looked as though Dewey had mixed with it. The property loss is variously estimated at from $10,000 to $20,000.

(219.) — One boiler out of a nest of four exploded, on August 8th, in the Star Washery, at Audenried, Pa. The building was badly wrecked, and the other boilers in the nest were more or less damaged. The only person injured was Fireman David Reilly, who received some slight bruises from falling timbers.

(220.) — A boiler exploded, on August 8th, in Charles Schwartz's sawmill, at Brownstown, Ind. The proprietor's son, David Schwartz, was badly scalded and fearfully cut about the head and body. He may not recover.

(221.) — On August 9th a boiler exploded in Bailey & English's canning factory, at Montross, Va. Lawson Bailey was killed, and Lee English and Rosa Sanford were fatally hurt. Several others also received severe injuries.

(222.) — On August 9th a boiler exploded at the new Greenough Shaft, at Marion Heights, near Shamokin, Pa. Fireman Chardle Rebuck was scalded so badly that he died before medical assistance could be had.

(223.) — On August 10th a boiler exploded at Williamstown, Pa., in the building occupied by Luxton's laundry, in the rear of J. W. Durbin's dry goods store. The entire building was totally wrecked. Superintendent Venner T. Commer had his skull crushed and was otherwise injured, so that he died shortly afterwards. Miss Salina Hayes was also badly scalded and bruised. The only estimate of the property loss that we have seen places it at "thousands of dollars," and adds that the damage to surrounding property was also fully one thousand dollars.

(224.) — On August 10th a threshing-machine boiler exploded on J. W. Allen's farm, near Tate, a small town nine miles northeast of Liberty, Neb. Ray Sherman was badly injured about the head by a flying fragment of the wreckage, and three other men were injured less seriously.

(225.) — On or about August 10th, Andrew Hoatson, an old-time Rock Island fireman, was killed by the explosion of the boiler of his locomotive, No. 213, on the M , K. & T. railroad, near Waco, Tex.

(226.) — A boiler exploded, on or about August 15th, at the Jackson Hill mine, near Sullivan, Ind.

(227.) — The boiler of a locomotive exploded, on August 15th, at the Cardenas round-house, near Tampico, Mex. Engineer Felix Limer, Engineer L. Fitzgerald, Engineer J. Hussey, Engineer William Gibson, and three firemen and wood passers whose names are not stated, were killed. An engineer by the name of Lockhart was blown ninety feet and fatally hurt, and two Mexican shop employes were also injured fatally.

(228.) — The boiler of the pump boat at the Albany mine, a mile and a half below Brownsville, Pa., exploded on August 15th, killing Night Watchman John H. Pratt.

(229.) — The boiler of Mr. J. C. Jones's threshing outfit exploded, on August 16th, on the farm of William Lyons, near Hidalgo, in Jasper county, Ill. Mr. Jones was injured so badly that he died on the 23d. Russell James received injuries which appeared to be fully as serious as those of Mr. Jones; but it is thought that he will recover. William Lyons was also badly burned.

(230.) — A boiler exploded, on August 17th, at Reynolds & Miller's sawmill, some eight miles south of Pittsburg, Tex., seriously injuring J. C. Miller, one of the proprietors, and instantly killing his brother, William Miller. Several others were badly hurt.

(231.) — On August 18th a threshing-machine boiler exploded on Michael Karns's farm, at Osborn, some five miles east of Empire, Mich. Lyman Philbeam, Robert Nephew, and Archibald Anton were killed, and William Gilbert, Peter Sillman, and Asher Atkinson were injured.

(232.) — On August 18th a boiler exploded in R. L. McAnn's sawmill, a mile and a half east of Houghton, La , on the Vicksburg, Shreveport & Pacific railroad. Frank McDade and several of the workmen were painfully scalded and otherwise injured, but nobody was killed.

(233.) — A boiler exploded on August 18th in Frank Hitch's lumber mill, at Portsmouth, near Norfolk, Va. Fireman Douglas Shearer was instantly killed. Augustus Osborne had his skull fractured, and Engineer Preston Williams was frightfully scalded, and it is considered certain that one (or both) of these men will die. A man named Ballard also received an ugly cut from some of the flying debris. The plant was totally destroyed, and the property loss is estimated at $10,000.

(234.) — A boiler exploded on August 19th in the vitrified brick works of Robert Nesch, at Pittsburg, Kan. Henry Heath and James Holman were instantly killed, and Engineer David Boyd was injured so badly that he lived only a short time after his removal to the hospital. The ten-year-old son of Henry Coles, who had just arrived, was so badly mangled that he died soon afterwards. Roy Cole, Grant Heath, John Thackery, and John and Henry Nesch were also injured. Great damage was done by the flying fragments of wreckage. The estimates of the property loss range from $25,000 to $75,000.

(235.) — On August 20th a boiler exploded in Liberty Township, near Findlay, Ohio, while being used to drill an oil-well on the Robert Worden farm. The explosion was violent, and the structure in which the boiler stood was torn to atoms. Only two men were near at the time, and they both escaped injury.

(236.) — On August 21st the boiler of a big traction engine exploded on the Webb Curtis ranch, in Yolo county, Cal. No one was injured.

(237.) — A boiler exploded on August 22d in Samuel Hechman's mill, four miles east of Bowling Green, Ohio. The mill was completely wrecked, and the debris was scattered in all directions. Nobody was in the building at the time, and there are no personal injuries to record.

(238.) — A boiler exploded on August 22d, in the E. H. Wiekert Company's sash, door, and blind factory, at Appleton, Wis. The explosion blew down the entire main building, and some eighteen men fell with it. Robert Pasch was buried in the ruins and instantly killed. Nathaniel Pattinson was scalded and cut so badly that he died while being removed to his home. William Bolduan was hurt fatally, and died a few hours later. Joseph Wettingel, John Foster, William Hoffman, Edward Koletzke, Paul Hoeppner, Herman Miller, August Rehfeldt, and William Weaver were also injured, and at last accounts it was said that Wettingel could not recover. The property loss is said to have been upwards of $20,000.

(239.) — The boiler of a threshing-machine outfit, belonging to Thomas Orr, exploded on August 23d at Dormody's place, Green Valley, El Dorado county, Cal. Fireman Henry Erickson was thrown some distance and severely bruised and scalded. It is believed that he will recover.

(240.) — On August 23d a boiler, used for operating Yoder & Son's stone-crusher, exploded at Linn Grove, a few miles south of Decatur, Ind. Fireman Alfred Minger was hurt so badly that he died two days later. Daniel Yoder, Simon Mincer, and seven employes, whose names we have not learned, were also injured.

(241.) — A small boiler exploded on August 24th at the pumping station of Gibson & Co's cotton gin, at Kosse, Tex. A Mr. Poole, who was in charge of the place, and his assistant, George Lee, were hurt, but both will recover. The boiler was thrown 200 yards.

(242.) — On August 24th the boiler of a threshing outfit exploded on Eberhardt Rocklemann's farm, at Mill Brook, near Jefferson City, Mo. Christopher Strobel was fatally injured. It is darkly whispered that "the wheat was loaded with dynamite"; but we guess the Supreme Court wouldn't consider this verdict to be justified by the evidence in the case.

(243.) — A boiler exploded, on August 24th, in Henry Gilbert's concentrating mill, located on the Beckwith & Hall lease, one mile south of Carterville, near Joplin, Mo. The mill was utterly destroyed, together with all the fixtures and machinery. Ernest Robyns, David J. Sinclair, Thomas Holman, Frank Huddleson, and Henry Gilbert were killed. (One account that we have received attributes the explosion to blasting powder ; but the others state that it consisted in the bursting of a boiler.)

(244.) — On August 26th a boiler exploded in Thomas Hale's sawmill, on Blackwater, in Knox county, near Barbourville, Ky. Eugene Williams was killed, and Walter Gilbert was fatally injured. Thomas Hale, John Taylor, and another man whose name we do not know, were seriously injured.

(245.) — William Smith and Walter Kessler were seriously injured, on August 26th, by the explosion of a threshing-machine boiler on the turnpike between Morgantown and Churchtown, in Berks county, Pa. It is likely that both the men will die.

(246.) — A boiler exploded, on August 28th, at Jesse Denbow's cotton gin, at Roane, near Corsicana, Tex. Nobody was injured, but the explosion did considerable damage.

(247.) — Oliver Bros.' Bedstead Factory, at Lockport, N. Y., took fire from some cause on August 28th, and during the course of the fire two boilers exploded, throwing burning debris in all directions, and adding to the general destruction.

(248.) — On August 29th a small boiler exploded on the A. P. McLeod farm in Center township, Marshall county, Kan. Fay Mullen and Evarts McLeod were badly injured, and Mrs. Fay Mullen and a Mrs. Appleby received lesser injuries.

(249.) — On August 30th there was an explosion of a safety boiler in the Republic Iron & Steel Company's plant at Toledo, Ohio. Three men were burned by fire blown out of the heating furnace by the explosion. The most seriously injured of these was William J. Noon, who was burned in a frightful manner. At last accounts, however, he was reported as doing well, and it was thought that he would recover.

(250.) — On August 31st a threshing-machine boiler exploded a few miles from Jamestown, near Grand Forks, N. D. Edgar Bingham was fatally injured, and Peter Kokott, son of the farmer upon whose place the explosion occurred, was also injured seriously, though he will recover.

(251.) — The boiler of the locomotive drawing express train No. 153, from Baltimore to Washington over the Pennsylvania Railroad, exploded, on August 31st, between Riverdale and Alexandria junction, near Hyattsville, Md., while the train was moving at the rate of 50 miles an hour. Engineer Stull and his fireman escaped without serious injury, although they were compelled to climb out upon the tender to avoid the clouds of scalding steam.

(252.) — A small boiler exploded, on August 31st, in C. A. Russell's laundry, Syracuse, N. Y. Nobody was hurt, and no serious damage was done.

Inspectors' Reports.

October, 1899.

During this month our inspectors made 10,250 inspection trips, visited 19,953 boilers, inspected 7,566 both internally and externally, and subjected 907 to hydrostatic pressure. The whole number of defects reported reached 14,384, of which 1,213 were considered dangerous; 77 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	96
Cases of incrustation and scale,	2,466	79
Cases of internal grooving,	113	8
Cases of internal corrosion,	695	43
Cases of external corrosion,	559	40
Broken and loose braces and stays,	264	189
Settings defective,	337	29
Furnaces out of shape,	454	22
Fractured plates,	376	50
Burned plates,	297	38
Blistered plates,	140	3
Cases of defective riveting,	2,249	65
Defective heads,	95	19
Serious leakage around tube ends,	2,896	209
Serious leakage at seams,	407	22
Defective water-gauges,	290	81
Defective blow-offs,	235	64
Cases of deficiency of water,	17	6
Safety-valves overloaded,	143	64
Safety-valves defective in construction,	104	31
Pressure-gauges defective,	493	32
Boilers without pressure-gauges,	23	23
Unclassified defects,	618	0
Total,	14,384	1,213

NOVEMBER, 1899.

During this month our inspectors made 10,063 inspection trips, visited 19,355 boilers, inspected 6,415 both internally and externally, and subjected 796 to hydrostatic pressure. The whole number of defects reported reached 13,054, of which 1,156 were considered dangerous; 54 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	930	55
Cases of incrustation and scale,	2,334	79
Cases of internal grooving,	139	10
Cases of internal corrosion,	553	41
Cases of external corrosion,	529	22
Broken and loose braces and stays,	243	37
Settings defective,	323	15
Furnaces out of shape,	360	16
Fractured plates,	331	42
Burned plates,	306	43
Blistered plates,	194	3
Cases of defective riveting,	1,654	154
Defective heads,	66	9
Serious leakage around tube ends,	3,014	441
Serious leakage at seams,	495	35
Defective water-gauges,	304	43
Defective blow-offs,	203	41
Cases of deficiency of water,	17	4
Safety-valves overloaded,	67	7
Safety-valves defective in construction,	94	21
Pressure-gauges defective,	298	34
Boilers without pressure-gauges,	4	4
Unclassified defects,	596	0
Total,	13,054	1,156

The Locomotive.

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Vol. XXI. HARTFORD, CONN., FEBRUARY, 1900. No. 2.

Boiler Explosion in an Iron Works.

We present, in this issue, several engravings showing the damage done by a water-tube boiler which exploded recently in an iron works, causing the death of eight men and more or less seriously injuring two others, besides doing a large amount of damage to property. The boiler was of the upright type, and consisted of an upper and lower drum, united by vertical tubes containing water. The explosion consisted in the failure of the tube-sheet of the upper drum, the tubes pulling out of this sheet, while the upper

Fig. 1.—General View of the Ruins.

drum itself, weighing about a ton and a half, was thrown up through the roof of the building and, after passing over numerous buildings, fell into an alleyway 660 feet from its original position. The ruins of the building in which the boiler stood fell back on the furnaces and took fire. A scene of the wildest excitement followed. Fire companies hurried to the place in response to a double alarm, and patrol wagons and ambulances joined them. The noise of the explosion beggared description. The concussion shook the buildings for squares around, and the echo of the report resounded from hill to hill, across the neighboring river and down the valley, for a time that seemed to be

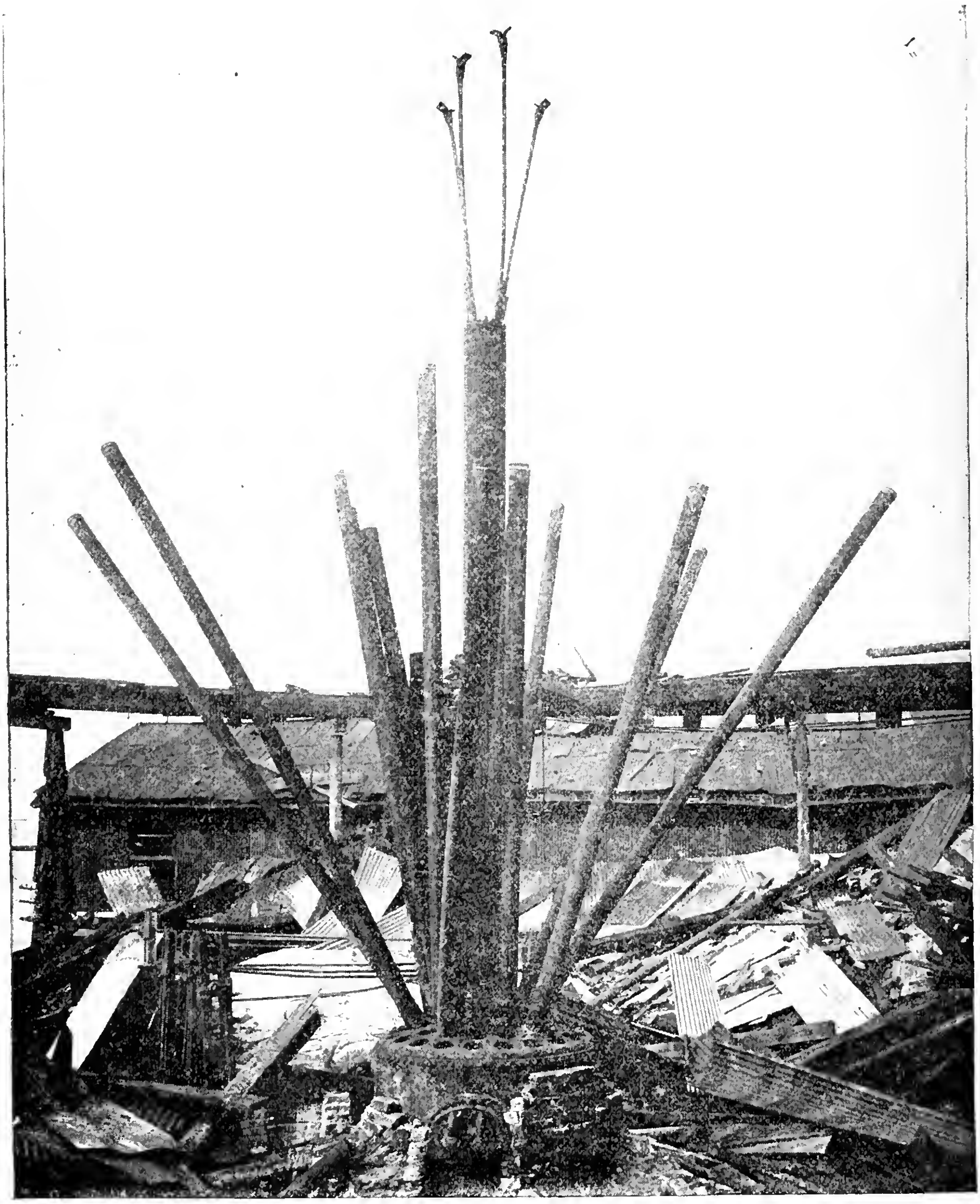

FIG. 2.— SHOWING THE EXPLODED BOILER IN DETAIL.

measured by minutes. Everybody in the neighborhood was instantly awakened; and, although the explosion occurred in the middle of the night, thousands of persons were soon on the scene, and other thousands joined them as daylight approached.

As the drum shot upward through the roof, liberating the steam and water from the tubes to which it had been attached, everything around the boiler was blown away. Large timbers were hurled against the main supports of the roof, twisting them or knocking them away, bringing down the roof with a thunderous crash, and pinning under it many of the men who had escaped the direct effects of the explosion. The fire which broke out in the ruins was bravely fought by the department, but it was impossible to bring it under immediate control, and a number of the injured were burned to death in spite of the most heroic efforts to save them. Some idea of the extent of the property loss may be had from an inspection of the accompanying photo-engravings.

The explosion here represented offers one element of decided novelty, which we

Fig. 3.—Showing where the Upper Drum Fell.

proceed to discuss. The upper drum, as we have said, was thrown to a distance of 660 feet from its original position. This fact, in itself, is not remarkable, for one of the most common and dangerous accompaniments of a boiler explosion is the projection of the parts of the boiler and its attachments to a greater or less distance, with a varying amount of destruction, according to the impetus of the fragments and the nature of the surroundings. An explosion of a boiler in a North Carolina mill, a few years ago, demolished the brick house in which the boiler was located, and one of the fragments of the boiler then passed through the second story of an adjacent building, where it carried everything before it. The fragment continued in its career, and eventually landed in a

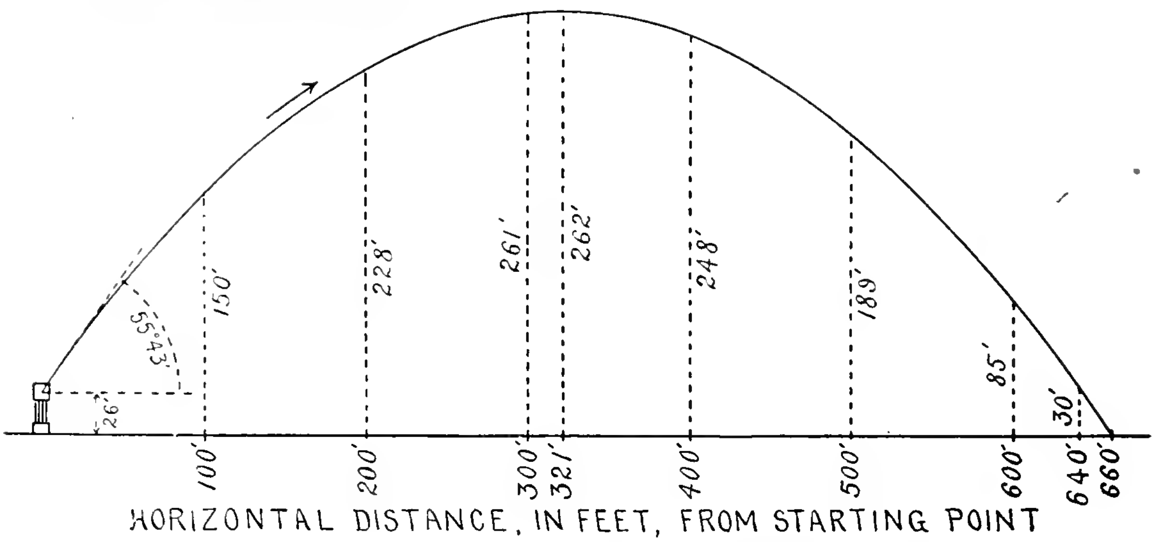

FIG. 4.—MATHEMATICAL DETAILS OF THE TRAJECTORY.

swampy piece of woods, after cutting off the tops of twenty-four trees and saplings in its flight, the largest of which was an ash tree whose trunk was cut off clean and clear, about four feet from the ground. When found it was partly imbedded in the earth, fully 1,200 feet from its starting-point; and upon tracing its course backward it was seen that it had passed over several dwelling-houses on the way, although, happily, it was then at too great a height to do them any harm. In the present case the projected fragment traveled only about half as far; but it so happens that we have data enough at hand to determine its entire trajectory, from the instant of the explosion up to the time the fragment again struck the ground.

It is a well-known fact in theoretical mechanics, that if three points in the path of a projectile are known, the whole path can be determined. The place from which it starts

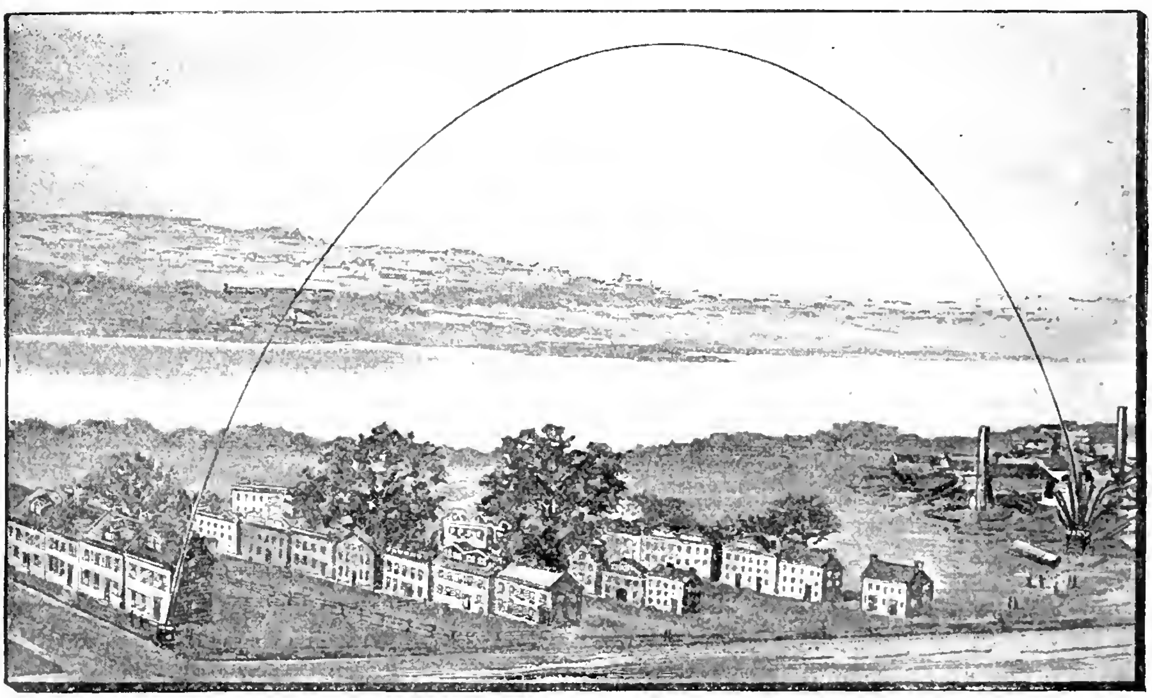

FIG. 5.—PERSPECTIVE VIEW OF THE TRAJECTORY.

and at which it lands furnish *two* of these points, but in order to be able to calculate the path that it followed, we must know some further fact about its motion, and it is sufficient if we know some other point that it passed through in its career. Ordinarily, we are not able to determine any such point in the case of flying fragments of exploded boilers. In the present instance, however, it happened that the drum struck against the corner of a wooden house as it fell to the ground, injuring the house in the manner indicated in Fig. 3; and a careful inspection of the damaged area showed that the course of the boiler as it brushed against the house could be determined with some approach to accuracy. It was estimated, in this way, that when the fragment had fallen so that its center was thirty feet above its position when upon the ground, it still had twenty feet to travel, in a horizontal direction, before striking the ground. It was also determined that the general course of the fragment was not materially changed by its collision with the house. The center of the drum was 26 feet higher, at the moment of the explosion, than when it again came to the ground; and the total horizontal distance traversed was 660 feet.

With these data given, it is no hard matter to determine all the circumstances of the motion of the fragment. We shall not enter into the details of the calculation, but will merely give the various final results, which are as follows:

The drum started off with a velocity of 149 feet per second, its initial course being directed upwards so as to make an angle of 55° 43′ with the horizontal. After traveling 3.83 seconds it reached the highest point of its course, it being, at this instant, at a horizontal distance of 321 feet from its initial position, and at a height of 262 feet above the ground (*i. e.*, 262 feet higher than its position at the moment of striking the ground again). It then began to fall, and 4.03 seconds after passing the highest point of its path, it struck the ground again. The total time of its flight was therefore 7.86 seconds.

We give certain of the mathematical elements of the trajectory in Fig. 4, and in Fig. 5 we present a sort of bird's-eye view of the course that the flying shell followed, so that the general character of its trajectory may be more clearly comprehended. Fragments of exploding boilers are often thrown to much greater distances than this one, as we have already said. Professor R. H. Thurston has shown, for example, in his little book on *Steam Boiler Explosions*, that in certain cases for which he gives numerical data, the energy stored in the boilers that he discusses would be sufficient to throw the whole boiler straight upward into the air to a height of from one to four miles. The particular data upon which he bases these results are well within the limits of ordinary practice, too, so that his conclusions are by no means fanciful nor extravagant. The reason that these great heights of projection are not attained in actual explosions is, that the total energy present is commonly liberated *in all directions*, so that only a relatively small portion of it is expended in actually raising the boiler itself from the ground, the balance being wasted in the surrounding air, or (as is too often the case) in destroying surrounding property.

Boiler Explosions.

SEPTEMBER, 1899.

(253). — The electric light plant at Ashley, Ind., was completely destroyed, on September 1st, by a boiler explosion. Engineer James Dunfee was talking with his wife in a room on the opposite side of the building when the explosion occurred. Mrs. Dunfee was terribly injured by the falling wreckage, so that she died a few days later. The engineer himself was also very badly hurt, though it is believed that he will recover. The plant was totally wrecked, and the property loss is variously estimated at from $7,000 to $10,000. The *National Engineer* for November gives a photo engraving of one of the heads, which was thrown to a distance of 500 feet or so.

(254.) — On September 1st a boiler exploded in the Chapman & Sargent Bowl and Tray factory, at Copemish, some thirty miles north of Manistee, Mich. Lee Estabrook, Charles Handy, and Perry Malafant were killed, and Howard Ketchum, Robert Peterson, Oliver Saunders, and Charles Taylor were injured so badly that two of them, at least, will undoubtedly die. George Rice was also scalded severely. The property loss is estimated at about $5,000.

(255.) — A boiler exploded, on September 1st, on William R. Pritchard's "Recess" plantation, in South Carolina, just across the river from Savannah, Ga. The exploded boiler was torn in fragments, and its parts were thrown to great distances, many of them being found a mile or more from the mill. Two other boilers were practically destroyed also, one of them being thrown to a distance of half a mile, while the other was thrown about half that distance. Richard Green and William Gillard were slightly injured. We do not know the extent of the property loss, but it must have been large, as the plant was worth about $30,000, and was considerably damaged. One fragment of the exploded boiler passed through a high brick chimney in its course, tumbling it down into a heap of debris. The fragment of the boiler which did this was not sensibly checked in its career by the collision, but traveled on for fully half a mile before it finally came to rest.

(256.) — On September 1st, a hot water boiler exploded in the basement of the Gramercy Park Hotel, New York City. Charles Ebbloc and Charles Singleton were scalded about the head and body, and bruised by falling bricks, and were removed to the Bellevue Hospital, where Ebbloc died. The boiler stood next to a brick wall, 12 inches thick, and a great part of this wall was thrown down. We do not know the amount of the property loss.

(257.) — A safety boiler exploded, on September 1st, in the Republic Iron Works, at Pittsburg, Pa. David Mathews, John Warzyski, William Thomas, Joseph Pytler, and Thomas Bevans were killed outright, and Frederick Herb, Malachi Danahy, and Neil Danahy died from their injuries shortly afterwards. John Evans and Steven Milakoski were also severely injured. The property loss was estimated at over $6,000, and the coroner's jury found that the cause of the explosion was low water.

(258.) — A boiler exploded in Chicago, on September 4th, and injured Frank Hopkins so badly that he died five days later, at the Presbyterian Hospital. We have not learned further particulars.

(259.) — A boiler at Allen Huffman's cider press, at St. Paris, O., exploded on September 5th, wrecking the plant and injuring Allen Huffman, Bailey Huffman, Benjamin Apple, David Poorman, and Bentley Beckwith. Mr. Apple has since died.

(260.) — On September 5th, a boiler exploded in John Weller's mill, at Dundee, near Montpelier, Ind. Elmer Weller was instantly killed, and John Weller and John Smithgall were severely injured. The mill was totally wrecked. The force of the explosion may be inferred from the fact that one of the tubes was thrown through the weather-boarding of a church, a quarter of a mile away.

(261.) — On September 7th, a slight boiler explosion occurred in the Republic Iron & Steel Company's rolling mill, at Toledo, O. (A similar explosion occurred in the same plant, on August 30th, as will be seen by the list of explosions published in our January issue.)

(262.) — Samuel Ifest was severely scalded and bruised, on September 8th, by the explosion of a boiler connected with the Iowa Central water tank, near Winfield, Ia. The boiler-house was almost totally wrecked.

(263.) — On September 8th, a boiler of engine No. 555, pulling a Rock Island north bound freight train, exploded, about a mile north of Fairview, Kan. Engineer Thomas Lee, Fireman Henry Meadows, and Brakeman A. H. McDowell, were all seriously scalded. The locomotive was blown from the track and torn almost to atoms. The engine had been inspected a week before, and was considered to be in good condition. Later information shows that Fireman Meadows has since died.

(264.) — The boiler of a threshing outfit, belonging to Hixson Bros., exploded on September 9th, on the Lester farm, near Newton, Ia. William Benjamin was scalded, and his brother, David Benjamin, was also burned and otherwise injured. In connection with this explosion, we find the not infrequent theory advanced that some "miscreant" had placed an "infernal bomb" inside of the boiler. The theory is even elaborated in the present case, as follows: "Said bomb was covered with some substance soluble only in hot water and with a potassium cap that would ignite as soon as water touched it. The bomb got to the bottom under the ash pit, and when the water got hot, after about four hours' work, the wax, or covering, melted, the cap ignited, and the boiler burst in a place where no one expected it to occur." We think this is the most elaborate theory of an intentional boiler explosion that we have yet seen!

(265.) — The crown sheet blew out of a threshing engine boiler belonging to Warren L. Sisler, near Redwood Falls, Minn., on September 11th. Nobody was injured. The necessary repairs cost about $400.

(266.) — A flue burst, on September 12th, in the power plant of the Terre Haute Electric Co., at Terre Haute, Ind. Fortunately nobody was injured.

(267.) — On September 13th a boiler exploded at the dry docks of the West Shore Railroad, at Weehawken, N. J., wrecking the building. George Hall was injured so badly that he died on the following day.

(268.) — A boiler exploded on September 14th, in the Penn Tack Works, at Norristown, Pa. One side of the boiler house was blown out, and the loss was considerable, but fortunately no person was injured.

(269.) — On September 14th a boiler exploded in the New Orleans Preserve Works, on the levee at the head of Lyon Street, New Orleans, La. The damage was not large, and nobody was hurt.

(270.) — On September 15th, a boiler used to operate a steam shovel belonging to Schultz & Gannon, contractors, exploded at Hayden, near North Vernon, Ind. Charles Kiefer was scalded so badly that he will be a cripple for life, and two other men received lesser injuries.

(271.) — A boiler exploded, on September 16th, in Andrew Ward's mill, at Wellsburg, near Albion, Pa. The boiler house was utterly destroyed, but nobody was in it at the time. The only person injured was the proprietor himself, who was in the basement of the main building, and who was severely hurt by the falling fragments of wreckage.

(272.) — A boiler exploded, on September 17th, in Charles Hall's sawmill, one mile west of Vibbard, Mo. Fireman Green Brooks was injured so badly that he died a few hours later. Henry Clevenger and Charles Hall (the proprietor) were also badly scalded and bruised, but it is believed that both will recover. The mill was entirely demolished.

(273.) — A boiler exploded, on September 18th, in Samuel Moore's sawmill, at Findlay, O. Grover Stump was badly hurt, and it is thought that he cannot recover. Several other men also received lesser injuries.

(274.) — A boiler used for cooking cocoanut candy exploded, on September 18th, in the factory of the Lancaster Caramel Co., at Reading, Pa. Five hundred pounds of the candy were distributed, gratis, in all directions. Two of the employes were severely injured in the panic which ensued. The loss was only about $500.

(275.) — The boiler of Marshall, Griffith & Co.'s threshing machine exploded, on September 18th, while the outfit was in operation on C. Odell's farm, some two miles northeast of Greeley, near Manchester, Ia. The boiler was destroyed, but nobody was injured.

(276.) — Mr. John R. Franey was killed, on September 18th, by the explosion of the boiler of a Northern Pacific Railroad locomotive, on which he was fireman. The accident occurred near Tacoma, Wash. We have not received further particulars.

(277.) — On September 23d a boiler exploded on the Steamer *Cherokee*, which was ashore on Naushon Island, near Woods Holl, Mass. Nobody was injured, although fully one hundred men were at work near by.

(278.) — A boiler exploded, on September 25th, in D. P. Hearn & Co.'s cotton-gin, near Palmetto, Ga. D. P. Hearn, J. P. Hearn, and Penn Hearn were killed outright, and several others were severely shocked. The boiler-house was torn to fragments.

(279.) — On September 25th a boiler exploded in Henderson Mangis' cotton-gin, near Brownsville, I. T. Grant Corder, J. A. Steel, David Jones, and a sister of the latter, were killed, and several others received minor injuries. The building in which the boiler stood was demolished.

(280.) — A small boiler, used for rendering lard, exploded, on September 26th, in Warrall's slaughter-house, at West Chester, Pa. Fortunately, none of the workmen were injured.

(281.) — A boiler exploded, on September 26th, in McLellan's sawmill, at Auburn, Ind. Waldo Shutt was instantly killed, and William Richmond, George Keester, and Frederick Gouley were badly injured. Several other employes also received minor injuries. The building and machinery were destroyed. The boiler was a new one, and was thought to be in good condition.

(282.) — On September 27th the boiler of a threshing machine exploded, on the farm of Henry Brandt, in Red Rock Township, some five miles north of Valley Springs, Minn. Mr. Brandt was instantly killed, and Frederick Lance and Robert Smith were seriously injured.

(283.) — A boiler exploded, on September 27th, near Rutherfordton, N. C. Two men were fatally scalded, and another man received serious injuries, from which, however, he will recover. Fragments of the boiler were thrown to a distance of a thousand feet, and some of them, in their course, cut off trees as large as 16 inches in diameter

The Locomotive.

HARTFORD, FEBRUARY 15, 1900.

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

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

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Sterilization of Drinking Water by Boiling.

In the prevalent low state of the water supply in certain parts of the country, it has become necessary in a number of cities (Hartford being one of them) to eke out the regular supply by drawing from some auxiliary source that would not ordinarily be considered good enough to use. The public has therefore been unusually interested to know what methods, if any, can be relied upon for the practical purification of water known, or believed, to contain the germs of disease.

It is important to understand that it is not the mere presence of *organic matter* in water which makes it dangerous to drink. Organic matter may, indeed, produce irregularities of the bowels, and perhaps feverishness and much general discomfort and distress; but an actual case of typhoid fever cannot be contracted without swallowing the specific germ, or spore, or *seed*, of a certain microscopic plant whose subsequent growth and multiplication in the intestine gives rise to the definite symptoms by which the disease is distinguished. The important question, then, is how to remove these germs from the water, or how to destroy their vitality. The first remedy to suggest itself is *filtration;* but filtration, as it is ordinarily practiced, is of no value whatever for this purpose. The typhoid germs are so small that a thousand or so of them could easily march abreast through a pin-hole; and when this fact is comprehended, it is easy to understand that no ordinary filter can stop their passage. They will pass through the interstices or pores of the filter, and are just as dangerous afterwards as they were before. An interesting case illustrating the inefficacy of filtration is quoted on page 74 of Dr. Floyd Davis's little book on *Potable Water.* "In August, 1872," he says, "an outbreak of typhoid fever occurred at Lausen, near Basel, in Switzerland. The village water supply was from a spring at the foot of the Stockhalden. Suspicion was directed to this water, for it was found that the six houses using well water were free from the disease, while scarcely one of those using the spring water escaped. Upon investigation it was found that typhoid fever had occurred at a farmhouse on the opposite side of the Stockhalden, and that the drainage from this house went into a brook, a part of which disappeared into the mountain about a mile from Lausen. Large quantities of salt were thrown into the stream, and the salt was soon detected in the Lausen supply, thus proving the connection between the two. Several hundred pounds of flour were then thrown into the stream, but not a trace of it was found in the water supply, showing that the water had been thoroughly filtered in passing through the mountain. The case was elaborately investigated by Dr. A. Hagler of Basel, and is of the greatest interest in showing that the most thorough filtration through soil is insufficient to remove typhoid fever germs from polluted water."

Leaving filtration out of account, as being an unreliable means of purification when applied with the devices that are practicable for general household use, we find that of the really effective methods of sterilization, the simplest and by far the most convenient is by *boiling* the water. Somebody, having this fact in mind, has remarked that water is one of the few really dangerous articles of diet that we consume *raw*. The vitality of certain kinds of microscopic spores, as evinced by their resistant powers even when exposed to the boiling temperature, is truly wonderful. It may be profitable to quote Dr. Davis once more on this point. "By boiling polluted water," he says, on page 78, "the living organisms in it may be entirely destroyed. Fungi and algæ are easily killed in this way ; but to destroy some bacteria [to which class of organisms the typhoid germ belongs], heat must be applied for several hours to the water containing them. Professor Tyndall has shown that there are periods in the life of bacteria when they can resist the action of boiling water ; but, as they soften before propagation, water containing them can be completely sterilized by repeated boiling, for, at the proper time, this not only destroys the bacteria themselves, but destroys their spores [or seeds] as well. In order, then, to guard ourselves against these organisms, polluted water should never be used for drinking without first being boiled for some two or three hours, as this prolonged operation thoroughly sterilizes it. Indeed, it is perhaps true that the two most effective measures which can be taken in avoiding zymotic diseases consist in boiling all the water and milk that we use for drinking."

While it is true that *certain kinds* of bacteria can survive the boiling temperature for a considerable time, we are not aware of any case in which typhoid fever is known to have been contracted from drinking water that has been thoroughly boiled for ten or twenty minutes. Twenty minutes, we think, is about the length of time that hospitals boil the water that they wish to sterilize for drinking purposes; and a much commoner practice (and a safe one, we think, unless the supply is known to be dangerously infected) is to boil the water for *ten minutes*. This, we are inclined to believe, will ensure the death of the specific microbe that produces typhoid fever. Janowski found that a ten-minute exposure to a temperature of 131° Fahr. killed all the typhoid germs that he was growing experimentally, in his laboratory. It is a different thing, however, to kill a few million germs in a test-tube, which nobody is going to swallow, and to engage in the practical operation of sterilizing drinking water for the use of one's family and one's self; and it is not wise to rely upon the sterilizing power of heat unless the water under treatment has been in *full ebullition* for at least ten minutes.

Professor Rowland on Scientific Research.

Professor Henry A. Rowland, of Johns Hopkins University, is president of the newly formed American Physical Society, and at its first meeting, on October 28th, he chose, as the subject of his presidential address, "The Highest Aim of the Physicist." We cannot print the address in full, but its closing paragraphs are so vigorous and striking that we reproduce them below:

"The ideal scientific mind must always be held in a state of balance, which the slightest new evidence may turn in one direction or another. It is in a constant state of skepticism, knowing full well that nothing is certain. It is above all an agnostic with respect to all facts and theories of science, as well as to all other so-called beliefs and theories. Yet it would be folly to reason from this that we need not guide our lives according to the *approach* to knowledge that we possess. Nature is inexorable; she punishes the child who unknowingly steps off a precipice quite as severely as she does the grown scientist who steps over with full knowledge of all the laws of falling bodies, and of the chances of their being correct. Both fall to the bottom, and in their fall obey the gravitational laws of inorganic matter, slightly modified by the muscular contortions of the falling object, but not in any degree changed by the previous belief of the person. Natural laws there probably are, rigid and unchanging ones at that. Understand them, and they are beneficent; we can use them for our purposes and make them the slaves of our desires. Misunderstand them, and they are monsters who may grind us to powder or crush us in the dust. Nothing is asked of us as to our belief: they act unswervingly, and we must understand them or suffer the consequences. Our only course, then, is to act according to the chances of our knowing the right laws. If we act correctly, right; if we act incorrectly, we suffer. If we are ignorant, we die. What greater fool, then, than he who states that belief is of no consequence, provided it is sincere!

"An only child, a beloved wife, lies on a bed of illness. The physician says that the disease is mortal; a minute plant called a microbe has obtained entrance into the body and is growing at the expense of its tissues, forming deadly poisons in the blood or destroying some vital organ. The physician looks on without being able to do anything. Daily he comes and notes the failing strength of his patient, and daily the patient goes downward until she rests in her grave. But why has the physician allowed this? Can we doubt that there is a remedy which shall kill the microbe or neutralize its poison? Why, then, has he not used it? He is employed to cure, but has failed. His bill we willingly pay, because he has done his best, and has given a chance of cure. The answer is *ignorance.* The remedy is yet *unknown.* The physician is waiting for others to discover it, or perhaps is experimenting himself, in a crude and unscientific manner, to find it. Is not the inference correct, then, that the world has been paying the wrong class of men? Would not this ignorance have been dispelled had the proper money been used in the past to dispel it? Such deaths some persons consider to be acts of God. What blasphemy to attribute to God that which is due to our own and our ancestors' selfishness, in not founding institutions for medical research in sufficient number and with sufficient means to discover the truth. Such deaths are murder. Thus the present generation suffers for the sins of the past, and we die because our ancestors dissipated their wealth in armies and navies and in the foolish pomp and circumstance of society, and neglected to provide us with a knowledge of natural laws. In this sense they were the murderers and robbers of future generations of unborn millions, and they have made the world a charnel house and a place of mourning, where peace and happiness might have been. Only their ignorance of what they were doing can be their excuse; but this excuse puts them in the class of boors and savages, who act according to selfish desire, and not to reason and to the calls of duty. Let the present generation take warning that this reproach be not cast on it, for it cannot plead ignorance in this respect.

"This illustration from the department of medicine I have given because it appeals to all. But all the sciences are linked together, and all must advance in concert. The human body is a chemical and physical problem, and chemistry and physics must advance before we can conquer disease. But the true lover of physics needs no such spur to his actions. The cure of disease is a very important object, and nothing can be nobler than a life devoted to its cure. The aims of the physicist, however, are in part purely intellectual: he strives to understand the universe on account of the intellectual pleasure derived from the pursuit, but he is upheld in it by the knowledge that the study of nature's secrets is the ordained method by which the greatest good and happiness shall finally come to the human race. Where, then, are the great laboratories of research in this city,—in this country,—nay, in the *world?* We see, indeed, a few miserable structures here and there, occupied by a few starving professors who are nobly striving to do the best with the feeble means at their disposal. But where, in all the world, is the institute of pure research in any department of science, with an income of $100,000,000 a year? Where can the discoverer in pure science earn more than the wages of a day laborer or a cook? But $100,000,000 a year is but the price of an army or of a navy, designed to kill other people. Just think of it, that *one per cent.* of this sum seems, to most persons, too great to expend for the purpose of saving our children and descendants from misery and even death!

"But the twentieth century is near. May we not hope for better things before its end? May we not hope to influence the public in this direction? Let us go forward, then, with confidence in the dignity of our pursuit. Let us hold our heads high with a pure conscience while we seek the truth; and may the American Physical Society do its share, now and in generations yet to come, in trying to unravel the great problem of the constitution and laws of the universe."

Inspectors' Reports.

DECEMBER, 1899.

During this month our inspectors made 9,036 inspection trips, visited 20,469 boilers, inspected 6,911 both internally and externally, and subjected 795 to hydrostatic pressure. The whole number of defects reported reached 12,550, of which 747 were considered dangerous; 55 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,070	73
Cases of incrustation and scale,	2,684	71
Cases of internal grooving,	157	18
Cases of internal corrosion,	722	21
Cases of external corrosion,	498	22
Broken and loose braces and stays,	164	44
Settings defective,	306	32
Furnaces out of shape,	431	20
Fractured plates,	333	47
Burned plates,	272	29
Blistered plates,	157	7
Cases of defective riveting,	1,709	67
Defective heads,	72	14
Serious leakage around tube ends,	2,346	99
Serious leakage at seams,	392	19
Defective water-gauges,	273	51
Defective blow-offs,	177	31
Cases of deficiency of water,	10	6
Safety-valves overloaded,	89	23

Nature of Defects.	Whole Number.	Dangerous.
Safety-valves defective in construction,	85	16
Pressure-gauges defective,	387	26
Boilers without pressure-gauges,	11	11
Unclassified defects,	205	0
Total,	12,550	747

Summary of Inspectors' Reports for the Year 1899.

During the year 1899 our inspectors made 112,464 visits of inspection, examined 221,706 boilers, inspected 85,804 boilers both internally and externally, subjected 9,371 to hydrostatic pressure, and found 779 unsafe for further use. The whole number of defects reported was 157,804, of which 12,800 were considered dangerous. A summary of the work by months is given below, and the usual classification by defects is likewise given:

Summary by Months, for 1899.

Month.	Visits of inspection.	Number of boilers examined.	No. inspected internally and externally.	No. tested hydro-statically.	No. con-demned.	Number of defects found.	Number of dangerous de-fects found.
January,	9,697	19,474	6,034	526	77	12,046	1,148
February,	8,018	16,314	4,952	540	62	9,780	929
March,	9,982	19,550	6,279	635	63	12,874	1,094
April,	9,237	18,280	7,646	793	53	13,799	969
May,	9,536	18,148	7,713	854	69	14,250	1,257
June,	9,066	16,976	8,466	847	57	14,390	1,131
July,	9,225	17,922	9,492	855	98	17,668	1,380
August,	9,116	17,400	7,016	898	57	10,839	810
September,	9,238	17,865	7,374	925	57	12,170	966
October,	10,250	19,953	7,566	907	77	14,384	1,213
November,	10,063	19,355	6,415	796	54	13,054	1,156
December,	9,036	20,469	6,911	795	55	12,550	747
Totals,	112,464	221,706	85,804	9,371	779	157,804	12,800

Summary, by Defects, for the Year 1899.

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	11,974	740
Cases of incrustation and scale,	29,052	817
Cases of internal grooving,	1,602	140
Cases of internal corrosion,	8,489	424
Cases of external corrosion,	7,018	482
Defective braces and stays,	2,166	809
Settings defective,	3,990	304
Furnaces out of shape,	4,820	238
Fractured plates,	3,622	512
Burned plates,	3,361	386
Blistered plates,	1,952	74

Nature of Defects.	Whole Number.	Dangerous.
Defective rivets,	24,550	1,358
Defective heads,	1,165	206
Leakage around tubes,	31,583	3,403
Leakage at seams,	4,783	313
Water-gauges defective,	3,253	626
Blow-outs defective,	2,059	581
Cases of deficiency of water,	188	80
Safety-valves overloaded,	972	433
Safety-valves defective,	1,028	275
Pressure-gauges defective,	4,947	394
Boilers without pressure-gauges,	203	203
Unclassified defects,	5,027	2
Total,	157,804	12,800

COMPARISON OF INSPECTORS' WORK DURING THE YEARS 1898 AND 1899.

	1898.	1899.
Visits of inspection made,	106,128	112,464
Whole number of boilers inspected,	208,990	221,706
Complete internal inspections,	78,349	85,804
Boilers tested by hydrostatic pressure,	8,713	9,371
Total number of defects discovered,	130,743	157,804
" " of dangerous defects,	11,727	12,800
" " of boilers condemned,	603	779

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

GRAND TOTAL OF THE INSPECTORS' WORK SINCE THE COMPANY BEGAN BUSINESS, TO JANUARY 1, 1900.

Visits of inspection made,	1,416,621
Whole number of boilers inspected,	2,814,398
Complete internal inspections,	1,083,571
Boilers tested by hydrostatic pressure,	152,395
Total number of defects discovered,	2,049,143
" " of dangerous defects,	232,348
" " of boilers condemned,	12,433

We append, also, a summary of the work of the inspectors of this company from 1870 to 1899 inclusive. The years 1876 and 1878 are omitted, because the data that we have at hand for those years is not complete. The figures, so far as we have them, indicate that the work during those years was in good accordance with the general progression observable in other years. Previous to 1875 it was the custom of the company to publish its reports on the first of September, but in that year the custom was changed and the summaries were made out up to January 1st, so as to agree with the calendar year. The figures given opposite 1875, therefore, are for sixteen months, beginning September 1, 1874, and ending December 31, 1875.

SUMMARY OF INSPECTORS' WORK SINCE 1870.

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

The Locomotive.

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A Landslide Explodes a Boiler.

We are often asked to give a general reason why boilers explode; and the only reason that it is possible to give, which will be broad enough to cover the great number of special causes is, that the boiler was not strong enough to hold the pressure. In other words, it gave way because it couldn't hold together! Unintelligent as this reply may appear to be, it is really all that can be given, in the way of a general explanation of boiler explosions. If it is asked *why* the erring boiler couldn't hold together, we are at once led into a long list of possible explanations, involving questions of design,

FIG. 1. — GENERAL VIEW OF THE RUINED QUARRY.

material, workmanship, and subsequent supervision and management. Nothing is more certain than the fact that there is no one tangible cause of weakness in boilers upon which a warning finger can be laid, so as to assure the owner of the boiler that if this one source of peril be avoided, he need fear no harm. We are well aware that the general public believes that low water is the one cause of explosions. The low water idea, in fact, has taken such complete possession of the minds of the uninstructed, that whenever an explosion occurs, it is the one prominent explanation that is advanced; and the local theorists appear to be universally afflicted with a sort of low-water frenzy,

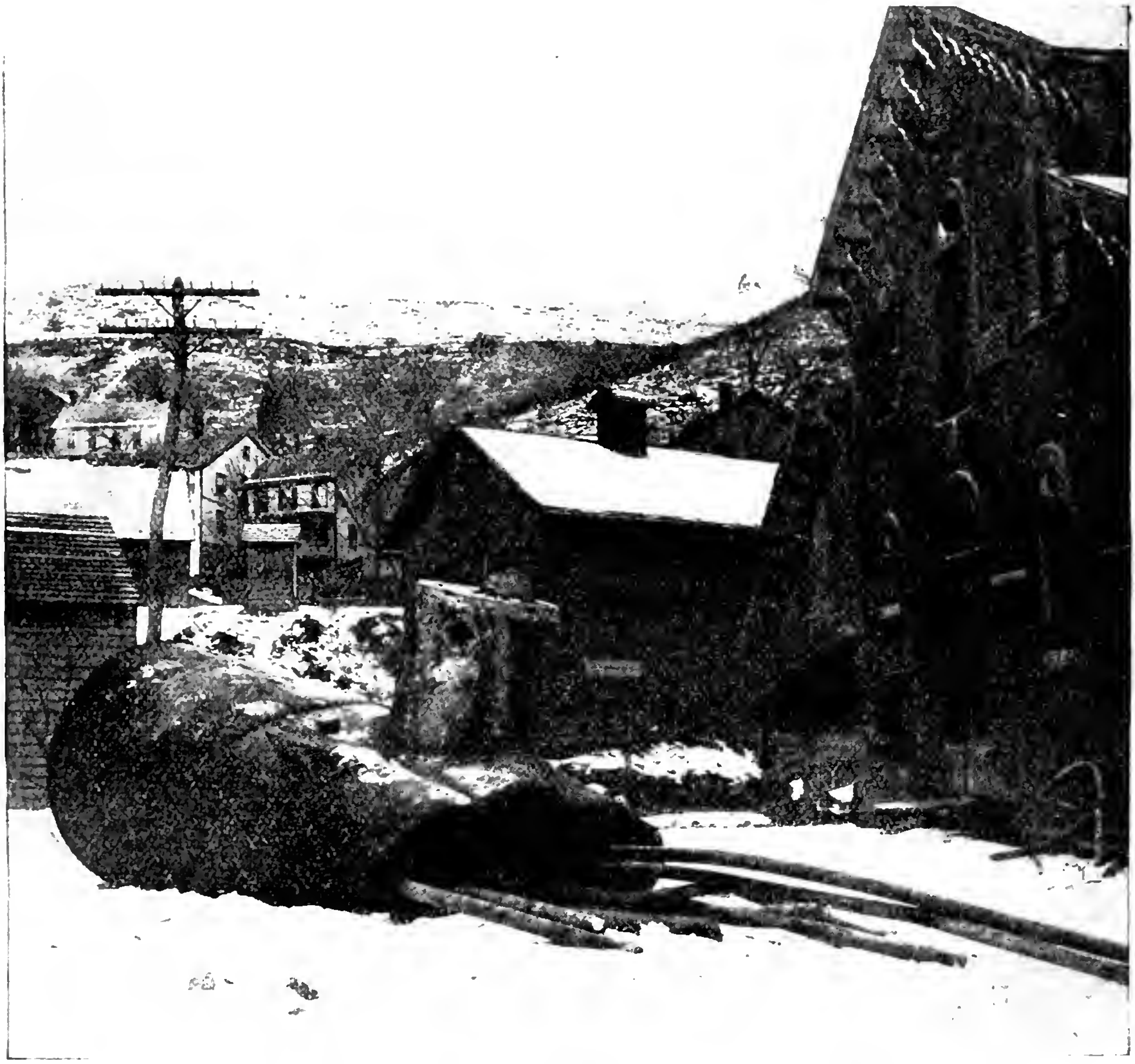

Fig. 2.—Forward Part of the Boiler, After the Explosion.

tempered, perhaps, by a suspicion that some miscreant (we believe "miscreant" is the usual word!) has been salting the coal-pile with giant powder or dynamite or lyddite or some other terrible explosive.

Sometimes, however, an explosion occurs under such circumstances that the most ardent disciple of the low water theory finds it hard to make his hobby apply. Such a case is illustrated by the engravings which accompany this article, and which relate to the boiler explosion that occurred, on December 19th, at the quarry of the New York and Rosendale Cement Company, at Rosendale, N. Y. The primary cause of this explosion was the caving in of the quarry, and the general appearance of the place after the accident is shown in Fig. 1. A slight fall of rock occurred early in the day, and drew attention to the possibility of further trouble. A number of the men who were at work about the place were ordered away by the superintendent, but the roadway, which ran along beside the canal, directly under the kilns and other buildings of the cement company, was still used by passers. About noon the final cave-in occurred, and a great many thousands of tons of rock fell down, burying the roadway completely, and practically sweeping the cement works out of existence. Some of the masses of rock struck the supports of the bridge of the Wallkill Valley railroad (which is shown on the left of Fig. 1) and damaged it considerably. One of the stone abutments which enclosed and supported the ironwork of the bridge was demolished and thrown into the canal.

The boiler that was used to operate the quarry was situated about where the small white cross appears in Fig. 1. A mass of rock, weighing about 15 tons, struck the boiler near the back head, and caused an explosion which was distinctly heard at Rock Lock, a mile and a half away. The rear sheet of the boiler and the back head were pinned down by the falling mass of rock. Every rivet was sheared in the girth joint which united this sheet to the rest of the boiler. The middle sheet was also flattened to some extent, apparently by the direct impact of the falling rock upon that part of the rear sheet which adjoined it. The front part of the boiler, consisting of the front head and front and middle sheets, went into the air about 100 feet, striking obliquely against the supports of the railroad bridge, and falling in the roadway, about 200 feet from its starting point. This part of the shell is shown in Fig. 2. It carried the tubes with it, and, although some of them dropped out during the flight through the air, a considerable number of them still remained attached to the shell when it fell, as will be seen in the engraving. The boiler was 60 inches in diameter and 16 feet long, with 76 3-inch tubes.

That nobody was killed or seriously injured, either by the land-slide or by the explosion of the boiler, was doubtless due to the premonitory evidences of the impending trouble, which were perceived earlier in the day, and which we have already mentioned above. The roadway which was buried under the débris was still in use, but it chanced that nobody was passing upon it at the moment of the accident. A tow-path runs between the roadway and the bank of the canal, however, and two men who were walking along this path narrowly escaped death. Hearing the rocks above them begin to crack and move, they ran for safety, and had passed under the railroad bridge and into a place of comparative security, when the front section of the boiler (shown in Fig. 2) crashed down into the roadway within 15 feet of where they stood. The only men who were injured at all were Richard Markle and Bradley Smith, who were thrown down and somewhat bruised and cut.

The question will naturally arise, whether the Hartford Steam Boiler Inspection and Insurance Company would be liable or not in a case of this kind, provided it was carrying a policy of insurance on the boiler. The answer is, that it would *not* be liable in such a case. Our policies contemplate the possible destruction of life and property by an accident in which the boiler is the *primary* cause of the trouble. Those of our patrons who have had claims against us will certify that we have always been very liberal in adjusting our losses, and that we have never been disposed to split hairs, nor to take advantage of those points of law that are sometimes too fine to be seen with the naked eye. We have always tried to adjust our losses with perfect equity, both because that is the honorable thing to do, and because it is also a good sound business principle. But we are always insuring against what the *boiler* may do, on its own initiative, and not against what earthquakes and landslides and cyclones and falling buildings may do. In the present case we might have insured the boiler against destroying the quarry, but we should not have insured the quarry against destroying the boiler.

Inspectors' Report.

JANUARY, 1900.

During this month our inspectors made 10,557 inspection trips, visited 20,867 boilers, inspected 6,345 both internally and externally, and subjected 627 to hydrostatic pressure. The whole number of defects reported reached 12,907, of which 1,135 were considered dangerous; 71 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	951	75
Cases of incrustation and scale,	2,246	93
Cases of internal grooving,	98	11
Cases of internal corrosion,	572	35
Cases of external corrosion,	441	35
Broken and loose braces and stays,	318	78
Settings defective,	364	53
Furnaces out of shape,	376	25
Fractured plates,	321	71
Burned plates,	353	66
Blistered plates,	92	6
Cases of defective riveting,	1,977	47
Defective heads,	94	10
Serious leakage around tube ends,	2,671	293
Serious leakage at seams,	476	46
Defective water-gauges,	294	36
Defective blow-offs,	151	37
Cases of deficiency of water,	24	14
Safety-valves overloaded,	102	44
Safety-valves defective in construction,	108	32
Pressure-gauges defective,	365	20
Boilers without pressure-gauges,	8	8
Unclassified defects,	505	0
Total,	12,907	1,135

Boiler Explosions.

OCTOBER, 1899.

(284.) — A heating boiler exploded, on October 3d, in the residence of Robert S. Fogg, at Salem, N. J. Albert Thomas, who had charge of the boiler, had both legs and one arm broken, and was otherwise badly hurt. The heating apparatus was destroyed, but the house was not seriously damaged.

(285.) — A boiler exploded, on October 4th, in Captain A. P. Cutting's cider press, near Kenton, O. Benjamin Koontz, Henry Koontz, Guy Koontz, Captain Cutting, Donald Cutting, and John Erwin, were more or less seriously injured, and it is thought that one of them, at least, will die.

(286.) — On October 4th a boiler exploded in Weidig & Co.'s foundry, at Zanesville, O. Fragments of the boiler were thrown in various directions, to a distance of from 300 to 1,100 feet. The property loss is estimated at about $3,000. Nobody was hurt.

(287.) — On October 4th a boiler exploded in a cotton gin, in the German settlement, some seven miles southwest of Cisco, Tex. The gin house and the boiler and engine were totally wrecked. Six workmen who were standing around the boiler noticed that it began to leak steam badly and they all ran away, but had gone only about one hundred yards when the explosion took place. They all escaped uninjured.

(288.) — A boiler exploded, on October 4th, in Mr. Robert Bruce's sawmill, situated some three miles west of Trevilian's Depot, near Louisa C. H., Va. Mr. A. Cambree and Alfred Poindexter were instantly killed, and the owner of the mill and one other man were very seriously injured. We have not learned further particulars.

(289.) — On October 5th a boiler exploded in the Farmers' Creamery, at Fairbank, near Waterloo, Ia. Nobody was hurt, but the interior of the building was pretty well wrecked.

(290.) — On October 6th a boiler exploded at Madisonville, Ky., in a sawmill belonging to Mr. Anton Bruckner. Two of the workmen were seriously injured.

(291.) — The boiler of a naphtha launch exploded, on October 8th, at Mayport, near Jacksonville, N. Y. One man was drowned, and three were badly injured.

(292.) — On October 11th a boiler exploded in Peter Snyder's cider press, in Moon Township, Allegheny Co., Pa. Hiram Wilson, James Knight, and Charles Poole were more or less seriously injured. The boiler-house was wrecked, and the cider press was destroyed.

(293.) — A boiler exploded, on or about October 11th, in Fitzpatrick's violet house, at Staatsburg, near Poughkeepsie, N. Y.

(294.) — On October 12th a boiler exploded in Lingeman & Adams' sawmill, at Brownsburg, near Danville, Ind. Nathan Cook, Leonard Wasson, and Milton Roberts were instantly killed. William Tyler, Jacob Hudson, William McNally, and Oliver Gilbert were seriously injured, and it is thought likely that Tyler will die. The property loss was probably about $5,000. This is the second boiler explosion that has occurred in Brownsburg within the past three months. By referring to explosion No. 209, in the issue of The Locomotive for December, 1899, it will be seen that a boiler in a gristmill belonging to the same company exploded on July 31st. The present boiler stood about fifty yards from the site of the one which exploded in July.

(295.) — A boiler exploded, on October 13th, in the Pottstown Rolling Mills, at Pottstown, Pa. William Laughead was fatally injured.

(296.) — A threshing-machine boiler, belonging to Peter Anderson, exploded, on October 13th, some twelve miles southeast of Britton, S. D. Geo. Gullickson, C. A. Ahlstrom, and two other men were killed, and one man was seriously injured.

(297.) — A heating boiler exploded, on October 13th, in the Fleming Flats, at Erie, Pa. A part of the heater, weighing some five hundred pounds, was thrown through the first and second floors, and partially through the third floor. The force of the explosion also blew out considerable window glass. Nobody was injured.

(298.) — On October 14th, the boiler of a threshing machine, owned by Hauskins & Waller, exploded about a mile north of Morris, Minn. Fireman Ingebret Waller and Engineer Thomas Jacobson were painfully injured.

(299.) — The boiler of Locomotive No. 896, on the C., R. I. & P. Railway, exploded, on October 14th, at Sand Ridge, about eight miles west of Joliet, Ill. Engineer Jansen and his fireman escaped serious injury, but Brakeman Michael Schwartz was thrown one hundred and fifty feet, and was badly hurt, although he will recover.

(300.) — A boiler exploded, on October 16th, in William Massey's mill, located at Sinepuxent Switch, about one mile north of Queponco, Md., on the D., M. & V. R. R. Frank L. Baker was instantly killed, and two other men were fatally injured. The mill itself was blown to atoms.

(301.) — A boiler exploded, on October 19th, in the electric light plant at Ludington, Mich., completely wrecking the building in which it was situated. Several men were in the building when the explosion occurred, but nobody was seriously injured.

(302.) — On October 19th a boiler exploded in Farmer & Weaver's sawmill, on the Cape Fear & Northern Railroad, near Blanchard Station, N. C. Silas Judd and Simon Wood were instantly killed, and Joseph Weaver, Troy Dennis, and five other persons were injured.

(303.) — On October 19th a boiler exploded in Smart's grain elevator, at Spencer, near Sioux Rapids, Ia. The building was entirely destroyed, with the exception of the front part. Fragments of the machinery were thrown in all directions, and one piece weighing between eight hundred and a thousand pounds was found four hundred and fifty feet from its original position. Fortunately, nobody was in the immediate vicinity at the time, so that there were no personal injuries to record.

(304.) — On October 20th Turner's sawmill was destroyed by a boiler explosion, some four miles west of Chunchula, near Citronville, Ala. Mr. Frank Lambert is said to have been fatally injured.

(305.) — On October 23d a boiler exploded in the Lutcher & Moore Lumber Co.'s mill, at Orange, Tex., instantly killing Lawrence Beuhler. Louis Ricks was also fatally injured, so that he died a few hours later. Benjamin Atkins, Amos Arnold, W. C. Diggs, George Matthews, Thomas Day, Sebastian Angelica, and a man named Peats were painfully injured, but they will recover. The boiler house was wrecked, and considerable other damage was done to property. One of the heads of the boiler, weighing some five hundred pounds, was found in a pasture more than half a mile away from the mill.

(306.) — A boiler exploded, on October 24th, in J. L. Erskine's meat packing house, at Waterford, Pa. John Berry and his father, Andrew Berry, were badly scalded and otherwise injured. It is doubtful if the father recovers.

(307.) — A boiler exploded, on October 25th, in T. D. Lawrence's sawmill, some thirteen miles west of Piggott, Ark. Edward Lawrence, Robert Garrett, Hubbard Vick, Thomas Burchet, and James Lusk were killed, and two other men were badly injured, although it is believed that they will recover. The building and machinery were destroyed.

(308.) — A flue failed, on October 26th, in a boiler at the National Mills at Angola, Ind. Fireman William Reeder was thrown against the side of the building and somewhat bruised and burned.

(309.) — On October 26th, the boiler of Captain O. R. Bouquette's pile puller exploded, at East Tawas, Mich. The crew were at dinner at the time, so that nobody was injured.

(310.) — On October 31st a boiler exploded in Benjamin Reed's cotton-gin, some five miles from Gainesville, Ga. J. J. Warff was killed, and Benjamin Reed and Alonzo Mooney were fatally scalded. The gin was badly wrecked.

Language in the Philippines.

Some of the linguistic difficulties that are met with in the Philippines are suggested by a recent article in the Washington *Post*, from which we quote:

For the butchering of good modern languages, and the ringing in of the worn-out dead ones, I defy anyone to find another town which can equal Manila. The Tagalic is at the bottom of it all. This language was crusted with the rust of centuries, ages before ages began to be reckoned — before the square corners of the earth were worn round. Those who have tried to learn it say that Chinese is kindergarten work in comparison. Then the Chinaman came, and the two languages met, clashed, and compromised. Then the Spaniard came, and not only covered the ante of the others, but saw them many better; because his language is easy. Now comes the American soldier, and he shoves into the nicely assorted pot the bowery and the backwoods slang, and the language of the barracks, which is impressive alike to man and beast.

Here is an incident which came to my notice, and which illustrates how things are done under the circumstances outlined above. Three correspondents who lived together in one house found it necessary to hire a new stable boy. A young Filipino presented himself for the place. Quite likely he knew about ten words each of English, Spanish, and Chinese. He was accepted, though, and went below to fix himself up a bunk in the stables. When the three Americans were at dinner they considered it time to feed the horses, and the boy was called.

"Go down to the stables and feed the horses," said one of the men kindly.—"No sabe 'go down,'" answered the boy.

"Sabe 'throw yourselves out'?" the scribe asked, impatiently. — "No sabe, señor."

"Sabe 'hike'?" suggested one of the other Americans. (This word is the American-soldierism for "hot-foot.") "Hike," repeated the young native meditatively. "Hike — vamoose. Si señor, sabe 'hike' — much vamoose."

"Hike out to the stables, then, and feed the horses," ordered the newspaper man who first spoke, resuming his dinner. — "No sabe 'sta-bulls'; no sabe 'feed.'"

At this juncture the three men said several things which we omit because they are not essential to the comprehension of the story.

"Sabe 'casa-de-caballes'?" was the next attempt. (This means, literally, "house of the horses," and is a pretty good stab at the Spanish for stables.)—"No sabe, señor," the native replied pathetically.

"Sabe 'casa'?" — "Si, señor."

"How the devil will we tell him 'horses'?" groaned the sweating reporter; but the language of the American soldier was still full of resource.

"Sabe 'skates'?" — "Si," cried the boy, "sabe mucha 'skates.'"

"Sabe 'chow-chow'?" (This was the last difficulty, and it is the Chinese expression for "feed," the world over.) "Si, señor; sabe 'chow-chow.'"

And so the command was finally given in the following intelligible form: "Hike out to the casa de skates and chow-chow."

The Locomotive.

HARTFORD, MARCH 15, 1900.

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

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Obituary.—Mr. Henry C. Robinson.

At a meeting of the Directors of the Hartford Steam Boiler Inspection and Insurance Company, held on March 9th, cognizance was taken of the lamented death of the Hon. Henry C. Robinson of this city, and the following minute was adopted and spread upon the records of the company: "It is with profound sorrow that we record the death, on February 14th, of Henry C. Robinson, who has been a member of this board for nineteen years (having been elected on February 15, 1881), and its legal adviser from its early beginnings. His wide experience in insurance and financial matters rendered his counsel and advice invaluable. As an associate he was generous and considerate of the opinions of others, kindly in his bearing, and sympathetic and courteous to all. His life and character have made an enduring impression upon those who were brought into intimate official and personal relations with him. We shall sadly miss his kindly greetings, cheery words and wise counsel. A sense of loneliness pervades the atmosphere of our meetings as we look upon the vacant chair. We record this minute as a tribute to his memory and as a mark of our high esteem for his life and character."

We acknowledge, with pleasure, a copy of the *University of Tennessee Record* for October, 1899, containing numerous articles of genuine merit upon various topics in engineering and chemistry. The *Record* is well illustrated, and is a credit to the university from which it comes. It is published at Knoxville, Tenn.

Mr. William Paul Gerhard, some of whose writings upon kindred subjects we have noticed in past issues of The Locomotive, has favored us with a copy of his paper on "The Safety of Theater Audiences and of the Stage Personnel against Danger from Fire and Panic," which is reprinted from the *American Architect* for October 21 and 28, 1899. Here, as elsewhere, Mr. Gerhard has something useful and suggestive to say, and he says it in an intelligent manner.

We are often asked to recommend books for engineers and firemen who are about to pass examinations for licenses, and we find it difficult to suggest any one book which will fit all cases. We have often suggested Mr. Emory Edwards' "900 Examination Questions," which is published by Messrs. Henry Carey Baird & Co., of Philadelphia. Mr. W. H. Wakeman has recently submitted to our notice two books that he has prepared, to meet this want. One is called "Modern Examinations of Steam Engineers," and sells at $2.00, and the other is called "Practical Guide for Firemen," and sells at 50 cents. Either book may be ordered from the author, whose address is 64 Henry St., New Haven, Conn., and who will be glad to give further information concerning them. Mr. Wakeman is a practical engineer with a good many years' experience.

THE *Engineering Magazine* printed, in its issue for November, 1899, an article by Mr. Harrington Emerson, entitled "The Proposed Pacific Cables"; and this article, with its several instructive illustrations, has now been reprinted and issued in pamphlet form. It is a valuable paper, and should be in the possession of every one interested in the subject. We do not know the price, but copies can doubtless be had from *The Engineering Magazine*, 120–122 Liberty street, New York city.

WE are indebted to Mr. Joseph H. McNeill, State Inspector of Boilers for the Seventh District of Massachusetts, for a copy of the *Report* of the Chief of the Massachusetts District Police for the year 1899. The volume contains, among other matters, the report of the boiler inspection department for the year, in which the work of the several inspectors is quite fully described. Two very excellent half-tone engravings are given of the examination room for engineers and firemen at North Adams, Mass.; and the description of this room and its contents, as given on page 379, is exceedingly interesting.

The Center of Gravity of a Locomotive.

When the uninstructed observer with a mechanical turn of mind looks at one of the gigantic locomotives that are now made for hauling heavy trains, he sometimes wonders whether the center of gravity of the structure is not so high that there might be some question about the stability of the machine when it goes around a curve at a fair rate of speed. Of course we know, from long experience, that the older types of locomotive are all right in this respect; but these great, big, mountainous, modern monsters with little dinky smoke-stacks and voices (when they exhaust) like a salvo of cannon — somehow, they look as though a quick trip around a sharp curve might be a sore test to their stability. A direct determination of the position of the center of gravity of one of these huge machines is described in the issue of *Locomotive Engineering* for January, 1900, and as the experiment is rather novel, and the result of it a little surprising, it may be worth while to give some account of it in THE LOCOMOTIVE.

The locomotive in question was built by the Rogers Locomotive Works, at Paterson, N. J., for the Illinois Central Railroad. Its total weight is 218,000 pounds, of which 198,000 pounds (or 99 tons) rest upon the drivers. It has a tractive power of 50,000 pounds, and was designed to haul a maximum weight of 2,000 tons over grades of 38 feet to the mile.

"The center of the boiler," says the paper from which we quote, "is 9 feet 2 inches above the top of the rail, the top of the boiler at the base of the dome 12 feet 6 inches, and the top of the stack, sandbox, and dome casing are all practically 15 feet.

The crown sheet of the firebox is 10 feet 6 inches above the rail at the flue sheet. As not much seems to be known as to how high above the rails the center of gravity of locomotives having their boilers unusually high, such as this one, may be expected to be found, taking the whole engine in working order as one mass, a test was made of this engine to determine the position of its center of gravity, by suspending the whole engine on the upper surface of two 3-inch steel pins or journals for pivots, one at each end of the engine. The one at the front end was placed six inches in front of the cylinder saddle, and the one at the back end was placed six inches behind the back end of the boiler, both being the same distance above the rails, and on the vertical center line of the engine. The engine was complete when suspended, with all its parts in place, and its boiler filled with cold water to the second gauge. The drivers and truck wheels all cleared the rails by about two inches, and the entire machine was as nearly as practicable in the same condition and of the same weight as it would be in working order. As already said, the steel suspension pins were 3 inches in diameter; they were supported at both ends, and the bearing surface resting upon them was horizontal, so as to reduce the friction at the bearing point to a minimum. On trial, it was found that the bearing points, as first located, were too high. They were lowered and tested again, and adjustments of this sort were made repeatedly, until the engine balanced on the pivots. Screws were used at the ends of the bumper for testing, and to keep the 'roll' to either side within limits when the pivots had been lowered to the level of the center of gravity. In the final position of the supporting pins, a lift of 100 pounds, applied to the bumpers when the engine was vertical, was sufficient to cause it to turn in either direction. The tests showed that the line of suspension, when the pins were in their final position, passed as nearly through the center of gravity as it was practicable to make it. Measurements which were then made showed that the bearing point on the top of the steel pin at either end of the engine, was 50½ inches above the level which would correspond to the level of the track, if the drivers were resting firmly upon it, instead of being suspended in the air. In other words, the center of gravity of the whole locomotive (exclusive of the tender) was found to be 50½ inches above the track, when the locomotive was in running order. That point is 3¾ inches above the top of the main frames. Assuming the bearing points of the drivers on the rails to be 56 inches apart, then the base on which the engine runs is 1.10 times as wide as the height of its center of gravity above the rails. Without positive knowledge to the contrary, most persons, we think, judging from appearances only, would conclude that the center of gravity of a locomotive like this must be considerably *above* this; yet the tests show conclusively that it is not.

"If the center of gravity of a locomotive like this is less in height by 10 per cent. than the width of the base on which it is carried, it is probable that the center of gravity could be carried slightly higher (if this were desirable for any reason) without any serious consequences, so far as the movement of the locomotive along the track is concerned."

According to the *Pharmaceutical Era*, out of 1,008,500 prescriptions examined, only 6 per cent. were written in the metric system. The information was obtained from druggists in forty-two states and territories. This shows that physicians do not seem to care much about trying the new system.— *Chicago Daily News.*

[If these figures are correct, they indicate that the metric system is coming into use in this direction more generally than we should have supposed. We should not have thought that the proportion of metric prescriptions was anything like one in sixteen.]

The Commemorative Meeting of the Franklin Institute.

On October 5th a commemorative meeting was held in Convention Hall, Philadelphia, on the occasion of the celebration of the seventy-fifth anniversary of the Franklin Institute. Several very excellent addresses were made, by eminent speakers, in which the progress of science and the arts was reviewed for the three-quarters of a century during which the Institute has existed. We should like to print them all in full, but cannot do so, because they would fill several issues of The Locomotive. We present below, however, a few short passages selected from them, and must refer those who desire a fuller report to the issue of the *Journal of the Franklin Institute* for January, 1900.

Dr. Coleman Sellers spoke upon the "Progress of the Mechanical Arts." "The greatest advance in mechanics," he said, "has been manifested since the advent of the locomotive. It so happens that the birth of the modern railroad system is coincident with my own birth. At that time the first railroad was put into operation in England, which development, taken in connection with the advent of the steamboat which preceded it, was certainly the exciting cause of the great industrial advance that has since been made. Previous to 1827 wooden rails had been laid to form roads over which ore was hauled from the mines, and coal was transported in the same manner by animal traction to better advantage than over common roads. Oliver Evans in our own country, and other engineers abroad, had conceived the idea of the high-pressure steam engine, and, with the full understanding of its value, a practical traction engine to use on roads was one of the first examples of its application. It was after the invention of the road engine that the locomotive upon rails became possible. The traction engine applied to the railroad was the basis of our present wonderful system of inland intercommunication, and its development has given an impetus to all trades. In fact, the wants of the railroads taken alone would have been sufficient incentive for what has since been done in the mechanic arts, engaging, as it has, the attention of engineers to produce the labor-saving tools required for the improvement and preservation of the railroads and equipment, including the great iron and steel works that supply the rails, bridges, and buildings. Special machinery has been constantly needed to render possible such industries as iron ship-building, bridge and structural work, and the appliances which have been introduced in place of hand labor throughout the industrial world. The progress of the single industry of machine tool building has, therefore, a most important bearing on this subject, and traced through the many stages of its rapid growth, the development of this one industry would be sufficient to illustrate the progress in mechanic arts during the period in question, and especially what has been accomplished in this country. The important relation which tools and implements bear to the mechanic arts and, in fact, to all arts and crafts, forms the subject of an interesting tradition which was published in the *Journal of the Franklin Institute* by the late Mr. Joseph Harrison, Jr. In his home at Philadelphia he exhibited a painting by Schusselle representing a blacksmith seated at the right hand of King Solomon's throne in his great temple, to illustrate a hypothetical event during the feast given in Jerusalem at the completion of the edifice. To this feast had been bidden the various artisans who had been engaged upon the construction and decoration of the building, those who had helped to shape the gold and silver and carve the ivory and weave the costly hangings that decorated its walls. There also came, unbidden and unrecognized, the swarthy smith, who, forcing his way through the courtiers and the guard to the throne of the king, claimed recognition as the one man to whom was due the creation of the entire work, for it was he who had forged the tools without which the other artisans could have done nothing. The wise king, recognizing the justice of the claim, gave to the smith the seat of honor. Antedating the smith of King Solomon's day, and the mechanics of all times, the progress of civilization can be traced by the study of the implements used in the daily life of different races of man, and prominent in the progress of the mechanic arts must be counted the tools with which work has been accomplished. . . . The early machine tools were of the crudest workmanship, and most of the lathes were made partly of wood. In fact, the transition from wood to iron in the construction of machinery was in progress during the early part of this century, and the formation of the tools themselves and much of the machinery built at that time involved the conversion of structural shapes required for wooden machines into similar shapes in metal. In the first change from wood to metal, architectural shapes and ornamentation were considered desirable to make machine tools and other machinery meet what seems to us now the rather barbaric taste of those who were to use them. The same might be said of locomotives, which almost up to the sixties were elaborately decorated with paint, polished brass, and scroll work. England gave us the first good machine tools, and set the example which has tended to simplicity in design. To that country we owe much that is valuable, not only in the direction of self-acting machine tools, but also in the various appliances for improving the character and quality of work to be accomplished. . . . . Reviewing the century's progress, one cannot but be impressed with the tendency to specialize all industries. It has been truly said that jobbing shops are and always will be a necessity, but that manufacturing establishments will lead in the march of improvement. Trades are becoming more diversified, and time, talent, and capital are being expended upon individual machines and appliances as special which were formerly but a part of the output of single establishments. To this concentration of the best thought upon special branches of all industries we may attribute much of the progress in the mechanic arts made during the past seventy-five years, which has opened the markets of the world to the products of our industry."

Speaking of the progress of physics and astronomy, Dr. A. E. Kennelly said: "Physics, in some form, however limited, must have been studied by man at every era of his existence; and we find that some practically-acquired knowledge of physical principles is to be found even in the lower animals. As for astronomy, or the natural philosophy of the heavenly bodies, it can be only second in antiquity to physics. There are two peculiarities of the exact sciences to which I must refer. One is that they manifest a tendency to speak in the exact language of mathematics, and the other is that difference of opinion tends to disappear upon the subjects which they adopt. Upon practically every subject which is not included in the exact sciences, except recorded history, there exists, as a rule, a great variety of opinions, and the difference of opinion generally increases with the distance of the subject from the sphere of exact science. On such questions as the Monroe Doctrine, or the comparative beauty of orchids and geraniums, or the probable future of the Chinese Empire, we may expect to find every variety of opinion and judgment. But upon the area of a circle of two feet radius, the shape of the earth, or the distance of the moon, there is practically no difference of opinion, and such difference of opinion as does exist is restricted to such narrow limits of uncertitude or precision as to the uninitiated seem trivial and incongruous. Yet we know from history that there have been times when men disputed vehemently upon all of these questions; that is to say, before the exact sciences were sufficiently powerful to annex them. We find, indeed, vexed questions and disputes in the domains of the exact sciences, but, as a general rule, these are only on matters which have thus far eluded complete measurement and systematic generalization. The law of these questions has not yet been discovered, and for this reason they are still outside the empire of exact science. As time goes on, labor achieves, and knowledge advances, these things become measured and known, whereby dispute terminates and dissension disappears. Whether we should care to live in a world where everything belonged to the exact sciences, and in which the cause and order of all things could be found in the encyclopedia, is, of course, open to debate; but it is beyond dispute that the practical unanimity of educated opinion, upon subjects included in the exact sciences, entitle those sciences to a dignity and importance that is withheld from communities of facts that obey, as yet, no recognized law.

"On looking back through the history of past centuries, it is impossible to avoid recognizing the fact that the exact sciences of the remote past had but very little practical application. Astronomers, while devoting their lives unremittingly to the study of the heavenly bodies, and fully impressed with the dignity of their task, cast horoscopes and predicted nativities. Physicists, such as Archimedes, occasionally performed useful services for the community; but many mathematicians, such as Pythagoras, disdained all utilitarian aims as unworthy of their study. To them, knowledge, jealous of the attention of her devotees, frowned at all flirtations with utility. The necessities of modern civilization, however, have swept away the prejudices that encompassed and secluded scientific research. We could not maintain the fabric of existing institutions without the aid of the applied sciences. It is very doubtful whether the existing population of cities like London and New York could even be sustained in food, if the applied sciences were in the stage of their development at the beginning of this century, before the locomotive steam engine made its appearance. Even if the necessaries of life could be carried in to the cities from the surrounding country, in sufficient quantities, by horse wagons, the cost of transportation would make city life economically impossible to a large section of the community. Without the machinery which is the outcome of applied science, our clothing, shelter, and food would require all the average man's time and efforts to secure for his family and himself, and luxuries would become impossibilities. The federal government of such a large area as the United States would become a practical impossibility under the same circumstances. It is recorded that in 1812, before the days of the electric telegraph, the government at Washington did not receive the news of the battle of New Orleans until more than three weeks after the event. The absolute dependence of modern civilized society upon the work of the applied sciences is so great that these sciences are taxed to their utmost limit. More and better machinery is needed, cheaper, simpler, and more effective than existing machinery. Competition among machines is to-day keener than competition among men; because even the most systematic men are subject to some erratic or variable impulses which reduce the closeness and keenness of their mutual competition; whereas machines, while maintained in repair, work with a zeal that knows no weariness, and a regularity that no emotions can disturb. The result is, that all the engineering sciences, and applied sciences generally, are taxed to their utmost to supply the needs of society. These applied sciences turn eagerly to the exact sciences for fresh material to place at the public hand. After looking back upon the past, it is impossible to look forward without being convinced that the practical man of the future will be more of a scientist than ever. Current literature, current speech, and current development all make this confession of faith. In the days that are now behind us, an inventor who had only acquired a very moderate amount of applied science, by untrained observation and experience, could, by native ingenuity, introduce great improvements in the relatively crude industrial processes of his time. In the days that are before us, however, industrial processes are becoming so specialized, so complex, and so linked with mechanical processes, that an inventor must be possessed of either greater natural ability to improve the result, or must have received some scientific training. In fact, whereas it was at one time true that 'necessity was the mother of invention,' it is now more nearly correct to say that science and necessity are the parents of invention. Natural science is, in the last analysis, only the study of natural phenomena and of their laws, and the more complex the machinery by which those laws are controlled for industrial purposes, the more intimate must be our knowledge of them."

Dr. T. C. Mendenhall, who spoke of the notable contributions of American physicists during the last seventy-five years, said: "The cheerfully optimistic spirit which, fortunately, prevails everywhere and always among the masses of the people, easily and naturally leads to the conclusion that the present age is the golden age. Of all times in the history of the world, NOW is the most important. Never so much wisdom as now; never so much wit and courage and beauty as now; never so many things that make life worth living as now. So it was one hundred and two hundred years ago, and so it will be one hundred and two hundred years hence; for the delightful disposition to accept things as they are, and not only to accept but to approve and admire, is a large and important element in that wonderful resilience which enables the human race to smile at discouragement and defy disaster. Moreover, it is a logical acceptance of evolution; an unconscious recognition of a development from worse to better, on the whole, steady and persistent. But when one makes even a superficial examination of the centuries that have preceded our own, notwithstanding the meager knowledge we possess of some of them, it is immediately evident that such a view of existing conditions has not always been sound. It is at once seen that the progress of the race has not always been steady; that it has sometimes and for considerable periods inclined toward the worse, rather than the better, and that certain centuries stand in marked contrast with others when measure is taken of the intellectual growth and material development by which mankind has been most profoundly affected. It is this fact which gives one whose life has been wholly in the nineteenth century courage to declare that the cycle of years now coming to an end is enormously more significant in its determination of the relation of men to each other and to the universe in which they live, than any that have gone before. Indeed, it is but conservatism to declare that the nineteenth century, along certain lines of development, especially those relating to the physical condition of man, must be credited with achievements beyond those of all past time. Argument in support of this proposition has become almost commonplace, and a brief reference to a few of the more striking illustrations will be sufficient, as it may also be necessary, to create a just appreciation of some contributions to this splendid evolution which will presently be considered.

"One of the most notable transformations wrought during the century is found in improved locomotion, including the transfer of goods. We do not know who invented the wheeled vehicle. It was probably in use in prehistoric times. Nor do we know who first tamed the beasts, thus substituting the muscular energy of animals for that of men. But we do know that from that remote period to the end of the first quarter of the nineteenth century, nothing essentially *new* in the way of locomotion on land was invented. The coach in which George Washington rode differed only in details of construction from that chariot into which Joseph stepped, 'arrayed in vestures of fine linen,' and its motive power was the same. We do not know who first spread a sail to catch the power of the wind for propelling a boat, but we do know that, previous to the nineteenth century, no ship was ever driven otherwise. It is doubtful if the speed of traveling on land and sea was materially greater in 1799 than a thousand years earlier, although improved roadways and larger vessels lessened the cost per ton-mile of freight. How startling is the contrast of these methods of locomotion, the total result of thirty or forty centuries of effort, with the accomplishments of the last three-quarters of the nineteenth century! But far more amazing is the revolution which has taken place within the same period, in the methods of conveying intelligence from point to point. The telegraph and telephone could hardly have been conceived by even the most imaginative of those whose day preceded ours, and their influence upon the social and material conditions of men is yet far from its maximum. One of the most pregnant discoveries of all time was the art of controlling fire. The use of flint and steel for its production, which comes to us from the remote past, was still general during the first quarter of the century, and many people are now living who were accustomed in their youth to 'borrow' fire from their neighbors, in the absence of any means of creating it. The artificial light of the early part of the century was produced by methods not essentially different from those in use for thousands of years, the first real advance being the improved draught of the Argand burner. The clothing worn by our revolutionary forefathers was generally woven on hand looms and the parts were stitched together by hand, the whole process of production not differing materially from that of the 'coat of many colors.' During the earlier years of the present century, the harvest was gathered just as it was in the days of Ruth, and the several processes by which grain was converted into bread had altered little in thousands of years. All of these are matters with which everybody is concerned, for food, clothing, fire, light, and the means of bringing supply and demand together may be said to constitute the minimum requirements of human existence. In all of them the marvelous work of the nineteenth century overshadows that of all that have gone before. The nineteenth is truly the 'wonderful century,' and whatever the twentieth or the twenty-first or the twenty-second may bring forth, this verdict is not likely to be reversed."

Abstract of Statement.—January 1, 1900.

HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

ASSETS.

Cash in office and bank,		$86,317.82
Premiums in course of collection (net),		289,109.17
Loaned on bond and mortgage, first liens,		305,250.00
Bonds and stocks, market value,		1,825,244.00
Real estate,		49,789.40
Interest accrued,		7,353.34
Total assets,		$2,563,063.73

LIABILITIES.

Premium reserve,		$1,481,857.50
Losses in process of adjustment,		34,732.19
Capital stock,	$500,000.00	
Net surplus,	546,474.04	
Surplus as regards policy-holders,	$1,046,474.04	1,046,474.04
Total liabilities, including capital and surplus,		$2,563,063.73

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

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Concerning Stay-bolt Inspection.

In the issue of The Locomotive for December, 1897, we printed an article on stay-bolts, in which the probable cause of the failure of such bolts is considered, and the method employed by experienced inspectors for detecting broken bolts is outlined. We present, herewith, an article bearing on the same subject, which was written by Mr. W. J. Eddington, and printed in the *Railway Master Mechanic* for April, 1900. Broken stay-bolts are so common in railway practice, that every master mechanic has an excellent opportunity for studying them; and for this reason anything concerning them, which comes from a railway repair shop, is of special interest.

The care of the stay-bolts in the locomotive boiler, says Mr. Eddington, is probably one of the most important duties of the railway master mechanic. The renewal of broken or defective stay-bolts, and the time an engine is held out of service, constitute a large item of expense. Much of this can be avoided by renewing bolts when an engine is shopped for general repairs, particularly those bolts that are located under the frame fastenings and other inconvenient places, and all that are considered uncertain. The service which an engine has to perform has much to do with regulating this work.

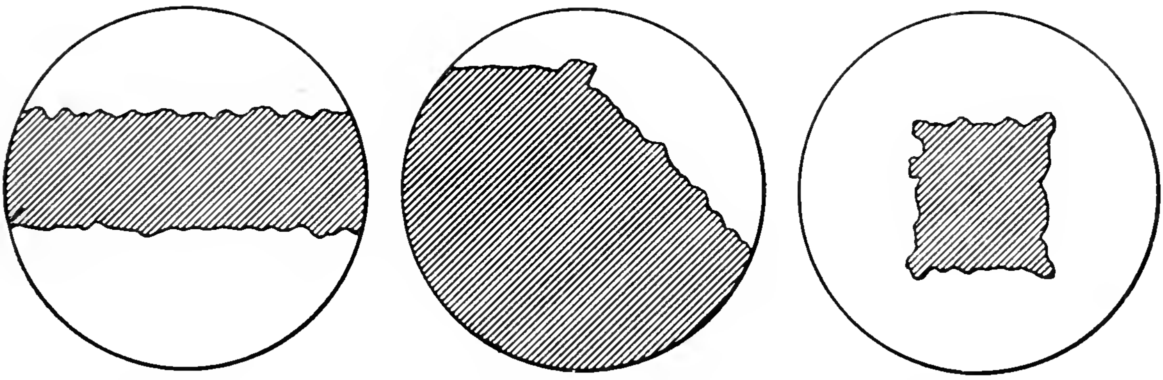

Fig. 1. Fig. 2. Fig. 3.

Stay-bolt Fractures. (Shaded Areas represent Sound Metal.)

Stay-bolt breakage in boilers of recent construction is more frequent than formerly, for several reasons. Among these reasons I may name the following: the increased size of the firebox; the thicker sheets; the irregularity and reduced area of the water space; the different shapes of fireboxes, and the higher pressures of steam. Doubtless, also, the quality of stay-bolt material has not improved. The frequency with which this subject is referred to in mechanical papers indicates that its importance is fully understood.

The method of detecting broken or defective stay-bolts is important. The general practice is to drill detector holes in the center of the bolt through the outside sheet, so that when broken it will leak. Some depend on the hammer test only. My experience has convinced me that detector holes are unreliable and a useless expense, and that the hammer test, conducted by an experienced inspector, is the safer method to follow. I have reached this conclusion for the reason that fully 60 per cent. of the stay-bolts we remove are *partially* broken, and are broken in such a way that the detector holes would be useless. As many of these bolts break gradually, the holes quickly fill with sediment, which prevents detection. The size and position of these fractures vary. Some bolts break on the top side, some on the bottom, some front and back, and others on both top and bottom, leaving the center solid, as shown in Fig. 1 — the average area broken being about one-half. This is a serious matter, for it would indicate that when only the *manifestly* broken bolts are replaced, the firebox may still be unsafe. Out of eighty-four bolts removed from one certain firebox in a year, only twenty-five were *clearly* broken.

In only a few parts of the firebox do the bolts break quickly after the fracture begins. Those in the curve of the side sheets and in the outside vertical rows of the back head give the most trouble. An expert will soon become familiar with the different kinds of fireboxes, and have no difficulty in locating fractured or broken bolts, and, when he learns the direction of the strains, he can show when a bolt is partially broken, just how much it is broken, and the side that is fractured. This last point is of value when they are being cut out.

I will take one firebox, with which we are familiar, for an illustration. Beginning with the first stay-bolt from the boiler head in the bottom row of the side sheet: — this one, if fractured, will show the defect on the bottom. Passing up this row until the bend is reached, the fractures, if any, will be next to the boiler head. Taking the first row in the bend, the defect will work around to the top at about the fourth bolt, and so on to the center of the sheet, where we may find several broken bolts. The second row in the bend will fracture on the bottom and the third row on the top. If there are diagonal rows between these, they will fracture on the top and bottom, leaving the center solid, as shown in Fig. 1. Continuing on the back row to the top, the corner bolt, if defective, will be broken on the back and top, as shown in Fig. 2. Passing along this row to the center, the fractures will show on the top. The same results will be shown by beginning at the throat sheet. In the boiler head we find that the outside vertical rows break first. If not renewed soon, they break toward the center — the top row first, if the boiler and frame braces are high on the boiler head. Very few partially broken bolts are found in the boiler head, as they break quickly after the defect begins. In the throat sheet the action is different on account of the heavy flue sheet. In this we find the bolts broken all around, leaving a small portion in the center solid, as in Fig. 3. There is little doubt that in a large percentage of the broken bolts the center is the last to break.

Broken bolts are detected by the sound. Those partially broken are found by the vibration of the sheet, taken off by the fingers. If there are any such bolts in the firebox they can be found as I have stated. An examination of the bolts removed will confirm this. Stay-bolts can be tested best by one man sounding on the inside of the firebox with a light hammer, while another examines the behavior of the corresponding bolt head, and the adjacent sheet, on the outside. Different parts of the firebox give different sounds. Stay-bolts under frame fastenings, if the bolt is touching, give a peculiar sound and often deceive inspectors. It requires a good deal of practice to become an expert at this work of stay-bolt inspection, and no doubt some can acquire the faculty quicker than others. The matter is so important, however, that every opportunity should be taken to train men for the work.

Inspectors' Report.

FEBRUARY, 1900.

During this month our inspectors made 8,898 inspection trips, visited 16,964 boilers, inspected 5,385 both internally and externally, and subjected 649 to hydrostatic pressure. The whole number of defects reported reached 10,869, of which 1,074 were considered dangerous; 48 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	873	40
Cases of incrustation and scale,	1,903	87
Cases of internal grooving,	75	10
Cases of internal corrosion,	482	35
Cases of external corrosion,	464	32
Broken and loose braces and stays,	131	34
Settings defective,	285	22
Furnaces out of shape,	302	12
Fractured plates,	196	37
Burned plates,	284	33
Blistered plates,	99	6
Cases of defective riveting,	503	209
Defective heads,	51	10
Serious leakage around tube ends,	2,877	220
Serious leakage at seams,	406	38
Defective water-gauges,	263	70
Defective blow-offs,	186	47
Cases of deficiency of water,	59	27
Safety-valves overloaded,	85	34
Safety-valves defective in construction,	123	32
Pressure-gauges defective,	231	26
Boilers without pressure-gauges,	13	13
Unclassified defects,	978	0
Total,	10,869	1,074

Boiler Explosions.

NOVEMBER, 1899.

(311.) — On November 1st a locomotive boiler exploded in the yards of the Pittsburg & Western railroad, at Painesville, O. The engineer was not injured; but Fireman Elmer Frederick, Conductor David Bradley, and Brakeman Edward Gallagher, who were on the engine, were badly scalded, and Mr. Frederick's injuries may prove fatal.

(312.) — A boiler exploded, on November 2d, at Coles' asphalt plant, on the Ann Arbor tracks, near Elm street, Toledo, O. Nobody was injured.

(313.) — On November 3d the boiler of a Lehigh Valley locomotive exploded near Wyalusing, a short distance from Towanda, Pa. Fireman Eugene Deegan and Brakeman Warren Robinson were instantly killed, and Engineer Daniel Georgia was fatally injured. The locomotive was blown to pieces, and traffic was delayed for five hours.

(314.) — On Nov. 7th Carl Johnson was seriously scalded by the explosion of the boiler of his threshing machine at Nadine, near Winona, Minn. It is believed that he cannot recover.

(315.) — A boiler connected with Peter Ziegenfuss' well-drilling machine exploded with terrific force, on November 8th, at Towamencin, near Souderton, Pa., while in use for sinking an artesian well. The boiler and machinery were wrecked, and Wesley Tully, Joseph Frederick, and Aaron B. Kriebel were injured. Mr. Frederick's injuries are serious.

(316.) — A boiler exploded, on November 8th, in R. R. Chaney's sawmill, at Haysland, some six miles south of Beckville, Tex. Fortunately, the employes had all just gone to breakfast, and nobody was hurt. One end of the boiler was blown to atoms, and the remainder of it was found on a hill, several hundred yards away from the site of the mill.

(317.) — A boiler exploded, on November 9th, at the Brier Hill Stone company's quarry, at Brier Hill, near Youngstown, O. Several persons were at work near the boiler at the time, but none was injured.

(318.) — On November 9th a boiler exploded in the pump house of the Northwestern Company, at Eden, near Fond du Lac, Wis. The pump house was totally destroyed, and Michael Flynn and John McDonald were severely injured. Flynn may not recover.

(319.) — On November 10th a rotary boiler, used in the preparation of pulp, exploded in George F. Jones & Co.'s Federal Park paper mill, at Baltimore, Md. The explosion occurred at 9.30 in the evening, when there were only four men in the mill; and it is doubtless due to this circumstance that nobody was injured. The building was somewhat damaged, and it is said that the total property loss was about $3,000.

(320.) — On November 11th the crown sheet failed on locomotive No. 661, of the Columbia & Port Deposit railroad. The locomotive was making the return trip between Perryville and Columbia, Md., at the time, and was drawing a heavily loaded freight train. Head Brakeman Neff, who was acting as fireman at the time, was almost instantly killed, and Engineer Donaghey was badly scalded.

(321.) — A boiler exploded, on November 12th, at the I. Wise oil well, at Dent's run, about ten miles from Mannington, W. Va. Augustus Forsythe had repaired the boiler, and while he was testing it under steam pressure, the crown sheet gave way, and he was fearfully scalded on the face and over the entire front part of his body. He was also thrown about fifty feet, and sustained injuries from which he could hardly be expected to recover. At last accounts, however, he was doing well. The boiler house was entirely destroyed.

(322.) — On November 12th a tube bursted in one of the boilers at the Baltimore & Ohio Power house, on Howard and Henrietta streets, Baltimore, Md. William Dryer and Frank Marshall were scalded, and Dryer's condition is said to be serious.

(323.) — On November 13th a boiler exploded in the Mortenson Lumber Company's sawmill, at Wausau, Wis. Engineer Herman Frenzel was slightly injured, and the boiler house was wrecked. The property loss was, probably, about $3,000.

(324.) — A heating boiler exploded, on November 13th, in the basement under the office of the Darlington Coal Company, at Darlington, near Pawtucket, R. I. The building was thrown considerably out of true by the explosion, and the boiler, which was a small one, was destroyed. Nobody was injured.

(325.) — A boiler exploded, on November 13th, in the J. Betts & Addis' sawmill at Fallen Timber, near Portsmouth, O. The dome of the boiler was thrown 700 feet, and fragments of the machinery were found a quarter of a mile away. Edward Wells was hurt painfully, but not seriously.

(326.) — On November 13th a boiler exploded in the Pycett Manufacturing Co.'s mills at Hamlet, a station just south of Woonsocket, R. I., on the Worcester Division of the Consolidated road. Frank Ruge, the night watchman, was instantly killed, and Henry Benoit, the day fireman, was severely injured. The boiler house, a brick structure 60 × 80 feet in size, was demolished, and the other mill property was damaged to a considerable extent. Large quantities of wreckage were thrown to a distance of a thousand feet, and bricks and pieces of iron were found half a mile away. The property loss is said to be about $20,000.

(327.) — On November 15th a small boiler exploded in the foundry of S. L. Moore's Sons, at Elizabeth, N. J. Carl Holdarth was seriously burned, and another workman was slightly injured.

(328.) — A boiler used by G. H. Bowie for running a stone crusher exploded, on November 17th, at Chaudière, near Ottawa, Can. John Tucker, who was ninety feet away, was struck by the flywheel of the machine, and instantly killed. John Basguin was also badly scalded.

(329.) — A boiler exploded, on November 17th, in the West Chicago Rail Mill, of the North Western railroad, at West Chicago, Ill. Fireman William Preham was thrown fifty feet and instantly killed. Foreman William Ehredt was fatally injured, and Jacob Kress and Oliver Keeffer were injured seriously but not fatally. The building in which the boiler stood was destroyed, no vestige being left of it but the smoke-stack.

(330.) — A heating boiler exploded, on November 20th, in the basement of James Farrell's residence, at New Britain, Conn. Large parts of the boiler were projected through floors and ceilings, into the second story of the house. Several of the inmates had remarkable escapes, but nobody was injured. The property loss was about $3,000.

(331.)— On November 20th a boiler exploded in a small pumping plant located on the river bank at Burnside, near Donaldsonville, La., and owned by the Mississippi Valley Railway company. Engineer Charles Winder was instantly killed. The plant was completely demolished.

(332.) — A boiler exploded, on November 21st, in Robert Keeler's distillery, some twelve miles above Greenville, S. C. Fireman Nicholas Williams was killed, and Matthew Keeler was painfully burned about the body.

(333.) — On November 21st a boiler exploded in a sawmill at Pembroke Springs, near Woodstock, Va. David L. Pence, of the Star Tannery, was instantly killed. He leaves a wife and seven children. (An Ohio paper states that Mr. Pence and all his family were killed — that, in fact, "the entire family was wiped out of existence." "All were instantly killed," it adds, "and the bodies of the victims were mangled." But we guess the editor of that particular paper was romancing. Anyhow, the mill was destroyed.)

(334.) — A boiler exploded, on November 22d, in Eddy & May's sawmill, located on Eddy creek, some eight or nine miles below Princeton, Ky. John Gray was instantly killed, and Earl Dunning and Urey Freeman were seriously injured.

(335.) — On November 23d a boiler exploded in the West Shore Wood company's mill at Wausau, Wis. Four boys were seriously injured.

(336.)— On November 26th a boiler exploded in Ford Bros.' cotton gin, at Mulberg, twelve miles northeast of Bonham, Texas. Robert Stephenson, William Smith, and William Archer were killed, and four others were injured.

(337.) — The boiler of a hay-pressing machine exploded, on November 28th, on the Fuller farm, between Hamilton and Poolville, N. Y. Thomas Dunn and Leonard White were fearfully injured, and White has since died.

(338.)— On November 29th a boiler exploded in A. C. Swickard's sawmill at Alfordsville, near Washington, Ind. Ira Harrall and John Potts were badly injured. Harrall cannot recover. The mill was completely wrecked, and the property loss is large.

(339.) — A boiler exploded, on November 29th, in the railroad pump-house at Cerulean Springs, near Princeton, Ky. Claude Mitchell was fatally injured, and his father, Calvin Mitchell, was seriously scalded. The pump-house and machinery were totally destroyed.

Transmission of Power by Ropes.

In the transmission of power, the shafting of large plants was first run by heavy gearing. This was superseded by belting, and to-day it is claimed that the leading engineers of the country recognize that the only true and positive system for conducting loads from the engines and heavy shafting is by means of ropes. Rope transmission has passed the experimental stage, and is now recognized in the field of mechanical engineering as a practical and efficient method. Many of the largest plants all over the world are to-day run in this way. It is especially applicable in dynamo driving, where belting cannot answer the purpose satisfactorily, for the simple reason that any fluctuation in the engine is transmitted through belting with a heavy jar, causing uneven lights; whereas with ropes between the two pulleys this fluctuation is taken up gradually, for the ropes are elastic and there is no jar transmitted to affect the lights.

Rope driving is accomplished by two methods. In both methods the ropes are run in pulleys, which are grooved so as to admit the rope. This groove is in the shape of the letter V. Some plants are installed with one continuous rope wrapped round and round and then taken over an idler to a tension weight which takes up the slack; but this method is not used in the heavier systems. The method called for by most modern engineers is that of separate ropes, each independent from the other, deposited in the grooves. The mills of the south of the United States which have been built in the past few years are all driven by ropes running on this system; and nearly all the plants which are being erected to-day in foreign countries call for the transmission of their power by rope driving.

Two classes of ropes are chiefly used in short-distance power transmission; that of the manilla fiber, and that made from cotton. The manilla rope is not in general favor, however, since the results obtained from it have not been entirely satisfactory. The manilla fiber, of which the rope is made, is very uneven, and as the rope revolves over the pulleys, chafing — called fiber friction — takes place, and the smaller fibers are chafed by the larger ones to a powder. In the cotton rope, which is made of single yarns, the yarn is all of the same given diameter, and the chances of fiber friction are reduced to a minimum. This rope to-day drives the largest plants in North and South America, British India, and even in China and Japan.

Rope transmission is employed not only on the main drives, but even in connection with smaller machinery to-day, especially in the textile trade. Most of the machines in cotton, woolen, silk, and jute mills are driven by means of cotton rope of various sizes, called banding. This machinery requires a rope which shall be elastic, and yet strong and durable, and, though other substitutes have been used, it is a well known and established fact that nothing fills the bill to the same extent as cotton.

There have been many kinds of rope made for power transmission, yet a four-strand rope with a core has been found the best. This rope, which is now used all over the world, is made with the inside strands entirely separate from those of the outside. The inside strands, or tension strands, are made of a loose bundle of yarns, which contain no twist whatever. These are covered with another layer of cotton yarn, which acts as an envelope for protecting the inside ones. There being no twist on the bundle of yarn on the inside, the full strength of these fibers is realized.

Out of every ten plants now being built all over the world, the plans of nine probably call for rope instead of belting. Rope is also carried where belting cannot be used. It is run in the West in mines, where it is carried under ground; and it can be made to be effective and reasonably permanent in places where belting would last but a short time. It also can be carried over the tops of buildings and across streets, and can be run in every conceivable form.—*New York Commercial.*

Ing. Alfredo Gilardi of Milan, Italy, sends us a copy of his book entitled "Manuale per il Conduttore e il Proprietario di Caldaie a Vapore" ("Manual for Steam Boiler Owners and Attendants"). His object is to explain the construction and operation of steam boilers of various types, together with the various valves, pumps, and other accessories which are used with them. His treatment of the subject is interesting, and the book will be useful to the readers for whom it is intended. Among the illustrations we find a number which are taken from The Locomotive; but we do not find credit given for them anywhere. Perhaps the ethics of this sort of thing is different in Italy from what it is in this country.

A young student once asked Emerson for directions for getting the most good out of books, and was told: "Do not attempt to be a great reader; and read for facts, and not by the bookful. What another sees and tells you is not yours, but his. Keep your eyes open and see all you can; and when you get the right man, question him close. So learn to divine books, to feel those that you want without wasting much time over them. Often a chapter is enough. The glance reveals when the gaze obscures. Learn to tell from the beginning of the chapters and from glimpses of the sentences whether you need to read them entirely through. So read, page after page, keeping the writer's thought before you, but not tarrying with him until he has brought you to the thing you are in search of; then dwell with him, if so it be that he has the thing you want."—*Metaphysical Magazine.*

The Locomotive.

HARTFORD, APRIL 15, 1900.

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

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

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

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

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

We have received from Dr. E. Mosler of Berlin, Germany, a reprint of his article on steam boiler supervision, which appears in the Handwörterbuch der Staatswissenschaften, under the title *Dampfkesselpolizei.* The bulk of the article is occupied by a statement of the way in which such supervision and inspection is controlled in the various countries of the civilized world, including Germany, Austria, Switzerland, France, England, Italy, the Netherlands, Denmark, the United States, and the Transvaal Republic. The labor involved in the preparation of such an article is great, and the work, in the present instance, is very well done.

Obituary.

Mr. John Rodgers.

Again it becomes our sad duty to announce the death of one who has been for a long time in the service of this company. Mr. John Rodgers died on Friday, February 23d, after an illness of considerable duration. Mr. Rodgers was 57 years of age, and was born in Albany, N. Y. He came to Hartford in 1882, and worked for a time for the Cushman Chuck Company, the Hartford Engineering Company, and the Hartford Machine Screw Company. In 1885 he became connected with the Hartford Steam Boiler Inspection and Insurance Company, as special agent for western Massachusetts. In his fifteen years of continuous service in this capacity, Mr. Rodgers became familiar with nearly all of our patrons in his territory; and his genial presence will be greatly missed.

Mr. Edward H. Warner has been appointed special agent of this company for western Massachusetts, in the place of Mr. John Rodgers, whose death is announced in the present issue. Mr. Warner formerly represented the Jewell Belting Company, and is, therefore, no stranger to the district in which he now represents the Hartford Steam Boiler Inspection and Insurance Company, nor to its patrons.

Mr. William M. Francis, who has been with the Hartford company for some fourteen years, has been appointed Chief Inspector in our Southeastern department, with headquarters at Charleston, S. C. Mr. Francis is a "graduate" of the home office at Hartford, and has an intimate knowledge of the company's methods, in all its departments.

Mr. H. E. Stringfellow has also been appointed Chief Inspector in our Southern department, where he has represented us, as inspector, for a number of years past. His headquarters are at Birmingham, Ala.

We bespeak for each of these gentlemen a kindly reception from all our friends and patrons.

On the Freezing of Water.

It is a common belief among plumbers and steam engineers, that water which has been boiled, or heated nearly to the boiling point, freezes more readily than water which has not been heated. Most general beliefs of this sort have *some* foundation in fact, even if it is not a very solid one; and without doubt it will be of interest to many readers of The Locomotive if we review the actual evidence that may be advanced in favor of such a belief.

In the first place, there is the question of *fact*, which ought to be settled before we begin to speculate on *causes*. Is it indeed *true* that water which has been heated will freeze more readily than water which has not been heated? Several years ago we made some experiments to test this point, and obtained evidence which seemed to confirm the common impression. Upon repeating them this past winter, however, we failed to obtain any decisive results, the samples of boiled water sometimes freezing first, and sometimes last. Notwithstanding these negative results, we are still inclined to think that there is a basis of actual fact underlying the general belief that the water that has been heated will freeze first, under the conditions which prevail in practice; because we have seen many cases in which hot-water pipes have frozen, while adjacent ones, carrying cold water, have remained free. We shall therefore assume, for the sake of the argument, that the phenomenon is a real one, and proceed to the consideration of certain causes to which it may be due; and since it takes a good many words to say "water that has been heated and afterwards cooled," we shall talk only of "heated water," with the understanding that this expression is used, for the sake of brevity, in the place of the longer one, which expresses more accurately what we mean.

Suppose that two masses of water are placed side by side, one of them being "heated water," while the other is ordinary faucet water, the two samples being at the same temperature when the experiment begins; and let them both be exposed, simultaneously, to a temperature a little below 32° Fahr. If it is found that the heated water freezes solid before the faucet water freezes solid, then there are only a limited number of causes to which the phenomenon can be due. These possible causes may be analyzed somewhat as follows:

(1) There may be a larger quantity of faucet water present, so that, even if the two specimens freeze with equal rapidity, the heated water will be solid first.

(2) The heated water may radiate its heat faster.

(3) The latent heat of fusion may be less for heated water than for faucet water, so that more ice is formed from it, per heat unit radiated.

(4) The actual temperature at which freezing takes place may be lower for the faucet water, so that as the two specimens cool down, the heated water begins to freeze first.

(5) Some unsuspected cause may be in operation, tending to retard the freezing of the faucet water.

Of these various possible causes, we consider the first and fifth to be responsible, in all probability, for the great majority of cases in which the heated water freezes first, under conditions which appear to be identical. Certainly we could not admit the effectiveness of the second and third suggested causes, without the most searching experimental proof; for although there is doubtless *some* difference between the radiating powers and the latent heats of specimens of distilled water, or heated water, and faucet water, yet this difference can only be due to the presence or absence of air and certain other substances in solution, and it would certainly be so slight that it could not have any sensible effect in practice. Concerning the fourth of the suggested causes, we may say that any solid substance lowers the freezing point of water in which it is dissolved. In ice-making plants a strong solution of salt is dissolved in the water in the circulating pipes, in order to prevent freezing, and the very operation of the plant depends upon the fact that ordinary water will freeze at a far higher temperature than is required to freeze the brine. Faucet water will always contain more or less solid matter in solution, and will therefore behave, so far as freezing is concerned, like a very weak brine:— that is, it will freeze slightly below the normal freezing point of pure water. The difference will be so slight, however, that it is doubtful if it could be detected without the use of very delicate apparatus, and the exercise of much experimental skill. Water which has been used in a boiler for some time might perhaps have its solids concentrated, by the continued evaporation, so that the change in the freezing point would become sensible, or the same effect might result from the introduction of soda ash or some other scale preventive. In such cases it might reasonably be expected that of two equal samples of water, one drawn from the boiler and the other from a radiator or trap (and being therefore free from solids), the one drawn from the radiator or trap would begin to freeze first, because its freezing point would be a little higher.

It might be urged, on the other hand, that under certain circumstances it is possible to cool pure water to a point considerably below its normal freezing point without solidification taking place. The French novelist, Jules Verne, who used to be the delight of our younger days, introduces this simple fact, with a characteristically dramatic effect, in his story of *Hector Servadec*. The little party on the comet had started off upon their celestial journey, and were getting into regions more and more remote from the sun, and therefore darker and colder. The temperature fell till it was considerably below the ordinary freezing point of water, and yet the sea remained as fluid as ever, with its surface glassy and without a ripple, and the air in a dead calm. The mystery of the continued fluidity of the water when, according to all ordinary experience, it ought to freeze, was solved by one of the voyagers, who announced that the water was simply *supercooled*, and that if it were agitated in the least degree the molecules of water would immediately rearrange themselves and take on the form of ice. So to test the idea the little company proceeded to the top of a high cliff overlooking the sea, and a stone was given into the hand of a young woman in the party ("Nina," we think she was called), and she was bidden to throw it out into the still waters, as far as she could. This she did, and when presently it fell into the mirror-like sea far below them, the disturbance caused the water around the stone to freeze, and — whizz! — a sheet of polished ice spread with the speed of thought in all directions, and the surface of the sea was instantly solid from shore to shore!

This is the novelist's way of telling of the phenomenon of super-cooling; and, of course, however entertaining the story may be, it is, nevertheless, extravagant and impossible. The physicist's more conservative and careful way of telling of the same thing may be illustrated by the following extracts from Preston's *Heat*: "A liquid which has a definite freezing point may, if carefully and slowly cooled, be reduced to a temperature much below the normal freezing point without solidification setting in.

This anomalous condition is, however, unstable, for, if the over-cooled liquid be disturbed, or if a small piece of the crystalline solid [*i. e.*, *ice* in the case of water] be placed in contact with it, solidification at once sets in and continues until the temperature rises to the normal freezing point. This phenomenon was noticed as early as 1724 by Fahrenheit. Gay Lussac also observed that water placed in a vessel and covered with a layer of oil remained liquid at 10° Fahr., but a slight shake was sufficient to start solidification. Dufour contrived to cool small spherules of water to —4° Fahr. without solidification, by suspending them in another liquid of equal density and lower freezing point." We refer to this matter of surfusion at some length, because the hypothesis might conceivably be advanced, that heating water, and thereby expelling the air that it normally holds in solution, might make it more (or less !) likely to exhibit the phenomenon we have described ; and that this phenomenon of surfusion or super-cooling without congelation, might explain the assumed difference in behavior between heated water and faucet water. But we do not think such a supposition is tenable. If two pipes running side by side, one filled with faucet water and the other with cooled water, were to exhibit the phenomenon of surfusion in different degrees, a slight tremor of the building which would cause one of them to freeze, might, possibly, leave the contents of the other still fluid ; but it can hardly be supposed that the mere expulsion of dissolved air, or the removal of other matters in solution, would give rise to enough difference in the liability to super-cooling, to explain why a pipe full of heated water, under the conditions which prevail in practice, would remain fluid while a pipe full of faucet water would freeze. A jar or shock would have to be very accurately gauged, in order to precipitate solidification in one case, and not in the other. Moreover, we are of the impression that such difference as *does* exist would tend to make the faucet water freeze first, and hence would act contrary to the effect we wish to explain; but we cannot, at the moment, refer to any statements made by experimenters on this point.

If we regard the second, third, and fourth of the conjectured causes as disposed of, we may now proceed to the consideration of the first and fifth. The first supposition that we made was (as will be seen by referring to the first part of this article) that even when the quantities of water may appear to be equal in two given pipes, there may, in reality, be a material difference, so that, even when the heated water and the faucet water freeze with equal rapidity, one of the pipes will be filled solid with ice while there is still a considerable amount of unfrozen water in the other one. It cannot be denied that this cause often *does exist*, even though its adequacy may be doubted ; for a pipe which never conveys anything but cold, faucet water may remain fairly clean and free from obstructions for a long time ; whereas it is a matter of common knowledge that a pipe in which warm water usually circulates becomes pitted and corroded and furred up, on the inside, so that its effective internal diameter may be considerably choked and reduced when there is no visible sign of such action on the outside. Thus it may happen that two apparently similar pipes, side by side, may contain materially different quantities of water ; and, though the heated water may not freeze any faster than the faucet water, the pipe containing it may nevertheless become full of solid ice first, and so burst first. Moreover, the pipe conveying the heated water will be weakened to some extent by the corrosion above referred to, and hence may be unable to withstand a pressure which would not suffice to destroy the pipe conveying the faucet water. How much of the apparent proneness of hot-water pipes to freeze first is due to this cause is a matter of conjecture and of individual opinion ; but one can hardly doubt that differences in effective diameters and in relative strengths do ordinarily exist, and that these differences have *some* effect, in determining which pipe will freeze first.

There remains one other explanation, namely, the fifth in our list, which may be called the "omnibus" or "blanket" explanation, since it includes all others not previously enumerated. But, although it is so general that it *must* be right (provided all the others are wrong), yet we had one particular thing in mind when we framed it, and to that one particular thing we will confine our attention. We refer to *leakage*, which may prevent a pipe from freezing, by the slow but continuous introduction of water that is some degrees warmer than 32° Fahr. Of course a hot-water faucet may leak just as well as a cold-water one ; and it is, perhaps, even more likely to do so. Nevertheless, a hot-water faucet is always situated where its leakage attracts attention — in the bathroom, perhaps, or at the kitchen sink, or in the laundry tubs — and as it costs good money to heat water, and as it is, moreover, impossible to have hot water at all if there is a continuous leakage of any amount through the kitchen boiler, a leakage in the hot-water system compels attention for a variety of reasons, and repairs are made when they might be deferred or omitted altogether if they were needed on the cold-water pipes. Again, the cold-water system may leak where it attracts little or no attention, for example through the water-closets. Leaks of this latter class are very common indeed, and might be quite sufficient to prevent the cold water pipes from freezing, even though the existence of such leaks had not been noticed. To show the efficacy of this cause in preventing freezing, let us suppose that a one-inch pipe is exposed to the cold for 20 feet of its length, and let us estimate what flow of water would be required, per hour, to keep this length of pipe from freezing. Of course, the requisite flow will depend upon the severity of the weather, and also upon the temperature of the water in the city mains where they enter the building. To make the example definite, we will suppose that the water enters the building at a temperature of 40° Fahr., and we will suppose that the weather is severe enough to freeze the pipe solid in three hours. A pound of water gives up about 144 heat units in freezing, and since we are assuming that the pipe would freeze solid in three hours, it is plain this amounts to the same thing as supposing that every pound of water in the pipe loses, on account of its exposure to the weather, 144 units of heat every three hours, or 48 units per hour. So, if we supply the pipe with 48 units of heat per hour for every pound of water that it contains, it cannot freeze. Now every pound of water which enters the pipe from the city mains can give up 8 heat units before it reaches the freezing point (since its initial temperature is 40° Fahr., and the freezing point is 32° Fahr.), and hence, if we allow 6 pounds of city water to flow through the pipes per hour, for every pound of water that the pipe can hold, we shall just prevent the formation of ice, because each pound gives up 8 heat units, and therefore 6 pounds will give up $6 \times 8 = 48$ heat units, which, as we saw above, is precisely the amount of radiation from the pipe ; and the supply of heat being equal to the loss thereof, there can be no freezing. In other words, if we wish to prevent freezing under the assumed conditions, the least amount of leakage water which will accomplish that end is the quantity which will just fill the exposed part of the pipe six times per hour. It is easy to show that a one-inch pipe, 20 feet long, contains about 207 cubic inches. To entirely protect this pipe from freezing, under the assumed conditions, the leakage through it would therefore have to be at least $6 \times 207 = 1{,}242$ cubic inches, or a little less than $5\frac{1}{2}$ gallons, per hour. It may be objected that this leakage is excessive, and that it could not occur unless the faucet were purposely turned on. Such a criticism would doubtless be just, and yet it should be remembered that we have been figuring on the hypothesis that *none* of the water freezes. If 2 gallons per hour were to leak through, in the place of 5¼, a layer of ice would, undoubtedly, form on the inside of the pipe, and this layer would go on increasing in thickness until it became sufficient to protect the central stream of water to such an extent that the heat loss from this central stream becomes equal to the reduced supply of heat brought in by the 2 gallons of city water. We don't know what thickness of ice would restore the thermal equilibrium under these circumstances, nor does it appear necessary to attempt to give any estimate of it, since our purpose is abundantly served by calling attention to the importance of possible leakage, in explaining the supposedly quicker freezing of hot-water pipes.

If none of the suggestions that we have offered appeals to the reader as an adequate explanation of what his experience with frozen pipes may have taught him, then we are afraid that we shall have to shift the burden of proof over upon his own shoulders; because the deponent sayeth not further, at the present writing.

The Metric System.

"Irrespective of all other considerations," says *Cassier's Magazine*, "the periodically recurring agitation in favor of the compulsory use of the metric system ought to concern itself, but rarely does, with the all-important question of what it would cost to effect the proposed change in the varied industries in which the inch, and foot, and pound, and other measures of the English-speaking race have been in time-honored service. More than twenty years ago, in a report on the subject, made to the Franklin Institute by Dr. Coleman Sellers and the late William P. Tatham, it was stated that, according to calculation, in a well-regulated machine shop, thoroughly prepared for doing miscellaneous work, employing 250 workmen, the cost of a new outfit, adapted to new measures, would not be less than $150,000, or $600 per man. If new weights and measures were to be adopted (so the report continued), all the scale beams in present use would have to be re-graduated and re-adjusted; the thousands of tons of brass weights, the myriads of gallon, quart, and pint measures, and of bushels, half-bushels, and peck measures, and every measuring rule and rod of every description throughout the land, would have to be thrown aside, and others, which the common mind cannot estimate, substituted. The great mass of English technical literature would become almost useless, and would have to be translated from a language which we, and the nation we have most to do with, understand perfectly, into a new tongue, which is strange to most of our people. As a question of cost, let those who advocate this change consider it carefully. To the teacher, to the closet scholar, to the professional man, to those who never handled a rule or a measure, but use weights and measures only in calculation, it may seem merely a matter of legal enactment; but to the worker, the dealers in the market places, to those who produce the wealth and prosperity of the land, the question is a most serious one. Altogether, the ultimate benefits of the change proposed would be of less value than the damages during the transition. Those who choose to do so can use the metric system, and no one can object to it; but for the government to require its people to use that and no other, would be an arbitrary measure which they would be neither willing nor able to bear. With this view of the subject the most of us will agree at this later day."

The editorial quoted above, and which was doubtless prompted by Dr. Sellers' excellent though adverse article on "The Metric System" which was printed in the March issue of *Cassier's*, gives, in small space, a good idea of the obstacles that lie in the way of the metric system, as well as of the inconveniences that would attend its introduction. The difficulties are admitted, however, and the advantages are open to discussion. Some of the readers of The Locomotive have inferred, from our interest in this matter, that The Locomotive is an enthusiastic advocate of the metric system, and heartily in favor of its unconditional and compulsory adoption. Such is not the case. We are inclined to the belief, nevertheless, that the metric system is an excellent one, and that if the people of the United States should adopt it in the place of our present illogical and heterogeneous system, they would be very glad they had done so, when the trouble and annoyance and expense of the change were all gone by and forgotten. The advocates of the metric system do not always appreciate the enormous trouble and expense that so radical a change in our units would imply; but it may also be fairly said, we think, that its opponents do not always give it credit for the full measure of merit that may be in it. Surely, when we think of the vast number of future generations of Americans that we hope will succeed us, it is unwise to make the positive statement (which occurs in the article quoted above) that "the ultimate benefits of the change proposed would be of less value than the damages during the transition." This statement may be true of the present generation; but we owe something (though who can say *how much?*) to posterity — to our grandchildren and to their grandchildren, as well as to ourselves.

From whatever point of view we regard the proposed change in our system of weights and measures, the subject is a live one, and is going to remain so for a long time to come. May we not, therefore, call attention once more to the little book called *The Metric System* which was published, not long ago, by the Hartford Steam Boiler Inspection and Insurance Company? This book gives extensive tables comparing the various metric units with the corresponding ones in our present system, and it has been uniformly commended both by the press and by the general public. It is published in two editions, one of which sells at $1.25, while the other (which is printed on bond paper) sells at $1.50. It is mailed to any address upon receipt of the price at our home office, at Hartford, Conn.

The Ferris Wheel.

When the Ferris Wheel is sent to the scrap heap — a thing likely soon to happen — the greatest engineering vagary of the century will have passed into that oblivion reserved for fads, flying machines, and perpetual-motion contrivances. Not that the great Ferris Wheel is any of these, but simply because it never could serve any practical use, because it embodies no distinctly new principle in engineering, and because it has a marvelous faculty of emptying the coffers of those who try to make its huge bulk earn even a small part of the cost of maintaining it — to say nothing of the cost of original investment. As one of the wonders of the world's fair of 1893 — perhaps the chief wonder — the Ferris wheel stood unique. Its great size, marvelous construction, and distinct novelty made it not only the crowning feature of the Midway, but the gossip of four continents. During the continuance of the exposition more than a million and a half of visitors from all quarters of the globe rode in its suspended cars, and from a height of 264 feet caught a bird's-eye glimpse of the fair grounds, the lake and the distant city. Though less than a third the height of the Eiffel tower of the Paris exposition, the Ferris wheel was a much greater wonder. The Eiffel tower was merely a continuous projection of successive towers one upon another. Given a suitable base, its construction simply meant the stringing of iron and steel straight into the air. But in the Ferris wheel something new in construction was accomplished — new because of its great size. It was the projection of a gigantic circle, carrying thousands of tons of steel and iron suspended from an axle and readily movable by the application of machinery. To have built the Ferris wheel simply to stand upon its periphery would have been a comparatively simple task. To suspend this mass of metal from a central point and give it motion was the conception of genius.

Eiffel and his engineers were three years building the tower in Paris. The Ferris wheel was constructed and carrying passengers within four months. The idea of erecting this great wheel came to George Washington Gale Ferris, a native of Illinois and an engineer for the Pittsburg Iron Company, about a year before the opening of the world's fair. Mr. Ferris was then known as one of the most expert bridge builders in America, if not in the world; but when his scheme was mentioned to other engineers it was promptly pronounced chimerical. Some went even so far as to laugh at him, and not one dreamed the project ever would get beyond the speculative stage. But Mr. Ferris was persistent, and, besides, had faith in himself. Courageously he set to work and succeeded in interesting sufficient capital to warrant him in ordering material for the wheel. About $25,000 was spent in plans, tests, etc., before the actual construction of the wheel began. Some thirty firms took part in its making, and a Chicago firm saw to its erection. When ready to be turned, the Ferris wheel had cost $362,000 and had consumed about 8,000,000 pounds of iron and steel. The movable part of it weighed 4,200,000 pounds, and it required two engines of 1,000-horse power each to keep it turning. And so nicely adjusted were all the parts, so well balanced was the great steel circle with its thirty-six cars, capable of carrying 2,160 persons, that it was under as full control as a sewing machine or a pony engine. Once or twice during the world's fair the motive power needed adjustment, but the only results, as far as the public was concerned, were humorous incidents which gave the newspaper men a few columns of anything but dull reading matter.

It is barely possible that had the world's fair lasted a year or two, the Ferris wheel might have paid for itself. This is based on the assumption that it would have continued to be a novelty for twelve months or more. As it was, the gross earnings of the wheel during the fair were $812,000. About one-fifth of this went to the stockholders as profits. The power necessary to operate the big wheel would have run a cotton factory of 100,000 spindles and 3,000 looms, employing 5,000 operatives. The boilers of the power plant consumed coal like an ocean liner. No other single feature of the great exposition represented such an expenditure of energy. But the fair lasted only six months, and the Ferris wheel ceased paying dividends with the closing of the exposition gates. Had it gone from its place on the Midway direct to the scrap pile, or to Coney Island, as was at one time suggested, more than one Chicagoan would have been some thousands of dollars richer to-day. The wheel that was such a drawing card on the shores of Lake Michigan, where the surroundings were somewhat proportioned to its size, was moved to the North Side of the city and placed in a space so small that the cars hung over other property while the wheel was revolving. There it has turned occasionally for the last few years, eating up coal, piling up cost, an eyesore to the neighborhood, and a white elephant to its owners. What has the big wheel cost to date? Deducting the sum paid to stockholders during the world's fair, and counting as part of the cost what it has lost to its owners, it is safe to say that $1,000,000 will not cover the total. To move it from Jackson Park to the North Side cost alone $175,000; and it is figured it will require an expenditure of at least $25,000 to take it down and remove it from where it now stands. It is questionable if a single new principle in engineering has been demonstrated by the Ferris wheel, since it is merely a bridge built till both ends meet, as the Eiffel tower is a bridge of simpler construction, built on one end. Suspending such a great weight on an axle was daring, but not new in principle.—*Chicago Evening Post.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

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A Boiler Explosion in a Sash Factory.

It has been our custom to publish in The Locomotive, from time to time, illustrated accounts of boiler explosions. Sometimes, when we have published a number of such articles in succession, we discontinue the series for a while, and devote our leading articles to the consideration of points on boiler design, construction, and management, or to such general principles of physics as have an important bearing upon steam

Fig. 1.—General View of the Ruins.

engineering. We do this largely to give greater variety to the matter that we issue; but we find that a certain proportion of our readers form the idea, when we drop the question of boiler explosions for a time, that it is because no explosions worthy of notice occur. Nothing could be more erroneous than this notion. There is never any dearth of boiler explosions, and we could more than fill every issue of The Locomotive with illustrated accounts of them, if we chose to do so. In fact, we publish, in each issue, a monthly list of such boiler explosions as come to our notice, and while we do not pretend that this list is in any sense complete, it is always extensive enough to satisfy anyone who takes the trouble to examine it, that data for illustrated articles on boiler explosions are always available in large measure.

The explosion selected for illustration in the present issue occurred, a short time ago, in a sash and blind factory at Appleton, Wis. It is not presented as an unusually disastrous one, nor as being entitled to special consideration for any reason whatever. It is merely one out of a considerable number of other explosions, any of which might have been chosen with equal propriety. The property loss was by no means excessive, since boiler explosions often do vastly more damage than this one did; and although the number of persons killed and injured was perhaps larger than usual, the explosion was not at all remarkable even in this respect, because it is unfortunately common for

Fig. 2.—Showing the Shell of the Bursted Boiler.

accidents of this nature to claim a much larger number of victims than are here recorded.

The explosion under present consideration occurred at twenty minutes past eight o'clock in the morning, when all hands were at work, and resulted in the immediate destruction of the engine and boiler house, which was about 33 ft. x 40 ft., and of the main factory, which was three stories high and 60 feet wide by about 130 feet long, and also of a drying kiln about 40 feet square. These three buildings were totally destroyed, together with much valuable machinery, and a considerable quantity of the finished stock. The general appearance of the wreck of the main building, immediately after the explosion, is shown in Fig. 1, which was made from a photograph taken within an hour after the accident occurred. (Shortly after this photograph was taken, fire broke out in the ruins and completed the destruction of whatever may have escaped immediate ruin from the explosion.) The ruins of the drying kiln do not appear in the illustration, as they lay too far to the right to be included within the field of the camera. The total property loss is said to have been upwards of $20,000.

Of the workmen present at the time, Robert Pasch, Nathaniel Pattinson, William Bolduan, and Joseph Wettingel were either killed outright or injured so badly that they died within a few hours. John Foster, William Hoffman, Edward Koletzke, Paul Hoeppner, Herman Miller, August Rehfeldt, and William Weaver were also injured more or less seriously. An inspection of the photograph from which the engraving was made shows such a complete demolition of the buildings, that it is a matter of surprise that a greater loss of life did not occur.

The boiler which exploded was comparatively new (it was built in 1891), and was supposed to be in first-class condition. It was of the horizontal tubular type, 60 in. in diameter and 14 ft. long, and was of the "single sheet" design, so-called because the lower half of the boiler, and the upper half, too, in this particular case, consisted of a single big sheet. Each of the two sheets composing the shell was of steel, of a nominal thickness of $\frac{3}{8}$ in. The horizontal joints by which these sheets were united to each other extended from end to end of the boiler, and were double lap riveted, the rivet holes being $\frac{3}{4}$ in. in diameter, and pitched 3 in. apart, from center to center. After the explosion an old fracture was discovered in one of the plates at the joint, which extended along the direction of the joint for a distance of 6 ft. 4 in. This fracture extended only part way through the sheet, and it could not have been discovered by inspection, because at the only places where it came to the surface it was completely covered by the other plate, where the two plates lapped over each other in making the joint. The weakening of the shell at this point was undoubtedly the cause of the explosion. After the explosion the two heads were found, still securely fastened together by the tubes. The shell plates tore free from the flanges of the heads by stripping and shearing the rivets, and were found lodged in the ruins, all in one piece. The testimony taken afterwards showed that at the time of the explosion the safety-valve was blowing, and the steam gauge stood at 90 pounds.

Boiler Explosions.

DECEMBER, 1899.

(340.) — Two boilers exploded, on December 1st, at the No. 5 shaft of the Pennsylvania Coal Company, at Inkerman, near Wilkesbarre, Pa. The boiler house was wrecked and the iron stack thrown down. Fireman Thomas Woodside had just left the building, and escaped injury. Engineer George Rutledge was slightly injured by a flying missile.

(341.) — On December 2d a boiler exploded in the Hatfield Lumber Company's plant, at Hatfield, Ark. The explosion occurred about half-past four in the morning, and resulted in the instant death of A. B. Walker, night watchman, and the serious injury of a man named Higgins, who was in the mill at the time. The boiler was thrown about 200 yards.

(342.) — On December 5th a boiler exploded in the billet mill at the Joliet, Ill., plant of the Illinois Steel Company. Frank Miller was instantly killed, and his body was buried under the wreckage. Z. S. Butler, Newton Farmer, Henry Isbester, John McBride, William McMillen, Augustus Rottate, Patrick Sullivan, and W. F. Thoma were frightfully scalded. It is said that Sullivan cannot recover, and that the recovery of Farmer, Isbester, and McMillen is doubtful. The property loss is said to have been considerable, but we have seen no estimate of its amount.

(343.) — J. T. Langley's cotton gin, located at Dudleyville, near Opelika, Ala., was destroyed by a boiler explosion on December 6th. Two men were killed, and another man was injured.

(344.) — On December 6th a boiler exploded in the electric light plant of the York Light and Heat company, on Common street, Saco, Me. The station, a two and one-half story building, was completely wrecked, nothing being left of it but a pile of bricks and timbers. The explosion was followed by a profuse hail of bricks, which came down upon the tenement houses near by in such numbers as to suggest to the inmates that they were undergoing a vigorous bombardment. A red-hot brick was hurled through the window of a house 200 feet away, setting fire to the floor where it lodged. Engineer Charles Harmon and Fireman Charles Sweetsir had left the building half an hour before the explosion (the city being lighted only until midnight), and to this fact they owe their lives. We do not know the cause of the explosion, but the property loss is said to have been $20,000.

(345.) — A heating boiler exploded, on December 7th, in a building on Exchange street, Portland, Me. Nobody was hurt, and the damage was small.

(346.) — A boiler exploded, on December 8th, in the Greensburg Limestone Company's plant, at Harris City, some six miles south of Greensburg, Ind. The boiler passed up through the roof of the building. Engineer Nels Goodwin was blown through a doorway, but received no serious injuries. The damage to the building and machinery is estimated at $1,200.

(347.) — A heating boiler bursted, on December 8th, in the Southwick House, at Smith College, Northampton, Mass. The building was severely shaken, and a panic followed among the young women. The Lowell (Mass.) *News*, being far enough away from the college for its editor to feel sure of his scalp-lock, made the following unchivalrous observations concerning the accident: "The house is occupied by the richer class of girls, who pay from $15 to $20 a week board, and the room furnishings are of a style to fit their purses. One girl threw out of a window a French clock which cost $80, and there were two elegant bronze mirrors thrown out by other students; while the girls who even have to have their hair done up by maids, grabbed their trunks and rushed down stairs with them with the ease that a college footballist displays in handling the pigskin."

(348.) — On December 9th a boiler exploded in the Metallic Casket Company's works, at Springfield, Ohio. The boiler was a small one, used for heating the building and the dry kilns. No considerable damage was done.

(349.) — A boiler exploded, on December 9th, at Saratoga, N. Y., in the Diamond Churn factory, now used by Messrs. Crippen, Reed & Coon as a branch wrapper factory. Nobody was injured except a young woman who sprained her ankles by jumping from a second story window. The local reporter says that the boiler "was not built to withstand a caloric pressure," whatever that may be; so we suppose that if there was any "caloric pressure" around there at the time, it is both morally and legally responsible for the explosion.

(350.) — A boiler is said to have exploded, on December 9th, at New Augusta, on the Big Four road (Chicago division), near Indianapolis, Ind. Two men are reported killed.

(351.) — On December 9th the boiler of A. W. Wills & Sons' steam dredge, which was in use for excavating the Monon river, exploded six miles south of North Judson, near Crescent, Ind. Engineer Sanders and a workman named Michael Hodeck were killed, and several others were injured. The dredging outfit was demolished.

(352.) — A boiler exploded on December 9th in Charles Ward's shipyard, at Kennebunkport, Me. Engineer Alden Wildes was instantly killed, his body being blown to pieces. Everything in the vicinity of the exploded boiler was totally wrecked. The explosion occurred at 6.30 in the morning, and the engineer was the only man near enough to the boiler to be injured.

(353.) — On December 11th a boiler exploded at the I. McIntosh Coal Company's No. 1 mine, at Brazil, Ind. Engineer Samuel Jones was severely injured, and the engine and boiler house was demolished.

(354.) — The boiler of Harlow & Blake's wood-sawing outfit exploded, on December 12th, at Albia, Iowa. Nobody was injured.

(355.) — On December 12th a main line locomotive boiler exploded on the tram road of the Sabine Tram Company, at Laurel, Tex. Fireman George Montgomery was instantly killed, and Engineer Bruce Smith was injured. Both men were thrown fifty yards or more. The engine was utterly destroyed, its parts being scattered over a radius of 500 yards.

(356.) — A boiler exploded, on December 12th, in A. M. Hardin's flour mill at Lodinburg, on the Texas railroad, in Breckenridge county, Ky. The mill building was wrecked, and Mr. Hardin, who was running the boiler himself at the time, was painfully burned and scalded.

(357.) — A boiler exploded, on December 13th, in the Troy Hill pumping station, at Allegheny, Pa. Engineer Thomas Patterson was fatally injured. The property loss was about $5,000, and fire broke out in the wreckage and completed the destruction.

(358.) — A boiler exploded, on December 14th, in the South Penn Oil Company's pumping station at Kenton, Doddridge county, W. Va. Frederick A. Holmes, a pumper, was scalded to death. We have not learned further particulars.

(359.) — Thomas McNerney was fatally injured and John Duffy was injured very seriously, on December 16th, by the bursting of a boiler tube in Baeder & Adams' Glue Works, at Philadelphia, Pa.

(360.) — A big landslide occurred, on December 19th, over the quarries of the New York and Rosendale Cement Company, at Rosendale, near Kingston, N. Y. The buildings occupied by the company were swept out of existence, and much damage was done. In the midst of the commotion the boiler exploded, and the greater part of it was thrown to a distance of 200 feet. Some warning of the impending slide was given by ominous cracking sounds, emitted by the ledges some hours before they fell, and the workmen had been instructed to keep out of danger as much as possible. Nobody was killed, and the only persons hurt were Richard Markle and Bradley Smith, who received slight injuries. [This explosion was illustrated and described in the issue of The Locomotive for March, 1900.]

(361.) — Engineer Leonard Wager was fatally scalded, on December 20th, by the explosion of a boiler on the tug *Governor Fenton*, while off Tottenville, near Perth Amboy, N. J.

(362.) — On December 20th a locomotive boiler exploded at South Athol, Mass., on the Athol branch of the Boston & Albany railroad. Engineer Henry C. Ingraham and Fireman Comans were seriously injured, but both will recover. The passenger train to which the locomotive was attached ran 150 feet before coming to a stop, but did not leave the rails. It was well filled with passengers, who were badly scared, but not physically harmed.

(363.) — The boiler of a locomotive drawing a heavy freight train on the Chesapeake & Ohio railroad exploded, on December 21st, while running at a good rate of speed, near Foster, Ky. Brakeman Michael Malloy was killed, and Engineer Sidels and Fireman Edward Murphy were scalded.

(364.) — A slight boiler explosion occurred, on December 21st, at the No. 4 furnace in the puddling department of the Harrisburg Rolling Mills, at Harrisburg, Pa. John S. Lukens was painfully scalded, but will recover.

(365.) — A boiler gave out, on December 22d, in the water works plant at Braddock, near Pittsburg, Pa. We judge, from the account at hand, that the fire had only recently been started under the boiler, so that only a few pounds of steam were on. Engineer Anthony Simons was scalded. The explosion appears to have been due to corrosion of the sheets.

(366.) — On December 23d a blow-off pipe gave way, close to the boiler, on the horse transport *Westminster*, just after she sailed from San Francisco for Manila, loaded with horses. The vessel had only got out as far as the lightship when the accident occurred, and she put back to San Francisco for repairs. Oiler L. Hansen, Engineer H. Wade, and a Chinese fireman were injured.

(367.) — A boiler exploded on December 23d, in the mines at Forbush, near Centerville, Iowa. We have not learned further particulars.

(368.) — On December 23d a boiler exploded in Waybright's sawmill, at Frozen Camp, three miles east of Ripley, Jackson county, W. Va. Benjamin Rose and Hiram Curry were instantly killed, and Mr. Waybright, the owner of the mill, was blown more than a hundred feet through the air, clearing a lumber pile five feet high, and landing upon a pile of boards. He was fearfully scalded and bruised, and his injuries are said to be fatal.

(369.) — On December 25th a small boiler exploded in the west laundry at Racine College, Racine, Wis. The damage done was small, but the building in which the boiler stood took fire, and the college was saved from destruction only by the strenuous efforts of some of the professors, who succeeded in controlling the flames before they had made much headway.

(370.) — A small boiler exploded on December 26th in the Northwestern laundry, at Des Moines, Iowa. We have not learned particulars, except that the damage was small and that nobody was injured.

(371.) — The boiler of locomotive No. 518 on the Denver & Rio Grande railroad exploded, on December 27th, at Minturn, near Denver, Col. Engineer S. H. Quackenbush was instantly killed, and fireman Irvine Salene was injured so badly that he died a few hours later. Thomas Richards, Alexander Wilson, William Vannati, and Michael Madden were also seriously injured. The explosion occurred a few minutes after the train pulled into the station at Minturn, with passenger train No. 2, from Grand Junction. The locomotive was blown to fragments, and pieces of it were scattered about over an area extending for 1,000 feet around.

(372.) — The boiler of locomotive No. 26, on the East New York branch of the Brooklyn, N. Y., elevated railroad, exploded on December 29th. The explosion occurred near Manhattan Crossing, about six miles from the Brooklyn City Hall. Engineer Joseph Green and fireman Henry Steiner were severely scalded, and Steiner was also badly bruised by being blown from the cab.

(373.) — On December 30th a boiler exploded in John Haviland's sausage factory, at Geneva, some ten miles south of Decatur, Ind. The building in which the boiler stood was completely demolished, and a neighboring one was also badly damaged. Mrs. Millette, who was sitting in her residence across the street from the factory, was struck by a flying fragment of the machinery and almost instantly killed. Miss Nancy Maclin, a domestic in the same house, was also seriously injured.

(374.) — A boiler exploded, on December 30th, on the line of the Pennsylvania railroad, a short distance west of Elizabethtown, near Lancaster, Pa. It was in use by Keller & Crossan, contractors, who were at work on the Elizabethtown cut. Burt Davis, Antonio Dominico, Donald Haldeman, and Witmer Sherbahn were killed, and several others had very narrow escapes. Of course the low-water theory had numerous adherents among the philosophers who sought to explain this explosion, but we also note that "a few incline to the belief that some wretch had placed a stick of dynamite among the fuel used under the boiler;" though what motive the said wretch might have had does not appear.

(375.) — Mr. C. C. Kubach, manager and part owner of the Berry Coal and Coke Company, at Stonecliff, near Charleston, W. Va., was killed on December 31st by the explosion of a vertical boiler used at that place for pumping water. D. C. Hinkle was also seriously injured.

"Wanted — Locomotive Engineer." — An advertisement, which appeared recently under this heading in a Minneapolis paper, is so suggestive of past experience and of future possibilities that we reproduce it herewith, all but the signature. We can certify to its genuineness, as the original is in our own possession. It reads as follows: "I want a man who can run a Shay Gear Lima engine for logging railroad; I don't want excuses, I want logs. I want a man who can climb into the firebox and caulk his flues with 60 lbs. of steam on, and who can 'get there' without having a machine-shop under the cab eaves. In short, I want an engineer who will not burn out the telegraph line with complaints to headquarters. Work in Wisconsin. Steady job with adequate pay to the right party."

The Engineering Society of Columbia University, New York City, has issued its *Transactions* for 1898–99, in the form of a very attractive book of something like 150 pages. There are eight papers on various engineering subjects, by well-known engineers, these papers being lectures, or abstracts of lectures, that were delivered before the society during the year. All of them are beautifully and appropriately illustrated, and the volume is full of interest, and will make a desirable addition to the library of any civil or mechanical engineer. Copies of it may be had at one dollar each, by applying to Mr. George D. Orner, Columbia University, New York, N. Y.

The Locomotive.

HARTFORD, MAY 15, 1900.

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

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

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

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

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

Mr. Overn's Retirement.

Mr. John Overn, who for twenty-eight years has been Chief of the Bureau of Boiler Inspection in the city of Philadelphia, resigned his position a few days ago, on account of "declining years, together with the physical infirmities resulting therefrom." The Director of the Department of Public Safety, to whom the resignation was sent, replied to it as follows: "In accepting this resignation, permit me to express to you, on behalf of Mayor Ashbridge, myself, and the community at large, a sincere regret that the city should be compelled to lose your services. You have served your fellow-citizens many years, faithfully, loyally, and honestly; and in your declining years it must be a source of pride to you that during your term so few accidents have occurred, and that there has been a sense of security in the minds of the people from boiler explosions, which was due to the confidence reposed in you." It gives us great pleasure to subscribe earnestly to these sentiments, and we take this opportunity to assure Mr. Overn of our high regard for him, and to wish him many years of prosperity and happiness.

The Number of Boilers in the United States.

We are often asked how many steam boilers there are in the United States, and every time we have to reply that we don't know. The United States Census Bureau enumerated the boilers in taking the tenth census, and the result, as published by the Government in the *Compendium of the Tenth Census* is, that in 1880 there were 72,304 stationary boilers in this country. In the census of 1890 the steam boilers were not enumerated, although President Allen, of the Hartford Steam Boiler Inspection and Insurance Company, knowing by experience the demand that there is for information on this subject, endeavored to persuade the Bureau to include them again in its statistics.

Notwithstanding these facts, our friends appear to expect us to know how many boilers there are in the country,—though by what process we can be supposed to have acquired such knowledge is not at all apparent. The only thing that we (or anyone else) can do, in the absence of an official count, is to make a variety of guesses, based upon hypotheses that are likely to be somewhere near to the truth, and then compare these guesses, and see if there is any sort of agreement among them.

For the sake of showing how the various methods that might be proposed for getting at the number of boilers desired agree among themselves, we are going to calculate that number for the year 1890, using the official count for 1880 (*i. e.*, 72,304) as a basis.

The first hypothesis that would naturally occur to us is, to assume that we insure, from year to year, about the same proportion of the total number of stationary boilers in the country. The total number of boilers in 1890 was of course greater than in 1880, and the number that we insured was greater in 1890 than it was in 1880; but we will suppose, for the moment, that the growth of our business just kept pace, during these ten years, with the increase in the total number of boilers in the country. Now, on December 31st, 1880, we had 12,320 boilers under insurance; and on December 31st, 1890, we had 38,341 boilers under insurance. Our hypothesis then leads to the proportion: (Boilers insured in 1880) : (boilers insured in 1890) :: (whole number of boilers in 1880) : (whole number of boilers in 1890).

That is,

12,320 : 38,341 :: 72,304 : (whole number of boilers in 1890).

Solving this proportion we have $72,304 \times 38,341 = 2,772,207,664$, and $2,772,207,664 \div 12,320 = 225,017$; so that according to this method of figuring, the whole number of boilers in the country in 1890 would be 225,017. We give this calculation because it would naturally occur to anyone; but we do not attach any value to the result, because we know very well that the hypothesis upon which it rests is incorrect. We know that the boiler-owning public has been educated more and more, every year, in the matter of boiler insurance, so that a continually-increasing fraction of them has seen the wisdom of insuring. This means that we certainly insured a larger proportion of the boilers in the United States in 1890 than we did in 1880. In other words, the total number of boilers in 1890 was undoubtedly materially less than 225,017.

We will next assume that the number of boilers increased in exact proportion to the *population* of the country. The population was 50,155,783 in 1880, and 62,622,250 in 1890. Hence we should have the proportion :

50,155,783 : 62,622,250 :: 72,304 : (whole number of boilers in 1890).

From this proportion we find that the whole number of boilers in 1890, if figured on the population basis, would be $62,622,250 \times 72,304 \div 50,155,783 = 90,275$. This estimate is undoubtedly much nearer the truth than the previous one, and we do not see how we can judge whether it is more likely to err in excess or in defect.

Our next supposition will be, that the number of boilers has just kept pace with the total actual valuation of property in the United States. According to the *Statesman's Year Book* for 1899, the total valuation of property in this country was $43,642,000,000 in 1880, and $65,037,000,000 in 1890. Hence, on this basis, our proportion would be

43,642,000,000 : 65,037,000,000 :: 72,304 : (total boilers in 1890).

Solving this proportion, we find that it indicates that the total number of boilers in 1890 was 107,750. This also appears to us to be as rational a basis as any, and it is noteworthy that it does not depart so very far from the estimate based upon the increased population.

We might also assume that the number of stationary boilers has increased proportionally to the number of locomotive boilers, and this would furnish us with still another proportion, since the number of locomotive boilers in the country is given, year by year, in Poor's *Manual of Railroads.* According to this authority there were 32,241 locomotives in use in 1890; and while we have not got the precise figures for 1880 at hand, we judge, from the data given for 1881, 1882, and 1883, that the number of locomotives in use in 1880 was very close to 18,260. Our proportion would therefore be,

18,260 : 32,241 :: 72,304 : (total boilers in 1890).

This proportion, based on the number of locomotive boilers in use, gives 127,664 as the total number of stationary boilers in the United States in 1890. We are inclined to think that this is a little large, as the railroad development of the United States has been very rapid since 1880, and it appears probable that the number of locomotives in use increased, between 1880 and 1890, with proportionally greater rapidity than the number of stationary boilers.

If we admit land traffic as a basis of calculation, there does not appear to be any good reason why we should not also admit water traffic. The total number of steam vessels in the United States merchant marine was 4,717 in 1880 and 5,965 in 1890 (including vessels on the Great Lakes); and if we base a proportion on these figures we shall have

4,717 : 5,965 :: 72,304 : (total boilers in 1890).

Solving this proportion, we find that if the stationary boilers increased in the same ratio as the number of steam vessels in the merchant marine, they would number 91,434 in 1890.

To recapitulate: The number of stationary boilers in the United States in 1890 was 225,017, if they increased in proportion to the number of boilers insured by the Hartford Steam Boiler Inspection and Insurance Company; it was 90,275 if they increased in proportion to the population; it was 107,750 if they increased in proportion to the total value of property in the United States; it was 127,664 if they increased in proportion to the number of locomotive boilers in use on the railroads; and, finally, it was 91,434 if they increased in proportion to the number of steam vessels in our merchant marine. If we omit the first of these estimates (based upon the number of insured boilers) as certainly excessive, we see that there is a rough agreement among the others; and the average of the remaining four estimates being 104,281, we should say that there is some probability that the number of stationary steam boilers in use in the United States in 1890 was not far from 100,000.

The figure we have thus obtained cannot have any great pretension to accuracy, but it is probably as good an estimate as can be made. We sincerely hope that in the coming Twelfth Census, the steam boilers of the country will be again enumerated, because, as we said at the beginning of this article, the letters that we receive on the subject indicate that there is a demand for more exact information upon it.

It may be of interest to note that the figures here given for the total number of boilers in 1880 and 1890 show that in 1880 the Hartford Steam Boiler Inspection and Insurance Company insured 17 per cent. of all the boilers in the United States, while in 1890 the percentage of boilers so insured had risen to 38 per cent.

MR. F. R. LOW, editor of *Power*, has favored us with a copy of his little book on "Condensers," containing a series of articles reprinted from *Power*. The book begins with the elementary principles of the condenser, explaining its application to the steam engine, and pointing out how the condenser increases the efficiency of the engine. It then proceeds to a consideration of the various forms that the condenser has taken in practice, and we find separate chapters on the jet condenser, the surface condenser, the injector (or siphon) condenser, and the exhaust steam induction condenser. A chapter on condenser capacities then follows, in which various rules and tables are given for proportioning the condenser and its accessories. The book is illustrated, and it is a praiseworthy attempt to popularize a subject which is rather obscure in the minds of many engineers. It is well worth the fifty cents that is charged for it. (The Power Publishing Company, World Building, New York city.)

Boiler Explosions During 1899.

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 1899, together with the number of persons killed and injured by them.

It is difficult to make out accurate lists of explosions, because the accounts of them that we receive are often unsatisfactory. We have spared no pains, however, to make this summary as nearly correct as possible. In making out the detailed monthly lists from which it is extracted (and which are published from month to month in The Locomotive) it is our custom to obtain as many 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. It may be well to add, too,

Summary of Boiler Explosions for 1899.

Month.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January,	49	21	50	71
February,	29	12	27	39
March,	42	35	41	76
April,	21	21	23	44
May,	28	19	31	50
June,	22	11	19	30
July,	25	26	38	64
August,	43	46	68	114
September,	31	33	47	80
October,	27	28	43	71
November,	29	19	33	52
December,	37	27	36	63
Totals,	383	298	456	754

that this summary does not pretend to include *all* the explosions of 1899. In fact, it is probable that only a fraction of these explosions are here represented. Many accidents have doubtless happened that were not considered by the press to be sufficiently "newsy" to interest the general public; and many others, without doubt, have been reported in the local papers that we do not see.

The total number of explosions in 1899 was 383, which is also the precise number that we recorded for 1898. There were 369 in 1897, 346 in 1896, and 355 in 1895. In several instances during the past year two boilers have exploded simultaneously, and in one instance four boilers have so exploded. When this has happened we have counted each boiler separately in making out the summary, as we have done heretofore; believing that in this way a fairer idea of the amount of damage may be had.

The number of persons killed in 1899 was 298, against 324 in 1898, 398 in 1897, 382 in 1896, and 374 in 1895; and the number of persons injured (but not killed) in 1899 was 456, against 577 in 1898, 528 in 1897, 529 in 1896, and 519 in 1895.

It will be seen from these figures that during the year 1899 there was, on an average, over one boiler explosion a day. The figures in the table also show that the average of the deaths and injuries during 1899, when compared with the number of explosions, was as follows: The number of persons killed per explosion was 0.78; the number of persons injured (but not killed), per explosion, was 1.19; and the total number of killed *and* injured, per explosion, was 1.97.

The Nicaragua Canal.

The famous trip of the *Oregon* around South America drew public attention to the naval importance of a canal between the Atlantic and Pacific oceans so emphatically and dramatically that the public has taken a much greater interest in the question of an isthmian canal since that trip than it did before. The naval advantages of such a canal are too obvious to need discussion. The most feasible route for it has appeared to be what is called the "Nicaragua route," which starts from the Caribbean Sea at Greytown, follows up the San Juan river to Lake Nicaragua, crosses Lake Nicaragua, and then descends to the Pacific Ocean by means of a system of locks extending, in all, for some sixteen miles. The water required for the operation of this system is supposed to be obtainable from Lake Nicaragua; and we are free to confess that it never occurred to us, until recently, that there was any question as to whether the water *could* be so obtained or not. Professor Angelo Heilprin contributes, to a recent issue of the *Scientific American Supplement*, an article entitled "The Shrinkage of Lake Nicaragua," which will cause every man who is interested in the canal to do some heavy thinking. In fact, he shows that the level of the lake is falling almost continuously; and the startling thing about this change is, that it is so marked and rapid and long-continued, that there does not appear to be any reason for supposing that it is a temporary phenomenon, which will presently be compensated by increased rainfall. Careful records have been kept at Rivas, on the Pacific side of the lake, since 1880; and it is from the data so accumulated that Professor Heilprin has arrived at the discouraging conclusion "that the lake — unless, indeed, the official reports are inaccurate — has been steadily and progressively undergoing shrinkage, and that it must continue to do so in the future."

The *Scientific American*, in its editorial comments upon Professor Heilprin's article, says: "The determinations of altitude of the lake made by Galisteo, in 1871, and by Baily, in 1838, show that it formerly stood at a much higher level than that established by recent surveys, a fact which is confirmed by the report of Collinson to the Royal Geographical Society, in 1867, who states that 'even the least observant native, dwelling on the lake, will tell how its banks are rising year by year visibly before his eyes.' The most comprehensive record of rainfall, evaporation, etc., is that contained in the report of the Nicaragua Canal Commission of 1897–99, which, although it makes no specific analysis of its own figures to determine the question of net gain or loss in the volume of the lake, does actually afford confirmation of the statements of the early engineers, as Prof. Heilprin shows in his article. It is made plain from the report that the intake of Lake Nicaragua — rainfall and drainage from its drainage basin — is apparently for almost every year less than the output — the loss due to evaporation and outflow; while in exceptionally dry years the evaporation alone is greater than the entire intake. From November 1, 1889, to June 1, 1891, the total rainfall would have raised the level of the lake 45.75 inches. The evaporation alone would have lowered it 95 inches, a loss, outside of what would have run off through the San Juan River, of over 4 feet. The aggregate loss during three dry spells, not taking count of outflow through the San Juan, was 10 feet 10 inches.

"The compensations for such losses must be found in periods of extraordinarily heavy rainfall; but despite the fact that immediately after excessive rains the lake has been known to rise two feet in six weeks, the greatest net accession to the lake for any entire year, during a period of 20 years, was considerably less than 2 feet. In the year 1898, when the rainfall was 108 inches, the net rise of the lake was only 18 inches, and a comparison of the records shows that during 19 years of successive observations (1880 to 1898) there were not more than four periods, the years 1893, 1897, 1898, and possibly 1886, when the lake held its own, and during these years combined the actual gains were less than 5 feet. On the other hand, in the single year 1890, when the rainfall at Rivas was only 31.81 inches, the loss was as great as the gains for the entire 19 years!

"In calculating the net result of all the causes of supply and loss affecting the lake level, the average recorded evaporation is taken as 55 inches, and the outflow through the San Juan as 42 inches, or one-half the amount in the extremely wet season of 1898. On this basis there is a total loss of 363 inches as against a total gain of 114 inches, or a net loss of 20 feet 9 inches. From this result the author of the paper concludes that for a long period of years Nicaragua has undergone a very marked and progressive shrinkage. It is true that the outflow through the San Juan may be controlled and water may be stored in wet seasons against the deficiencies due to drought; but although the evil day may be thus postponed it is only a question of time, if the lake be steadily shrinking, when the surplus storage will be inadequate to meet the ever-growing deficiency.

"We agree with the author of this paper that 'it is hardly less than amazing that these reports should not have been analyzed before, and their bearing given full consideration;' and we trust that Congress will recognize, in the grave considerations thus presented, a further inducement to await the results of the searching investigation which is now being made by the President's commission."

Inspectors' Report.

MARCH, 1900.

During this month our inspectors made 10,740 inspection trips, visited 21,028 boilers, inspected 7,004 both internally and externally, and subjected 739 to hydrostatic pressure. The whole number of defects reported reached 12,713, of which 1,160 were considered dangerous; 63 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,168	69
Cases of incrustation and scale,	2,620	50
Cases of internal grooving,	128	14
Cases of internal corrosion,	591	30
Cases of external corrosion,	464	33
Broken and loose braces and stays,	180	98
Settings defective,	305	35
Furnaces out of shape,	339	15
Fractured plates,	291	34
Burned plates,	348	30
Blistered plates,	106	6
Cases of defective riveting,	1,538	41
Defective heads,	48	16
Serious leakage around tube ends,	2,328	445

Nature of Defects.	Whole Number.	Dangerous.
Serious leakage at seams,	364	13
Defective water-gauges,	192	71
Defective blow-offs,	155	48
Cases of deficiency of water,	12	6
Safety-valves overloaded,	77	31
Safety-valves defective in construction,	106	21
Pressure-gauges defective,	355	36
Boilers without pressure-gauges,	4	4
Unclassified defects,	994	14
Total,	12,713	1,160

The Sky-Scraper Guide.

Omniscience, nothing less, is expected of the men who direct visitors to the multitude of offices in the modern down-town "sky-scraper." Often it is nearly attained, and the New Yorker takes that as a matter of course; but to the stranger, particularly to the foreigner, it is apparently very wonderful.

"But I say," exclaimed a newly-arrived Britisher, as his eyes rolled painfully heavenward in an effort to follow the lines of a towering down-town "sky-scraper" — "I say, don't they have guides or couriers or some one like that in there — somebody to show you about? I should hate awfully, you know, to attempt it alone; why, it must be quite like to scale the Matterhorn all by yourself."

"Of course they have guides," answered the New Yorker who was with him, glowing with pride; "most wonderful guides you ever saw,—regular walking Baedekers, with an alphabetical appendix of the population thrown in. Why, for plain, simple fountains of facts they make those London-tower chaps of yours seem like an expurgated primer. Come on; we'll go inside and I'll introduce you to one. And I'll just tell you what I'll do," continued the New Yorker arrogantly, as the two men passed through the heavy swinging doors into the corridor of the building. "You take any name that comes into your head and ask the guide about him, and I'll lay you a small one he will tell you instantly whether the man is a tenant in the building now, or ever has been, or expects to be one in the next four weeks."

"But how many tenants are there in the building?" asked the Englishman.

"Five thousand, including clerks, bookkeepers, office boys, stenographers, and private secretaries. Take any name you want; it does not matter to me, nor to the guide."

"On the strength of those odds I'll have to go you," said the foreigner. "How will 'Davidson' do?"

A moment later the New Yorker and his friend were standing before a placid man in uniform, who was waiving a group of elevators skyward and answering the queries of a long line of impatient individuals.

"Can you tell me," asked the Englishman, when the man in the uniform had dismissed the half-dozen men ahead of him, "can you tell me whether Mr. Davidson is in the building?"

"John C., Samuel R., or W. R. C. Davidson?" asked the man in uniform, neglecting to count two for a comma and four for a period. "JohnCnineteenthfloorroomtwosixfiveeight. SamuelRfifteenthfloorroomsevenfournine. W.R.C.auditor'sofficeC.R.and S.twentysevenfloorroomtwofournine. Wanttakeexpresselevatorotherside."

When the man in uniform paused, not from want of breath, but lack of Davidson facts, the Englishman seemed dazed. Suddenly a thought seemed to come to him, and his face lighted with new hope. "But where is Charles Davidson?" he asked. "It's Charles I'm looking for."

"Dead. EstatenumberfortyfiveBroadMillerBuilding."

The foreigner turned hopelessly to his friend. "Where's the refreshment room?" he asked. "You win."

"Restaurantinbasementthirdturntoyourleftclosedafterfiveo'clock," the oracle continued, mechanically.

"Look here," exclaimed the Englishman, "is it true that you know by name every one of the four or five thousand tenants in this building?"

"Try me and see," the man in the uniform answered, pointing to a huge frame containing in columns eight feet long the names of all the office-holders. "There are about three thousand five hundred of them there, and they are scattered around in two thousand rooms and over twenty-three floors, not counting this main corridor and the basement. You pick out any one of them, and if I can't tell you in a second just where he is, I will give you my job. That's what I'm here for — it's my business to know where they are, and keep track of them — that's what I get $12 a week and this uniform thrown in for.

"How long did it take me to learn them all? Just as long as the people have been moving in here. As fast as they come I commit them to memory — that makes it easier, of course. I don't know what a brand new man would do if he had to learn the names of all our tenants at once, and keep these elevators running on schedule and the corridor from getting blocked up all at the same time. I guess he would go to some insane pavilion about the end of the first week. I sort of grew up with the building — came here when it was first opened — so you see it was easier for me. All the new tenants are supposed to hand their names to me as soon as they rent offices in the building. A great many of them forget to do it, and then I catch it when some one comes in to inquire for them."

"But you're not expected to know the names of all the clerks, typewriters, and stenographers, are you?" asked the New Yorker.

"We're not expected to, but I'll bet you there are not more than a hundred persons, all told, in this building to-day whose names I don't know and whose faces I can't recognize. I say 'good morning' to at least two thousand people every day, and call them by name. Of course, I'm a little deficient on office-boys — they don't count much anyway — but I can tell in what office more than two-thirds of them work."

"What do you do when a foreigner comes in who can't speak English?" asked the Englishman.

"If he's French, we call one of the waiters; if Dutch, one of the barbers; if Italian, one of the bootblacks. If he's anything else, we take chances on him. But the foreigners are not the people who worry us — it's the countrymen — the lawyers and small bankers from the villages up the State. I'll bet I can recognize ninety-nine out of every hundred that come in here. Exactly ninety-nine in every hundred will turn back at least twice, and probably three times, to ask the question all over again. After we've told them the first time they usually get about half way to the elevator before they forget. Then they come back to us with 'You said the ninth floor, didn't you?' or 'Did you say turn to the right or to the left?' About half of 'em try to throw the blame for their not understanding on us. 'You know I said Clarence Jones, not William,' is an old one. I guess I hear it twenty times a day. Oh, I guess we earn our money, all right. We're here from 8 o'clock till 7, and sometimes 8." — *New York Evening Post.*

The Locomotive.

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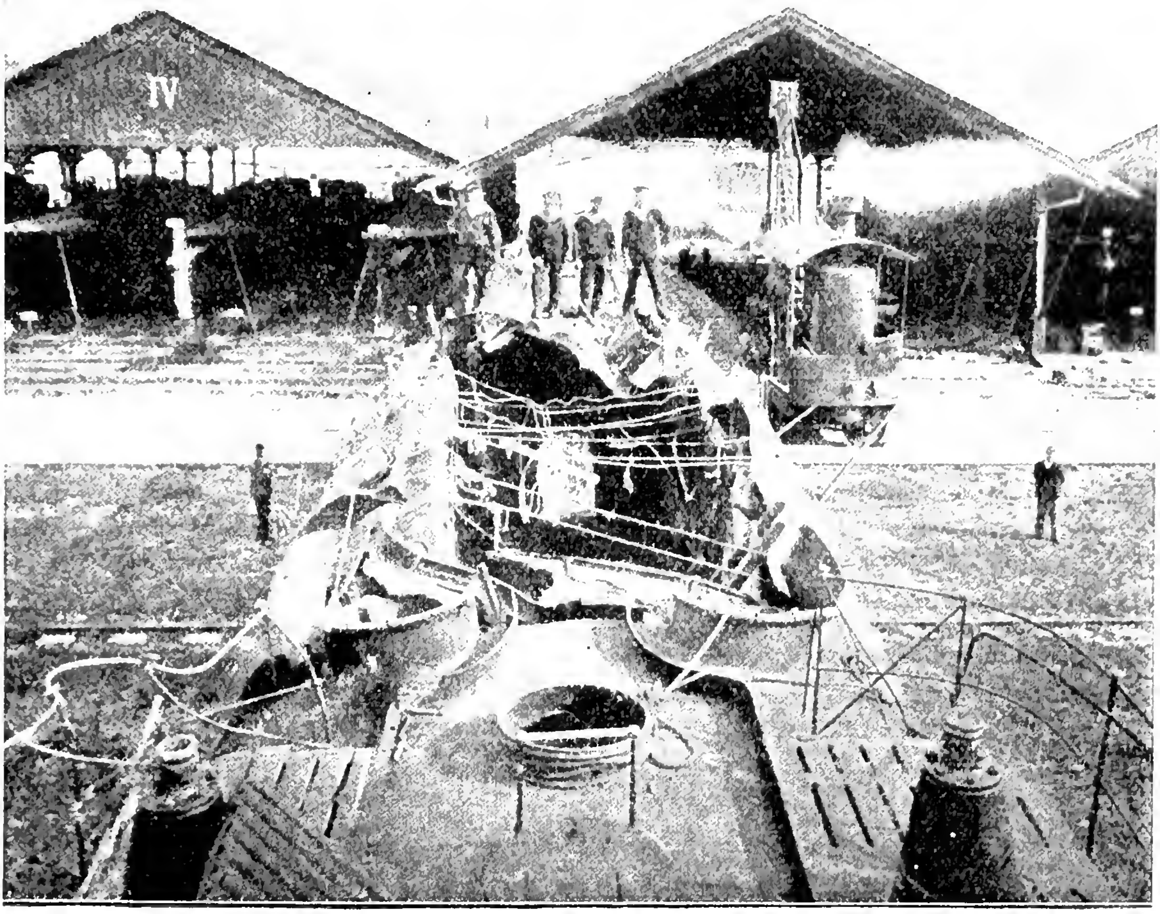
Boiler Explosion on an Austrian Torpedo Boat.

Since the wreck of the frigate *Radetzky*, which occurred thirty years ago, the Austrian navy has never had to record a greater disaster than that which occurred to H. M. Torpedo Boat *Adler* on July 22, 1899.

This vessel was built by Yarrow & Company, Ltd., London, in 1885, and was of the following dimensions: Length, 135 ft.; beam, 13 ft. 9 in.; mean draft, 5 ft. 6 in.;



APPEARANCE OF THE "ADLER" AFTER THE EXPLOSION.

displacement 95 tons, and bunker capacity, 28 tons. The engine developed a maximum power of 1,200 I. H. P., giving a speed of 22.2 knots. The boiler was built by Hicks & Hargreaves, of Bolton, Manchester, England, and was of the locomotive type, as adapted for marine work, and was connected to two funnels placed athwartships of each other.

The vessel had been ordered in commission for the summer of 1899, and after the usual overhauling, cleaning, and scaling, and dock trial, she left her anchorage at Teodo at 6 A. M., July 22, for a run to Sebenico. The crew consisted of 17 men. As is customary for long runs, she was run under reduced speed, making 12½ to 13½ knots, with 220 revolutions per minute of the engine, and carrying 120 lbs. of steam.

The disaster occurred while the *Adler* was steaming in the Adriatic Sea, near the Isle of Lesina, off the coast of Dalmatia, at about three o'clock in the afternoon, the vessel being three miles off shore. The explosion manifested itself by a heavy vibration and roar, followed immediately by a sharp report. Then a hail of splinters fell on the deck and a shower of hot water from the boiler fell on the after deck. For a time the vessel was enveloped in a cloud of steam, and after this had disappeared the survivors were able to get an idea of the damage. Of the crew, two were killed by falling timbers, three were hurled out of the vessel and drowned, and four were more or less injured. The deck over the boiler room was torn up and showed a gaping hole, as the boiler had torn itself from its fastenings by the reaction of the escaping steam and had hurled itself bodily overboard. The mast of the vessel flew upward and fell on the deck, the starboard stack hung over the side of the vessel, and the port stack was bent forward. The bulkhead between the engine and boiler rooms was broken through at its upper parts, and all gear on deck above the boiler room, such as small boats, etc., had disappeared. The deck aft of the boiler room looked like a scrap pile, but the deck forward suffered little damage.

After an unsuccessful attempt to rescue one of their comrades who was hurled overboard, the survivors set to work to save what was left of the vessel, as she began to roll heavily and shipped water. A sail was rigged with awnings and spare spars, and she was laboriously worked to shore and beached. The engine and boiler rooms had meanwhile filled to the water level. Divers were sent down to stop the leaks, and after the boat was pumped out she was towed to the naval station at Pola for survey and investigation. A comparison between the vertical section through the boiler room before and after the explosion showed that the pressure due to the reaction of the steam had bulged out the sides and the bottom, and portions of the framing which, on superficial examination, seemed to be sound, were tested and found to have far exceeded the elastic limit. The boiler breeching was intact at its lower end, but the upper part was badly injured. The boiler saddles were partly bent and partly torn off, and the ash pan still remained in place, although bent. Among the ashes and clinkers which remained in the ash pan were found copper rivet heads and sheared rivets, which had come from the fire-box seams, as well as pieces of sheared staybolt threads. The boiler mountings had all gone with the boiler, with the exception of one safety valve, which was picked up in a damaged state. The stokehole floor plates had also gone with the boiler, with the exception of those which were covered with coal. Of the two main steam pipes, the port pipe had torn off at the boiler stop valve, but was intact, while the starboard pipe was sheared off at the engine room bulkhead. The entire engine space was intact, except that it was filled with soot and ashes.

The boiler was 18 ft. long, the cylindrical part was 7 ft. 7½ in. dia., 8 ft. 9 in. between tube sheets; grate surface, 40 sq. ft.; working pressure, 150 lbs. The boiler weighed 35,300 lbs. when empty. The boiler was one of the largest of its kind, and was a duplicate of the one on the sister boat, the *Falke*. The fire box was made of copper plate, the tubes of brass, and all mountings were in duplicate.

The boiler, although built in 1885, had seen very little service. It had been tested with cold water pressure to 240 lbs. per square inch four months previous to the accident, and had also a dock steam trial with full boiler pressure. Furthermore, it had been caulked and several staybolts had been renewed.

According to the testimony of the survivors of the crew, the boiler had had an examination and cleaning two days previous to the accident. The braces and tubes were found clean, and the vertical stays were slightly rusted. There were no defects of any kind, with the exception of a slight pitting at the bottom hand holes. The refuse removed during cleaning consisted only of rust scales. There was no doubt that all accessible parts of the boiler were clean, but the condition of the bottom of the water legs unfortunately could not be ascertained. The boiler feed had always been fresh water, and the water level indicators were always in good condition. The amount of auxiliary feed required was minimal, and the salinometer tests had shown the water to be pure. As the boiler-room crew had been killed, it was impossible to find out the exact state of affairs shortly before the explosion, but it was noticed that an hour and a half previously the water stood slightly high in the glasses. The commissioners appointed to investigate the cause of the explosion were convinced that the rupture occurred in the seam at or near the top of the firebox, but no definite reason could be assigned to the cause of the break. An attempt was made to drag the bottom of the sea at the place of the accident to recover the boiler and thus get better evidence. Four navy vessels worked for twelve successive days at this task, using every modern appliance, but were unsuccessful, as the water at that spot averaged 230 feet in depth, and the bottom consisted of jagged rock and coral, with steep declivities.

The possible causes of the rupture of the fire box could have been either a heavy deposit of scale, or low water. [We should not want to admit, without further evidence, that these two causes were all that could be admitted in seeking an explanation. The plates may have been grooved or fractured or otherwise impaired.— Editor Locomotive.] The first conjecture, of course, is out of the question, since the boiler is known to have been quite free from scale. The second suggested cause may have been responsible for the accident, as will appear from the following facts: The feed pumps had always been in prime condition, and there is a possibility that, knowing this, the crew had been somewhat negligent in attending to them, and a stoppage of feed may have occurred for this reason, with the result that the water became low. It was stated that the quantity of water in the boiler could be evaporated in seventy minutes. An examination of the water chamber of the pump, shortly after the accident, showed that the contained water was salty, so that a sudden breakage of a condenser tube, or leakage in the condenser, would account for the extra height of water in the glass previous to the accident.

[This account originally appeared in the *Mittheilungen aus dem Gebiete des Seewesens*, published at Pola, Austria. It was translated into English and published by *Marine Engineering*, to which journal we are indebted for permission to reproduce it.]

Boiler Explosions.

January, 1900.

(1.) — A boiler exploded on December 30th in Willis & Mack's quarry, near the Penrhyn mills, at Granville, N. Y. Frederick Harte, Sr., was badly burned and bruised. The account that we received says that the heads of the boiler "now resemble a can of bad corn, being about the shape of a rainbow, with nearly all the tubes torn out. Superintendent Williams says he saw the whole thing go up, but did not know that the objects which he took to be large birds in the air were simply portions of the stack. Iron surely took a rise that morning." [Received too late for insertion in the December list.]

(2.) — On January 1st a boiler exploded at W. C. Russell's Silver Run coal mine, near Pomeroy, Ohio. Engineer M. D. Sisson was fearfully injured, and it is believed that he cannot recover. Mr. Russell, the proprietor of the mine, was seriously scalded about the arms, face, and head, and also received internal injuries; but he will recover. The boiler was thrown 400 yards, and a portion of it was projected across the Ohio river.

(3.) — A new heating boiler failed on January 1st, in the basement of the new library building at Oshkosh, Wis. Fortunately nobody was hurt, and the damage was mostly confined to the boiler.

(4.) — On January 2d a heating boiler exploded in the basement of the John Henry Knapp block, on South Main street, Norwalk, Conn. We have not learned of any serious consequences.

(5.) — A boiler connected with a sawmill on the Clay lot, about one mile from Candia village, near Manchester, N. H., exploded on January 3d, instantly killing the fireman, Henry Wilson. Two other workmen, who were near by, were not injured. The boiler was thrown about a quarter of a mile.

(6.) — John Q. Adams, and Nelson McGinnis and his son Maddy McGinnis were instantly killed, on January 4th, by the explosion of a boiler in Oscar Stout's mill, about two and one-half miles from Elvira, near Vienna, Ill. The three men who were killed were buried under the débris of brick, timber, and iron. Mr. Stout, the owner of the mill, received severe injuries from flying fragments of wreckage, and according to some accounts he is likely to die.

(7.) — A boiler exploded on January 4th in a rock-crushing plant at Fayetteville, Ark. We have not learned further particulars.

(8.) — A small boiler, belonging to Contractor Thomas Reilly, exploded on January 4th, in the rear of St. Joseph's College, Philadelphia, Pa. The shed in which the boiler stood took fire, but the prompt arrival of the fire department saved the college itself from injury. The property loss was about $1,500, and it does not appear that any person was injured.

(9.) — A small boiler used for heating water for the bath rooms in the gymnasium of the State Normal School at Geneseo, N. Y., exploded on January 5th, shortly after midnight. Owing to the hour at which the accident occurred, nobody was injured; but if it had taken place in the day time the results would have been very serious. The gymnasium was badly wrecked, and the estimates of the property loss range from $4,000 to $10,000. The boiler was thrown up through the hardwood floors of the building, and finally lodged on the third floor.

(10.) — A heating boiler exploded on January 5th, in the basement of the conservatory at Evergreen, the house of Mrs. T. Harrison Garrett, at Notre Dame Station on the Baltimore & Lehigh railroad, near Baltimore, Md. The property was somewhat damaged, but nobody was hurt, although some of the workmen had narrow escapes.

(11.) — A peculiar accident occurred on January 6th, at the Aurora Furnace at Wrightville, near Columbia, Pa. The account that we have received does not make the nature of the accident perfectly clear, but it is stated that "one of the large boilers broke completely in half." Nobody was injured.

(12.) — On January 6th a boiler exploded at Galena, Kans., at the mine owned by State Geologist Haworth. Nobody was killed, but William Rogers, John Carrollton, Alfred Macomber, and George Simmons were injured. Simmons was thrown into the shaft, and fell a distance of about fifty feet. The part of the plant which was above ground was entirely demolished.

(13.) — A boiler exploded on January 6th, in Nathan Horn's mill, about two miles northwest of Dotsonville, near Clarksville, Tenn. Samuel Garrard was fatally scalded, and a boy was also scalded to a lesser extent. The place was wrecked.

(14.) — A slight explosion occurred on January 6th in David F. Brown's soap factory, North River, New York city, between Fifty-first and Fifty-second streets. Nobody was injured. The damage was about $1,000.

(15.) — A heating boiler exploded on January 7th, in a private dwelling house on West Seventy-first street, New York city. Watchman William Adams, who was the only person in the house at the time, was severely injured. He was taken to the Roosevelt Hospital.

(16.) — A boiler exploded on January 9th, in the Gottfried company's brewery, on Archer and Stewart avenues, Chicago, Ill. August Seiecel was scalded so badly that his recovery is doubtful. Alexander Branzler and Frank Winters were also painfully injured, though they will recover.

(17.) — On January 9th a boiler exploded in the soap factory of James Beach & Sons, at Dubuque, Ia. Engineer Matthew Kieffer was buried in the ruins and instantly killed. Bernard Dreese, operator of the glycerine machine, was also partially buried, and was seriously hurt, but will recover. The boiler house, engine room, and a part of the main building were wrecked.

(18.) — The boiler of a sawmill belonging to Joseph Wilkinson, of Right, near Nashville, Tenn., exploded on January 11th. Hugh Yancey, John Evans, and another man, whose name we have not learned, were fatally injured, and the building was wrecked.

(19.) — On January 11th a boiler exploded at the Bergen County Gas & Electric Co.'s plant, at Hackensack, N. J. Three men were severely injured, and nearly all the business houses were closed by the shutting off of their light and power. The newspapers were unable to get out their issues.

(20.) — On January 13th a boiler exploded in Leavell & Stevens' Tobacco Rehandling Establishment, at Hopkinsville, Ky. The rear wall of the brick factory was blown out, and several buildings near by were wrecked, but no lives were lost, and no one was seriously injured.

(21.) — A boiler exploded on or about January 15th, on the farm of Elias Kline, at Shawnee, near Lockport, N. Y. The damage was small and nobody was injured.

(22.) — On January 17th a boiler explosion occurred at Frank Farquhar's flouring mill, at Lima, near Lagrange, Ind. Engineer George Lamphear was fatally injured and the building was completely wrecked. Several neighboring residences were also damaged. The explosion was heard for miles, and pieces of the boiler were found half a mile distant.

(23.) — By the explosion of the boiler of the steam launch *Caperon*, at Delaware City, Del., on January 17th, about fifteen persons were severely scalded. The yacht

Caperon is in the service of the Government. Those injured most seriously were Capt. George A. Cleaver, Engineer John Swann, Assistant Engineer Samuel Weaver, Sergeant George Weinholdt and his wife, and John W. Coy. It is thought that Weaver and Coy will die.

(24.)—A boiler exploded at Redd's sawmill, at Greenfork, near Waynesboro, Ga., on January 18th. John Burke was instantly killed, and several others were seriously injured. The plant, consisting of the engine house, mill, and gin house, was destroyed, but we have seen no estimate of the amount of loss.

(25.)—On January 19th a boiler exploded at Converse, near Peru, Ind., in the Logansport & Wabash Valley Co.'s pumping station. Fireman John E. Clark was thrown one hundred and fifty feet and instantly killed. The property loss is estimated at $5,000.

(26.)—A small boiler exploded on January 19th, in George Biddle's bakery, at Dover, N. H. Our account states that "Mr. John Reynolds lost a very necessary part of the rear portion of his trousers by flying splinters," but this seems to be the most serious damage done by the explosion.

(27.)—A boiler exploded on January 20th, at the Wuench Gin, at Runge, Texas. Mr. Wuench, the owner of the plant, was badly cut and scalded, and his son was seriously bruised.

(28.)—A boiler exploded on January 23d, in the Hartje paper mill, at Steubenville, O., wrecking a large portion of the plant. About one hundred and twenty-five employes were at work in the buildings at the time, but no one was injured except the fireman and a boy named Mackinaw. The boiler house was wrecked, and the property loss will amount to over $5,000.

(29.)—On January 23d a boiler exploded in Charles White's mill, at Grafton, some twelve miles from Bellows Falls, Vt. Engineer Moultrop was instantly killed, and three other employes were seriously injured. The building was completely demolished, and heavy fragments of iron were scattered about for hundreds of feet in all directions. We have not seen any estimate of the property loss.

(30.)—An upright boiler exploded on January 23d, in Henry Adams' syrup-mixing house, Front street, Brooklyn, N. Y. Engineer Charles Williams was seriously injured, and several others received lesser injuries. The property loss is said to have been about $2,000.

(31.)—A boiler exploded on January 24th, in the Baldwin Locomotive Works, at Philadelphia, Pa. Samuel Ganoski and Michael Hoolihan received injuries which are likely to be fatal. Another man was also hurt to a lesser extent.

(32.)—A boiler exploded on January 24th, at Catoctin Furnace, at Frederick, Md. Engineer Emanuel Carbaugh was severely injured.

(33.)—A fitting failed, on January 24th, on the blow-off pipe of a boiler in the Pulitzer building, in New York city. James O'Brien was badly scalded and burned, but it is believed that he will recover.

(34.)—On January 25th a boiler exploded in the Tennessee Soap Factory, at New Decatur, Ala. The building was considerably damaged, but fortunately no one was hurt.

(35.) — The boiler of locomotive No. 902, one of the largest on the Grand Trunk railroad, exploded with terrific force, on January 27th, while nearing Edwardsburg, Mich. Engineer John Stockhouse and Conductor William Webber were fatally scalded, and Fireman Arthur Burchard was seriously injured. The locomotive was totally wrecked, and the track was torn up for several rods.

(36.) — One of the boilers connected with the heating apparatus of the Second Congregational church, at Waterbury, Conn., exploded on January 29th. We have not learned further particulars.

(37.) — The steel department of Phillips, Nimick & Co.'s rolling mill, at Pittsburg, Pa., was wrecked on January 29th, by the explosion of a battery of four boilers. Simond Holland was killed, and David Noone, Edward Kirkpatrick, W. T. Cook, Peter Bynos, Barney Easterburg, Frank Stone, Constantine Gallagher, William Scott, Jeremiah Collins, and Patrick Daly were injured. Three of the injured will die. The damage to the property is said to have been about $10,000.

Inspectors' Report.

April, 1900.

During this month our inspectors made 9,834 inspection trips, visited 19,874 boilers, inspected 8,411 both internally and externally, and subjected 867 to hydrostatic pressure. The whole number of defects reported reached 16,072, of which 1,131 were considered dangerous; 47 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,298	48
Cases of incrustation and scale,	3,029	53
Cases of internal grooving,	198	8
Cases of internal corrosion,	938	37
Cases of external corrosion,	660	50
Broken and loose braces and stays,	240	78
Settings defective,	448	49
Furnaces out of shape,	410	20
Fractured plates,	352	48
Burned plates,	357	33
Blistered plates,	148	2
Cases of defective riveting,	2,307	146
Defective heads,	94	12
Serious leakage around tube ends,	3,069	294
Serious leakage at seams,	403	30
Defective water-gauges,	331	66
Defective blow-offs,	161	38
Cases of deficiency of water,	21	9
Safety-valves overloaded,	88	34
Safety-valves defective in construction,	82	25
Pressure-gauges defective,	429	35
Boilers without pressure-gauges,	16	16
Unclassified defects,	993	0
Total,	16,072	1,131

The Locomotive.

HARTFORD, JUNE 15, 1900.

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

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

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

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

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

WE have received, from the Power Publishing Company, World Building, New York City, a little book entitled *The Compound Engine*, which consists of three lectures, written by Mr. F. R. Low, editor of *Power*, and now reprinted from that paper. The first lecture deals with the general principles which govern the operation of the compound engine, the second tells how to combine indicator diagrams taken from the high and low pressure cylinders, and the third gives a clear and well-illustrated discussion of the receiver question, upon which Mr. Low differs somewhat from the opinions of the authorities. The book is well written and well printed, and it will be very useful to those who wish to "read up" on the principles upon which the compound engine depends. (Price, 50 cents.)

WE desire to acknowledge a copy of Mr. Peder Lobben's *Machinists' and Draftsmen's Handbook*, which is published by The D. Van Nostrand Company, of 23 Murray Street, New York city. As the author states in his preface, the present volume "is not intended solely as a reference book, but it may also be studied advantageously by the ambitious young engineer and machinist." The general arrangement of the subject matter is similar to that adopted in other handbooks of this sort, and Mr. Lobben's chief claim to originality, we suppose, would be based upon the way in which he has treated the different topics. We have examined the volume carefully, and we can cheerfully commend it. It is a welcome addition to our own library, and we have no doubt that others will find it equally serviceable. (Price, $2.50.)

THE FRANKLIN INSTITUTE was founded on February 5, 1824, and it therefore passed its seventy-fifth anniversary last year. The occasion was celebrated, during the first week of last October, by a series of commemorative exercises held in the convention hall of the National Export Exposition, at Philadelphia. Addresses were made by Dr. W. P. Wilson, Dr. Joseph W. Richards, Prof. Harvey W. Wiley, Dr. Charles F. Himes, Prof. George A. Hoadley, Dr. Edwin J. Houston, Mr. Ralph W. Pope, Mr. James Christie, Mr. Charles Kirchhoff, Mr. John Fritz, Mr. Wilfred Lewis, Dr. Coleman Sellers, Dr. A. E. Kennelly, Dr. T. C. Mendenhall, Dr. Robert H. Thurston, Rear-Admiral George W. Melville, and Mr. John Birkinbine. These various addresses, together with the anniversary sermon, delivered on February 5, 1899, by the Rev. Dr. Henry C. McCook, have now been collected and published by the Franklin Institute, in the form of a book which is admirably printed, finely illustrated with half-tone cuts, and tastefully bound in cloth. The volume is exceedingly interesting, and forms a valuable contribution to the history of the arts and sciences during the last seventy-five years. Further information concerning it may be had by addressing The Franklin Institute, Philadelphia, Pa.

A copy of the fifth edition of Mr. William Kent's *Mechanical Engineers' Pocket-Book* is at hand, and we note that it has been carefully edited and brought up to date. The first edition of this work appeared in 1895, and when the number of pocket-books already on the market is considered, it is certainly a high compliment to Mr. Kent, and to his publishers, that five editions of this one should be called for in an equal number of years. The favorable judgment that we passed upon it, in reviewing the first edition in THE LOCOMOTIVE for May, 1895, has evidently been shared with us by the engineering fraternity at large. Mr. Kent's book is of great value, and every mechanical engineer ought to have it. (Published by John Wiley & Sons, 53 East 10th street, New York city. Price, $5.00.)

Daguerre's Contribution to Photography.

IN the issue of THE LOCOMOTIVE for September, 1889, we published an article on photography, in which an account is given of the early beginnings of the art, and something is said of the relations of Daguerre to his contemporary and co-worker, Niépce. We intimated that Daguerre perhaps did not give Niépce as much credit as was due him; and as Dr. Himes, who spoke on "The Making of Photography" at the recent Commemorative Exercises of the Franklin Institute, does not appear to entertain this view, we reproduce herewith an abstract of such parts of Dr. Himes's address as bear upon the point in question.

For the ten years preceding 1824, there was one man (a Frenchman named Nicéphore Niépce), who had been working away with great tenacity of purpose, trying to fix the images of the camera. He did not approach the subject from the scientific side, nor from purely scientific impulses, but with a desire for immediate practical results. He had become interested in the recently-discovered process of lithography. The difficulty of procuring suitable stone suggested the use of metallic plates, and it occurred to him to substitute light for the hand in drawing the pictures. After experimenting with various substances, among them silver chloride, he discovered that bitumen of Judea is rendered insoluble in certain solvents by the action of light. He coated metallic plates with a thin varnish of it; exposed them when dry to sunlight, under engravings which had been previously varnished to render them more transparent, and then dissolved out the unchanged bitumen of the parts protected from the light. After a measure of success in thus copying engravings, he experimented with the images of the camera on similar plates, and there seems to be no question that about 1827 he had obtained pictures by this process, however imperfect. In 1824, Daguerre, entirely ignorant of Niépce or his work, entered upon a similar pursuit, upon parallel lines, inspired by a similar desire for immediate practical results. He was a scene painter in Paris, and an artist of no mean character, and of great popularity in that city. The "diorama," invented by him, was the sensation of the day, and crowds were entertained by its surprising effects. He was aided by the camera in preparing his scenes. The wish to fix its fleeting pictures might occur to anyone, but it took complete possession of him, although the pursuit was more unpromising than that of the alchemists. He worked alone and in secrecy, with but little encouragement. His methods were empirical rather than scientific. About 1826 he learned of another worker (Niépce) in the same field, and immediately wrote to him. Niépce, distrustful of the unknown writer, threw the letter in the fire. A letter sent a year later met with a better reception, however, and a correspondence followed, which was distinguished, at first, by an almost suspicious reserve. Niépce then visited Paris, met Daguerre, and was greatly impressed with his diorama. Both appeared to enjoy an exchange of experiences that belonged to them alone. Niépce wrote his son that Daguerre persisted in regarding his (Niépce's) process as better than his own, but that one thing was certain, they were entirely different. A partnership, styled Niépce-Daguerre, was formed, with equal interest, and under the terms of this partnership Niépce contributed his process and his experiments, which Daguerre agreed to assist in improving, and Daguerre contributed his improved camera. Daguerre did improve the process, but was diverted from it altogether by the accidental discovery of the sensitiveness of silver iodide to light. In the bitumen pictures the blacks of the original were represented by bright polished metal, from which the unchanged bitumen had been removed, while the whites were represented by the changed bitumen. The pictures were therefore negatives, and to convert them into positives Niépce experimented with a variety of substances, among which was iodine vapor, with the idea of darkening the exposed metal, and then dissolving off the bitumen from the whole plate. It is said that Daguerre observed that the shadow of a spoon that happened to be lying on a polished silver plate that had been exposed to the vapor of iodine was permanently impressed upon it. Slight as everyone knows this direct effect of light on iodide of silver to be, Daguerre appeared to see in it new possibilities for camera pictures. Niépce, however, after experimenting with it at Daguerre's suggestion, expressed regret that he had lost so much time in following his recommendation. Niépce died in 1833, with success still apparently as remote as ever. The partnership was renewed with the son, Isidore Niépce, and Daguerre entered into the pursuit with undivided effort, and even greater enthusiasm than before. He neglected his diorama and lived in his laboratory, to which no one had access, not even Isidore Niépce. He became so much wrought up by his unsuccessful experiments, that his wife, according to Dumas, consulted physicians in regard to his sanity. Finally there came to his assistance an accident which led to a fundamental discovery — a discovery as fundamental to-day as it was then. The way in which the discovery was made has a romantic interest of its own ; and as it was cited in one of Professor Liebig's lectures as one of the finest specimens of the inductive method of reasoning, it has an added air of authenticity which may excuse the narration of it in this connection. Daguerre's method of experimenting was to expose polished silver plates to the vapor of iodine until they were coated with a layer of iodide, and then to subject them to the image in the camera. These plates, always without the hoped-for result, or, at most, the very feeble, direct effect, were re-polished, re-iodized, and re-exposed in the camera with the same disheartening results. On one occasion, upon removing an exposed plate from a closet in which it had been stowed, to re-polish it for a new experiment, he found upon it, to his great surprise, the view to which it had been exposed in the camera.— not an uncertain, feeble picture such as he had been accustomed to, but a strong, clear, unmistakable one. He exposed another plate in the camera, without visible effect, and stowed it in the closet. After leaving it there for a time he removed it and found that the invisible picture had again put in an appearance. He had no way of explaining this result, as all his years of investigation furnished him no clue to the influence at work. He then set himself at work systematically to discover it. He could only conclude that the mysterious agent at work was something in the closet. He placed plate after plate, after exposure in the camera, in the closet, each time removing from the closet some one thing. Each time the invisible became visible, until at last the closet was empty, and still the pictures came. Further search revealed some mercury spilled upon the floor; and, by his process of elimination, he was driven to the conclusion that in this mercury he had detected the magician that he sought. It was a short step to subject plates that had been exposed in the camera to vapor of mercury, and the daguerreotype process was complete. But the discovery was far more than merely that of a process. It was, that light can produce an invisible or latent effect, previously entirely unsuspected, which may be rendered visible by suitable agents which we call developers; and that this effect can be produced in so short a time as to render camera pictures easily possible. Upon it all modern photography, the prime factor in which is the negative, is based, and a great part of the photographic literature of to-day deals with development and developers. If one name, then, is to be selected as representative in the history of photography, there can be no question but that it should be that of Daguerre. This appears to have been the view taken by the authorities of the Congressional Library at Washington, and there was a singular fitness in placing his name there in the Hall of Inventors, with that of Guttenberg. The name of Niépce might have been placed there too, but certainly in a subordinate position; or it might be left out, as it has been, without manifest injustice, although his merit is of a high order. He was an independent, ingenious, indefatigable experimenter and investigator. His bitumen process may be regarded as entirely his own, although the important principle underlying it, of change of solubility effected by light, was at least suggested to him by the experiments of Wollaston with gum guaiacum,— which experiments, however, his own failed to substantiate. It might be said that Daguerre's discovery was only a happy accident, after all; but that might be said of many discoveries, and the list of such accidents to scientific men would be a long one. Such accidents only happen, however, to such men as work their way across their paths, and can appreciate them. Otherwise they come and go unnoticed. The "accident" is frequently the final event of a long series, and it often appears to get too large a share of the credit for the ultimate success. Daguerre was a lucky fellow, but he was not a scientific Micawber.

Submarine Boats.

Although it would not be quite accurate to say that there has been no advancement toward the solution of the difficulties inherent in submarine navigation, a glance at the successive experiments that have been made is not by any means encouraging. It is true that submarine boats have exercised the minds of laymen more perhaps than those of experienced contractors; the list of accidents might not have been quite so long if the lay element had kept aloof. But submarine boats remain dangerous crafts; and if we have had no fatal accidents in recent years, it is largely because we have learned to be careful, and have at least grasped the nature of the problems.

The first submarine boat, indeed, did not drown anybody; but whether or not the great Cornelius van Drebbel actually submerged the boat which he exhibited before James I. on the Thames in 1624, is not quite clear. Day did go down at Yarmouth in 1660, and when he repeated his experiment, boat and crew failed to reappear. Fulton was more successful; he remained four hours under water in 1801, and exploded a mine at Brest from his boat. Phillip's wooden boat was crushed by the water pressure on Lake Erie, and the same fate befell Bauer's iron boat in 1850 at Kiel; he and his two men had a marvelous escape, being carried up by the huge compressed air-bubble. The boat of McClintock and Howgate, constructed in 1863 for the Confederates in the American Civil War, sank four times, and each time killed its volunteer crew, 32 men in all. All these craft had less than 30 tons displacement, employed water ballast and manual propelling power, and resembled plumply-built fish in their shape.

With the same year, 1863, began the days of the cigar-shaped boats of considerably larger tonnage, fitted with steam, pneumatic, petroleum, or electric power, and sometimes with two separate sets of motors, for motion on the surface and under water. Noteworthy among these are Nordenfelt's four boats, which burned fuel when on the surface, and relied on the heat stored in the boiler when under water. During the last fifteen years another type has come to the front: boats which keep just under the water line, and which are to dive below only in extreme cases. To this class belong the boats of Hovgaard and of Peral, the several craft which Admiral Aube had constructed, the two boats of Goubet, Zédé's *Gymnote*, and the *Gustave Zédé*. France has been most persevering in these endeavors. Last summer, Romazotti's *Morse* was launched at Cherbourg, and she is to have two sisters, the *Français* and the *Algérien;* and there is finally Laubert's *Narval*, also launched at Cherbourg in October last, which is fitted with petroleum and electric motors and accumulators, while the other French boats mentioned depend entirely upon accumulators. Giorli's boat of 1893 is distinguished by three horizontal rudders, one of which is automatically adjusted by a pendulum. Finally, there are the six Holland boats, the last of which is entirely of Mr. Holland's own design.

The flooded boats which keep awash, just under the water surface, look like torpedo boats. They are spacious enough not to need any compressed air stores for breathing; and the tube projecting above the water level, provided with a mirror at an angle of 45 degrees, is a help to the man at the helm, although the elevation is too small to give a proper field of view. In stability these craft are superior to the totally submerged boats, but they suffer from many of the drawbacks of submarine boats which are regarded as serious, notably by such an expert as Professor Busley. Among these serious inherent difficulties Professor Busley places, first, the low stability of submarine boats. Some persons appear to forget that the displacement center of gravity of a totally submerged boat is simply the mass-center of the water displaced, and does not alter its position whatever inclination the boat may assume. There is no buoyancy. Yet transverse stability (or prevention of rolling) is not so difficult to obtain, provided the section of the boat is like that of an egg poised on its point. If we use ballast, the center of gravity of the system may be made low and the displacement center high, and this will tend to prevent rolling. The low *longitudinal* stability — the tendency to *pitching* — is the trouble, and a man needs only to step forward to send the nose of the boat down. For this reason the *Plongeur* of Bourgeois failed, and the length of the boats has been reduced again. Goubet has gone furthest in this direction, and his two men always sit in the middle of the boat. Bauer tried to apply counterpoises, and Holland tried automatic pumps, to restore longitudinal equilibrium. Nordenfelt did not deprive his boat of all buoyancy, but used a screw propeller on a vertical axis to submerge it. The flooded boats are better in this respect, but even in their case we notice a reduction in length; the *Zédé* had a length of 45 meters, the *Morse* of 36 meters, and the *Narval* of 34 meters.

Submarine boats remain dangerous to manage. On the average, perhaps, we may make them strong enough to descend to a depth of 100 feet. Suppose, now, that such a boat, moving at the usual speed, under water, of eight knots, is to discharge a torpedo. Two men are sent forward; the boat at once inclines 15 degrees or so, and within half a minute it will have gone down to its critical depth. If there is then any delay, or any fault in the steering gear or in the application of safety-weights or other such devices, every second will seriously increase the pressure of the water on the outside of the vessel. Trials made with the *Gymnote*, moreover, indicate that submarine boats do not obey their horizontal helms with sufficient rapidity. The *Gymnote* always overshot her mark, and would not keep on a straight course, but described a succession of curves.

These dangers are increased by the exceedingly limited range of vision under water. Light emanating from a focus under water will lose all but the ten-millionth part of its intensity at a distance of 100 yards, and daylight does not penetrate into the water very far. On a clear day a diver 20 feet below the surface is hardly able to see further than 25 feet. Searchlights would be of little service, and would, moreover, betray the position of the craft. Hence the boat must approach her enemy very closely, and if the ship to be attacked is moving, the case is almost hopeless. — *Engineering* (London).

A Notable Engine.

"The President," which, in its day, was a wonder among steam engines, is being reduced to scrap at the works of the Friedensville Zinc Company, in the Lehigh Valley. The engine was built thirty years ago, and three years were required for its construction. Three months will be sufficient to reduce it. Part of the remains will go into the construction of the new battleship *Maine*, and in the same sense that "Imperious Caesar, dead and turn'd to clay, Might stop a hole to keep the wind away," so may this largest triumph of mechanical skill still be useful, a section of it in defending a nation's right and maintaining a nation's honor.

A few months ago (says the *American Manufacturer*) the firm of Ernest Law & Co., of Philadelphia, bought "The President" from the New Jersey Zinc Company for $9,500. The engine weighs about 1,500 tons. Its cylinder has a diameter of 110 inches and a ten-foot stroke. Its two fly-wheels weigh 107 tons each, and are 40 feet in diameter. The two walking beams weigh 44 tons each. Forty-four mules pulled them over the mountain when the engine was erected, and it took two years to place them in position. The connecting rods were 44 feet long, and each weighed ten tons. The nut that secured the piston rod on the engine was of brass, and weighed 1,100 pounds. It was the largest nut ever made. The wrench that tightened it weighed a ton and a half.

These figures give some idea of the heroic size of "The President." In dismantling it the condensing cylinders are first removed, and the last thing to be taken down will be the main shaft. This shaft is as good as it ever was. If a purchaser can be found for it, it will be saved from the dynamite and sold intact. At present the main cylinder and pipes are being taken out. The first shipment of the remains has been made to Cramps'. This firm contracted for 200 tons of the machinery cast scrap, including cylinders, fly-wheels, walking beams, etc. It will be remelted at Cramps', and used in the new castings for the *Maine*.

The Kutztown Foundry and Machine Company gets 400 tons. Rebman & Co., of Philadelphia, buy 100 tons, which will be used in making outside castings for Cramps'. Three hundred tons go to the American Iron and Steel Company, of Lebanon, to be used for plate iron. Part of the shafting, connecting rods, etc., has been bought by the

Tioga Forge Company, of Philadelphia. Rosenthal & Co., of Philadelphia, bought the 60 tons of brass on the engine. Other firms bought smaller quantities, and the remains of the monster engine of the world will be scattered in many directions by the scrap-iron dealers who bought it. — *Pittsburg Dispatch.*

A "WHIZZER" ACCIDENT. — James McMullen recently lost an arm in a laundry at Hutchinson, Kans. The accident is thus described in the *Hutchinson News:* "Mr. McMullen stopped at the wringer and held his hands over it to dry them. He got one hand too low, so that the air suction caught it, and his arm from the elbow down was taken off as by a miracle. The wringer is a large circular iron affair, with a smaller bowl inside it, in which the clothes are placed. The smaller apartment is perforated with holes on the sides, and the whole thing revolves at the rate of several thousand revolutions a minute. The effect is that the air currents within the wringer are as terrific in their power as the center section of a Kansas cyclone. When a cyclone strikes a brick building and hurls it to atoms, the force appears appalling and incomprehensible. The accident to Mr. McMullen was equally mystifying. The instant his arm came into contact with the current of air it was parted at the elbow. One part lay on the clothes that were in the machine, and the other dangled from his shoulder. There was nothing about the machine to give him even a scratch. The nerve exhibited by McMullen was wonderful. 'It never touched me,' was the first thing he said. The girls in the room were screaming, and McMullen calmly informed them that it was not his head that was taken off, and told them to be still. He was taken to a hospital, and his arm was amputated close to the shoulder." — *American Machinist.*

DEATH OF MRS. ROSWELL SMITH, WHO SENT THE FIRST TELEGRAM. — Mrs. Roswell Smith, seventy-three years old, widow of the founder of the Century Company, died at her home in the "Tolosa," at New York City, on January 21, 1900. It was Mrs. Roswell Smith who, as Miss Annie Ellsworth, then a girl of seventeen, sent the famous first telegraphic message, "What hath God wrought!" Her father, Henry L. Ellsworth, a son of Chief Justice Oliver Ellsworth, was the first Commissioner of Patents, and has been called "the father of the Patent Office." He had been a college friend of Professor S. F. B. Morse. Together they had endeavored to induce Congress to pass a bill granting $30,000 for the construction of a trial line between Washington and Baltimore. Morse had been seeking the help of Congress since 1838, but it was not until the last hours of the session of 1842–'43 that the bill was passed, by the close vote of 89 to 83, and then went to the Senate. At twilight on the last evening of the session there were 119 bills ahead of it, and, as it seemed impossible that his measure would be reached, Professor Morse, disheartened, went to his hotel and prepared to return to New York by an early morning train. His friend, the Commissioner of Patents, kept doggedly working for the bill, and at five minutes before adjournment it was passed, only one measure going through after it. It was Miss Ellsworth who carried the news of the passage of the bill to Professor Morse the next morning. It was then that he assured her that she should send the first message, and a little more than a year after, at her mother's suggestion, Miss Ellsworth wrote down the words of the Psalmist, "What hath God wrought!" and they were sent in triplicate in the dot and line alphabet from Washington to Baltimore. The original message was given to Miss Ellsworth, and has always been in her keeping. The duplicate, which was returned from Baltimore to Washington, is in the Connecticut Historical Rooms at Hartford. In 1852, Miss Ellsworth married Roswell Smith in Lafayette, Ind. In 1870 they moved to New York, where Roswell Smith, in connection with the late Dr. J. G. Holland and the house of Charles Scribner & Co., founded *Scribner's Monthly*, the name of which was changed to *The Century Magazine*, published by the Century Company, in 1881. Roswell Smith, who was the publisher of the magazine from the start, continued as president of the Century Company until his death, in 1892. Since then Mrs. Roswell Smith had, for the greater part of the time, made her home in New York. She leaves one daughter, the wife of the artist George Inness, Jr. — *New York Tribune*.

We have received from the Power Publishing Company (World Building, New York city) a copy of Mr. Cecil P. Poole's excellent little book on "Electric Wiring," which we have examined with satisfaction and profit. Electric wiring, nowadays, has been reduced to what may be fairly described as an exact science; and a thorough knowledge of this science calls for considerable study on the part of the individual who aspires to proficiency in it. Mr. Poole has succeeded in producing a little book which will be of great service. It is not a treatise on electricity. It presupposes a knowledge of electrical principles, and then proceeds to show how to apply those principles in laying out electric wiring of all kinds. The section on alternating-current wiring will be found of special value; for we concur with the author in the opinion that "it contains the only comprehensive data, in work-a-day form, that have yet been offered." The illustrations in this little book are good, the typography is excellent, and the many tables will greatly facilitate calculations. (Bound in leather covers; price one dollar.)

The issue of Fowler's *Mechanical Engineers' Pocket Book* for the year 1900, sustains the excellent reputation of that publication. The present edition is enlarged by the addition of much new matter, the total additions filling some 200 pages, and swelling the book itself to something like 500 pages. It is impossible to review it adequately in this place, but we may say that we are very much pleased both with its contents and with its general appearance, and that we believe that Mechanical engineers will find it a very useful volume in this country as well as in England. The growing importance of electricity in the arts and manufactures is recognized by devoting about one-third of the book to this subject. It is published at Manchester, Eng., by the Scientific Publishing Company ; and copies may be had (unless we are mistaken) through the D. Van Nostrand Company, of 23 Murray street, New York.

It is probable that the metric system will be introduced before long in Russia; the bill which has been prepared to this effect by the Minister of Finance has received the approbation of the State Council, with the understanding that the University and the various scientific societies will give their assistance in the verification of the weights and measures necessary for commercial use. The details have been nearly all decided upon, and will be submitted to the Council in the near future. Since 1896 the metric system has been used by the medical service of the army in the compounding of formulas, this having been made obligatory. — *Scientific American*.

The Locomotive.

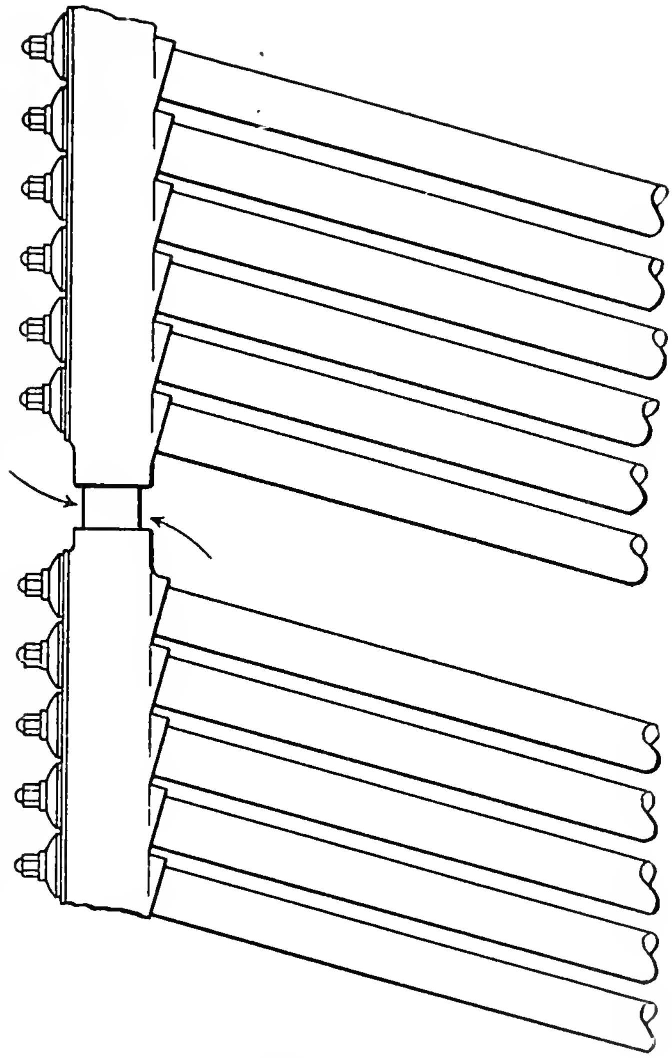
PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XXI. HARTFORD, CONN., JULY, 1900. No. 7.

Short Pipes in Sectional Boilers.

There are several types of sectional boilers, in which the several parts are joined together by short tubes or nipples which are expanded in, in the same manner as the ordinary tube in the horizontal tubular boiler, the Dudgeon or roller expander being used to set them out; and we are pleased to say that much more attention is now paid to the setting of these tubes than they formerly received.

That the expanding of such tubes calls for special tools, and for special care on the part of the workmen, is, we believe, an undisputed fact. Strains of some considerable intensity, due to the expansion and contraction of the parts of the boiler, are thrown upon these short nipples, and the effects of the vibration which is common to all steam generators are also concentrated at these points, so that there is a tendency to loosen the hold of the nipples upon the headers or boxes with which they connect. The loosening action of the vibration is important, because the holding power of such tubes is largely frictional when they are simply rolled in, and there is liability of the joint becoming weakened so that the holding power of the tubes will become materially diminished. Slight leakage, or "weeping," is not uncommon at these points, and when it occurs, rapid deterioration from corrosion is likely to ensue, and this will certainly reduce the holding power of the nipples very quickly.



SHORT NIPPLE CONNECTING TWO HEADERS.

In some types of sectional boilers the nipples in question have to support a considerable dead weight in addition to the load which is laid upon them by the pressure that is carried; and as the tendency nowadays, especially with sectional boilers, is continually towards higher pressures, it is very important that the precaution of setting the tubes in such a manner as to obtain the greatest holding power, or largest factor of safety, should not be neglected.

The distance that these tubes project through the metal into which they are expanded is something to be considered; and in this connection we will say that with the introduction of the roller expander, and after experiments made therewith, $\frac{3}{16}$ths of an inch was adopted as the standard, and the directions for the use of the roller expander, which are sent out by the makers of it, give this as the proper projection for tubes to be set with this tool.

In the issues of THE LOCOMOTIVE for May, June, and July, 1881, we printed articles on the holding power of tubes set in various ways; and we give certain of the tabulated results again in this place, in order to emphasize the fact that the holding power of tubes is greatly increased when the projecting end is belled or spread or riveted over.

PRESIDENT J. M. ALLEN'S TESTS OF THE HOLDING POWER OF TUBES.

Number Used to Designate Test.	Stress at Which Tube Yielded.	Remarks.
1075	6,500 lbs.	Tubes expanded, but neither flared nor beaded.
1076	5,000 "	
1077	7,500 "	
1078	20,500 "	Tubes expanded, and ends flared.
1079	19,000 "	

We recognize, of course, that access to the ends of the nipples that we are discussing is much more difficult, in sectional boilers, than in the case of the tube-ends of a fire-tube boiler; but that fact is no excuse for neglecting to set such nipples properly. It merely shows that the skill of the workmen who assemble the boiler, and the care that they take with their work, should be correspondingly greater.

The durability of these nipples in sectional boilers depends very much upon the care they receive. The engineer in charge should see that they are kept clean, and are not allowed to corrode. When they are inserted in thick metal with a counterbored hole, the narrow space of the counterbore should be kept free from soot and ashes. This involves some trouble, it is true, but it ought to be done, and it is altogether too much neglected, in the general run of boilers of this type. The tubes are often found coated with a hard crust, which is formed by the union of ashes with moisture oozing from slight leaks, or with dampness from some other source. Underneath this crust corrosion and consequent destruction of the tubes goes on rapidly. As a check to such corrosive action a paint composed of red lead and boiled oil may be used with advantage. The tube and the counterbore should both be thoroughly cleaned before applying it, and the paint should then be thoroughly worked into the counterbore, so as to cover the tube completely, at all points.

To prevent misapprehension on the part of any reader who may fancy that our illustration bears a resemblance to some one particular sectional boiler, we desire to state that neither the illustration nor the text of this article are intended to refer to any one make of boiler. Numerous types of sectional boilers have these nipples, and what we have said is intended to apply to all such types, without distinction. We may add, too, that this company has paid a number of losses, on various styles of sectional boilers, through the pulling out of such nipples.

Inspectors' Report.

May, 1900.

During this month our inspectors made 9,120 inspection trips, visited 19,421 boilers, inspected 8,740 both internally and externally, and subjected 1,001 to hydrostatic pressure. The whole number of defects reported reached 15,559, of which 1,482 were considered dangerous; 113 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,252	63
Cases of incrustation and scale,	3,150	97
Cases of internal grooving,	153	27
Cases of internal corrosion,	798	48
Cases of external corrosion,	759	55
Broken and loose braces and stays,	178	45
Settings defective,	512	68
Furnaces out of shape,	473	15
Fractured plates,	411	99
Burned plates,	469	85
Blistered plates,	201	28
Cases of defective riveting,	1,512	93
Defective heads,	112	16
Serious leakage around tube ends,	2,899	468
Serious leakage at seams,	486	37
Defective water-gauges,	258	51
Defective blow-offs,	182	53
Cases of deficiency of water,	15	6
Safety-valves overloaded,	142	38
Safety-valves defective in construction,	115	38
Pressure-gauges defective,	455	26
Boilers without pressure-gauges,	26	26
Unclassified defects,	1,001	0
Total,	15,559	1,482

Boiler Explosions.

February, 1900.

(38.) — On February 1st a boiler exploded in J. P. Wolf & Sons' leaf tobacco warehouses, at Dayton, Ohio. The immediate damage from the explosion was not great, but the burning coals that were scattered about set the buildings on fire, and several large establishments were destroyed, the total property loss being upwards of $500,000. George Coy, George Nienaber, and George Griecemeyer were injured, and T. J. Snediker was rendered unconscious by the smoke. Coy may not recover.

(39.) — On February 2d a boiler exploded in A. O. Morris's mill, on Island Creek, some twelve miles from O'Keefe, near Charleston, W. Va. A. O. Morris and a man named Rives were killed, and George Morris, a man named Ashbarker, and the fireman were fatally injured.

(40.) — A small boiler exploded, on February 2d, in M. D. Lagan's Iron Works, corner of Calliope and Annunciation streets, New Orleans, La. Henry Lemney and Martin Schneider were injured, but not seriously. The property damage was not large.

(41.) — Two boilers bursted, on February 3d, in the Standard Novelty Works, at Texarkana, Tex. Fireman John Fisher was seriously scalded. We have not learned further particulars.

(42.) — The tug *Petrolia* drifted upon the rocks at Hell Gate, near New York City, on February 3d, and the tug *Mischief* passed her a line and tried to pull her off. While so engaged, the boiler of the *Mischief* burst, and she keeled over and sank. She had a captain and a crew of five, and in a few seconds all were in the water, surrounded by drifting ice-cakes. The tug *Stag* picked up the captain and four of the men, but the fifth man was drowned.

(43.) — A boiler exploded, on February 5th, at Akron, Mich. Engineer Thomas Emerson was killed outright, and two other men, named Cook and Zulke, respectively, were fatally injured. The mill in which the boiler stood was completely demolished, but we have seen no estimate of the property loss.

(44.) — A boiler exploded, on February 5th, in John Collins's saw-mill, at St. Bernice, near Dana, Ind. Nobody was seriously hurt, but it is said that the property loss was large.

(45.) — On February 6th a boiler exploded in O. H. Campbell's saw-mill, four miles west of Iron River, near Ashland, Wis. Engineer Charles Tuttle was killed, and J. E. Coty and one other man were seriously injured. This explosion was a most peculiar one, if reports are always to be believed. "The movements of the exploding boiler are what give the explosion its unusual character," says the Ashland *News*. "When the boiler first exploded it shot up through the ceiling and the roof of the filing room with such force that it ascended forty feet or more. When the boiler alighted on the ground it struck with such force that a second explosion was caused, and again the boiler went skyward. This time it fell on a car of lumber, with a force sufficient to about demolish the car." We don't recollect, at this moment, of ever having heard, before, of the same boiler exploding twice in rapid succession, with no repairs made in the interim.

(46.) — On February 9th a tube failed in a boiler in the Riverside Fiber company's plant, at Appleton, Wis. Joseph Sheldon was perhaps fatally injured.

(47.) — On February 10th a boiler exploded in Ayers's sawmill, six miles west of Pagosa Springs, Col. One man was injured, and the mill was completely demolished.

(48.) — A boiler exploded, on February 10th, in the basement of F. Schill's bakery, on Kinsman street, Cleveland, Ohio. Martin Heaver, a baker, was badly scalded about the face and head. The building was not badly damaged.

(49.) — An upright boiler exploded, on February 10th, on a pump boat at Malone's Coal Works, Pomeroy, Ohio. Huston Malone and George Partlow were seriously scalded.

(50.) — On February 11th a boiler exploded in the Durham Electric Light Plant, at Durham, N. C. Superintendent H. T. Brown, Engineer Clyde Dickson, Lineman James L. Lumley, Fireman William Burnett, and an outsider named Alexander Lyon were injured. The entire plant was demolished, and the estimates of the property loss range from $15,000 to $25,000. The Court House, the Central Hotel, and several other smaller buildings were damaged more or less, and the Seaboard Air Line Railroad was completely blocked by brick and other débris. It is amazing that any of the injured should have escaped instant death.

(51.) — A boiler exploded, on February 12th, in the Cottage Creamery Company's plant at West Richfield, Ohio. Charles Smith, who had just left the boiler room, was thrown down and slightly injured.

(52.) — On February 13th a boiler exploded in the Chadwick Thread Mills, at the foot of Greenville Ave., Jersey City, N. J. The fireman, whose name we have not learned, was somewhat injured about the head. The boiler room was badly wrecked. An interesting thing about this explosion is that the Chadwick Company has systematically drilled its employees, so that they might escape from the building without panic, in case of emergency. An alarm bell was provided, and this was rung occasionally for practice. On every such occasion the employees would march quietly out of the building, while the volunteer fire brigade would hurriedly get the fire-fighting appliances ready. In case of fire this preparatory drill would probably have shown its good effects; but in the present case the accident was of an unknown and unexpected nature, and the explosion shook the building so that the girls feared it was going to collapse, and they tumbled over each other in a mad rush for the solid ground. Many jumped from the lower windows; but fortunately nobody was hurt, except the fireman, as already recorded.

(53.) — A boiler exploded, on February 14th, at Boyd's No. 1 Barkville oil well, near St. Mary's, W. Va. The men were all in the derrick at the time, and nobody was injured.

(54.) — On February 16th a boiler exploded in Boggs & Co.'s saw and grist mill, at Warnock, near Greenup, Ky. The entire place was wrecked, and John Braden and Harrison N. Ratcliff were fatally injured.

(55.) — A boiler exploded, on February 16th, in Jules Deschaux's sawmill, at Gibson, La. Two men were injured, but nobody was killed. We do not know the precise amount of the property loss, but it was several thousand dollars.

(56.) — The boiler of a newly-constructed compressed air switch engine exploded, on February 16th, in the Santa Fé roundhouse paint shop, at Topeka, Kans. Nels Linden and John Huestis were instantly killed, and J. L. Beardsley was fatally injured. Arlie Sayler, Herbert Shields, and several other men were more or less injured. The roundhouse in which the accident occurred was badly wrecked.

(57.) — A paraffine tank exploded, on February 19th, in Hoard's creamery, at Fort Atkinson, Wis. August Hansen was badly scalded and otherwise injured, and will probably die.

(58.) — On February 19th a boiler exploded in M. M. Sweezy's laundry, at Middletown, N. Y. Nobody was injured.

(59.) — A heating boiler exploded, on February 19th, in the Eutaw House, at South Cumberland, Md. Nobody was injured, and the property loss did not much exceed $500.

(60.) — A boiler, situated on top of No. 1 heating furnace in the Columbia mill of the Susquehanna Iron and Steel Company's plant, at Columbia, near Lancaster, Pa., exploded on February 20th. Two or three men were working near the boiler at the time, but nobody was hurt.

(61.) — On February 21st the boiler of a donkey engine exploded on the lighter *Captain Rafferty*, owned by McCallon Brothers, of New York City, while the *Rafferty* was lying in dock at the foot of Remsen street, Brooklyn. The boiler was thrown a hundred feet into the air, and a fragment of it damaged a house on Remsen street, nearly 800 feet away, to the extent of about $800. We do not know the extent of the damage to the lighter. Only one man was aboard of her at the time, and he escaped injury.

(62.) — A boiler exploded, on February 22d, in the Ames shingle mill, on the Bonnerville Southern railroad, near Jonesboro, Ark. The fireman was killed. We have not learned further particulars.

(63.) — A boiler exploded, on February 22d, in Mr. Green Cockerham's sawmill, on the Osyka road, four miles from Liberty, Amite county, Miss. Green Cockerham was killed, and Wallace Cockerham, a Mr. Boyd, and two other men were seriously injured.

(64.) — A heating boiler exploded, on February 22d, in the No. 3 station of the St. Louis, Mo., Waterworks, situated at Baden. Herman Bergman was struck by a flying fragment, and his arm was injured so badly that amputation was necessary. The plant was damaged to the extent of $2,000 or so.

(65.) — On February 24th a boiler exploded in the plant of the Pullman Lumber Company, at Pullman, Ark., some forty miles north of Texarkana, Tex. Hoover Thompson and Alfred Hutton were killed. J. W. Dicus, Taylor Brown, Lloyd Busby, James Busby, Dr. Baldwin, and James Brown were seriously injured, and it is certain that two or three of them will die. The mill and the surrounding buildings were thrown down and destroyed.

(66.) — On February 26th a boiler exploded in the Lowell (or Cornwell) mill of the Ypsilanti Paper Company, situated just west of Ypsilanti, Mich. William Horton was instantly killed, and Fireman Martin Tholl was severely scalded. Portions of the boiler were thrown nearly half a mile, and the boiler house was wrecked. The property loss is variously estimated, some of the estimates running as high as $50,000. (A similar accident occurred at this mill in August, 1888, one man being killed.)

(67.) — A heating boiler exploded, on February 26th, in William Miers's barber shop, at Barre, Vt. Frederick Beckman, a barber, was terribly injured, and it is doubtful if he can recover. The property loss was not large.

(68.) — A boiler in the Winthrop building, Boston, Mass., used for heating the building and running the elevators, exploded on February 27th. The explosion consisted in the failure of a tube, and the property loss was probably not over $500. Carmino Fortunado and John Bell were slightly injured.

(69.) — On February 28th the boiler of a portable engine exploded on Samuel Phillips's big stock farm, at Lebanon, Pa. Mr. Phillips was seriously injured, but at last accounts it was thought that he would recover.

"Wanted — Locomotive Engineer." — We published a striking and somewhat peculiar advertisement under this heading, in the May issue of The Locomotive. We have since received the following letter from the man who inserted it in the Minneapolis paper from which we copied it: "Gentlemen: I am the guilty party who inserted the Ad. It was an eminent success. I got a man who did, and is doing, all the Ad.

called for. Men that are not 'quitters' are scarce. While on the Canadian Pacific, in my desperation I wired the master mechanic: 'For ———'s sake send me a Yankee engineer who can run an engine without water, coal, waste, or oil'; and I got the man. He has now been at work for the company I represent about six months, and his engine has been in the house only once, and that for general overhauling and repairs. Carry the message to Garcia! As a compliment to my judgment, I picked this man out of over thirty applicants, all of whom had the best of references as to ability to run a locomotive. But I want men who can do more than that. Any ass can run when everything is all right; but I want men who can run when the flues leak, when the injector won't work, when the boiler foams, and when they are out of coal. I want men who will get out in the night and chop wood to keep her going; and I want men who don't have to be towed in. Yours very truly, E. T. A."

We are glad Mr. E. T. A. had such success in reply to his advertisement. Men such as he describes are met with hardly more than once in a lifetime: and if he has such a man, he had better hold on to him. And doubtless he will!

The Poleforcia Business.

We have received, doubtless from the promoters of the device therein described, a pair of neatly-printed circulars relating to "Poleforcia." "Poleforcia" is said to be "a mechanically made power, made by the Multiple Energizing Momentum Engine (patented)," which is manufactured, or at any rate projected, in London. It must be quite an engine, for it is certainly unlike anything else we have ever seen or heard of, and although we have labored long and hard in the effort to understand it, we find it beyond our comprehension. Let us quote a few words from "Paper No. 1." "The Multiple Energizing Momentum Engine," it says, "is for the purpose of manufacturing and making the new Power, *Poleforcia*, revolve a driven shaft; the Power being the Momentum of several fly-wheels. So that the working driven shaft has motion imparted to it, *not* directly as has been the case in the ordinary engine, where the driven shaft is made revolve with the working load by the direct pressure derived from that placed upon the head of a piston, and from thence transmitted to the radius of a crank-pin. *But in this engine work is* to be performed *indirectly* by the pulling power of several fly-wheels, and this is brought about by closing a friction clutch, of (Impact and Collision) one fly-wheel; one at a time. (Any device which will lock and unlock for this particular purpose can be used.) Attaching it (said fly-wheel) to said driven shaft (and the *Momentum Engine itself*, performs this duty of attaching and detaching said fly-wheel, automatically and periodically.) Thus Multiple Fly-wheels are pushed by Multiple independent engines, and singularly pull by the *momentum* of a value; the radius of the rims of the fly-wheels when attached to the working driven shaft." So here we doubtless have something of the general idea of the thing. The Poleforcia Multiple Fly-Wheel Energizing Business is being quite widely advertised in papers whose advertising rates are high; so presumably its backers have the ready shekels to pay for such publicity; and therefore we won't give them any more of it. Such as we have given above they are welcome to; but we may as well say that this notice is for the benefit of our readers more than anybody else. We haven't got a word to say against the Energizing Poleforcia Multiple Engine. Let her energize! But if any of our readers are thinking of investing in the stock, we advise them to wait awhile. The stock of the Poleforcia Multiple Energizing Engine can be bought a whole lot cheaper ten years from now than it can be to-day. There will be a bargain sale of it before long.

The Locomotive.

HARTFORD, JULY 15, 1900.

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

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

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

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

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

THE June issue of the *Technology Quarterly* is at hand, and we have examined it with much interest. It is published at the Massachusetts Institute of Technology, Boston, and is highly creditable both to the institution from which it comes, and to the board of editors who have immediate charge of it. Mr. A. Lawrence Rotch has an illustrated article in it upon scientific kite-flying, which will appeal to the general reader. The "Review of American Chemical Research," which always forms the latter part of the *Quarterly*, is a feature of extreme value.

"Fifteen Miles of New Vessels."

Our esteemed New York contemporary, *Marine Engineering*, issues a striking little pamphlet under this title, the contents of which we reproduce below :

"The year 1900 is the beginning of the revival of the American merchant marine. The ship-building capacity of the country has been doubled within the past eighteen months, and yet all the yards, with an exception or two, have a large amount of work in hand and in sight. Contrast this with three years ago, when there was scarcely a new merchant vessel on the stocks on the Atlantic coast, and nothing but repair jobs to keep the shipyards from closing up! This marvelous growth has not been limited to any part of the country. The Pacific coast yards are so busy with work on hand, that ship-owners have been placing orders on the Atlantic coast, and several orders from the Atlantic coast have been placed with builders on the Great Lakes.

"During the period of great depression in 1897–1898, the few sailing vessels built averaged only 96 tons each, and the steam vessels 261 tons. No steam vessels worth mentioning, intended for foreign trade, have been built for years, except the *St. Louis* and *St. Paul*. This year, however, ten steamships, aggregating 81,600 tons, are under construction for this service alone, forty-five steamers of 76,000 tons for coastwise service, and thirty steamers varying from 1,200 to 8,000 tons for Lake traffic. These, with the many smaller vessels being built, aggregate the enormous amount of *over five hundred thousand tons* under construction. The Newport News yard alone, according to the last Government report, had under construction (not including a large amount of tonnage in the draughting rooms), 102,680 tons, of which 52,600 is merchant marine work; and of the total tonnage in the Cramps' yard, not including that in the draughting rooms, of 89,865 tons, 66,000 is for the merchant service.

"These figures are very interesting in comparison with the records of some of the world's great shipyards. The world's record for tonnage built in one year is held by

Harland & Wolff, Belfast, Ireland, who, in 1897, built 84,204 tons. Last year this firm built 82,634 tons, while the Clyde record was made by Russell & Co., with 52,462 tons, and the English record by William Gray & Co., 77,501 tons.

"The growth of any industry could scarcely present a more striking contrast than that of ship-building in this country three years ago, when near the zero mark, and to-day. If all the new vessels which are now under construction in the seacoast yards were afloat, stem touching stern, they would make a solid line about *twelve miles* in length. On the Great Lakes there would be *two-and-a-half miles*, and the inland waterways would furnish almost a *mile* more, making in all *over fifteen miles*.

"But, with all the increase in our merchant marine, and although the number of vessels documented by the Government on June 30, 1899, was the largest since 1865, yet we carried a smaller percentage of our foreign trade than in any year since the Federal Government came into existence. The year 1900 sees the turn in the tide. 'This is a billion dollar country,' some bright newspaper writer says. He might have made it two billions, for the last annual statement shows that our exports and imports aggregated nearly $2,000,000,000; but we paid British and other foreign ship-owners *nearly ten per cent.* in freight money for the privilege of doing this magnificent business. Nor is this all that we paid, for we furnished millions of dollars worth of pumps and other auxiliaries, plates, boiler tubes, and steel and iron in many other forms, together with lumber, etc., with which to help build these vessels. Furthermore, American shipbuilders and mechanics lost the profits and wages in not having the building of the vessels, and American seamen lost greatly in wages in not operating them.

"With a business paying such profits and showing such marvelous development, and in a country with such brains, mechanical skill, financial capacity, cheap raw materials, and such a positive necessity for a merchant marine, who dares question that the United States will at once take first rank as a ship-building nation, and that each year, from now on, the 500,000 new tonnage of 1900 will be the annual increase over the previous year?"

The Electric Furnace.

Chemical changes at high temperatures have long been an object of research, but it was not until the introduction of the electric furnace that it was possible to command temperatures high enough to make exhaustive studies. In the last few years several chemists, especially Moissan, of Paris, and his pupils, have done systematic work with the aid of the arc furnace. The furnace used in the laboratory for high temperature work is a small and simple apparatus; Moissan's furnace is a block of quick-lime a little longer and wider than a page of The Locomotive, and about three inches thick. A rectangular cavity is cut on the upper surface of this block. A similar block forms the cover. In opposite grooves between the top and bottom piece are placed the carbons, such as are used in ordinary arc lights. The arc plays across the cavity in such a manner that the substance to be heated is not brought into the arc itself, which is vaporized carbon, but below it. The cavity thus represents a tiny reverberatory furnace; the arc heats the roof and sides to an intense heat, which is radiated upon the open dish or closed crucible or tube containing the substance heated. This is the simplest form of laboratory furnace. Various modifications are used, but in all the size is small and the arrangement simple. A powerful arc plays in the smallest possible cavity with the object of attaining the maximum of temperature, expense and duration of material being secondary considerations. Lime and magnesia are the best materials, because they are at the same time the most refractory substances available and are poor conductors of heat. A furnace top one and one-half inches thick may be heated by so powerful an arc that the melted quick-lime drips from the inner surface, while the outer surface is scarcely warm to the touch of the hand. Moissan has utilized in these little furnaces currents of electricity of varied strength, the lowest being that given by a four-horse power dynamo, while the highest is that generated by three hundred horse power. The highest temperatures obtained were about 3,500° Centigrade (6,300° Fahrenheit), with the heat constantly increasing; the limit to the obtainable temperature — as far as the experimental evidence showed — was merely the lack of any known substance refractory enough to bear the heat; for at the temperature mentioned quick-lime and magnesia not only melt, but are changed into gases, so that the furnace was filled with the vapors of its own material.

The effect of the heat on simple substances is very interesting. Refractory metals, such as iron, manganese, uranium, and platinum, melt rapidly and then become gaseous; the most refractory non-metallic elements, such as silicon, boron, and carbon, are also changed into the gaseous form. Such are the astounding changes wrought by simple heat upon those substances which we are accustomed to regard as infusible. — From an article by Professor RENOUF, on "Some Phases of the Earth's Development," in *The Popular Science Monthly*.

The Growth of the United States.

It is often said that a man should not "blow his own horn," but should leave that job to others. We think, however, that there are some cases in which this maxim loses its force. It does indeed offend the ears to listen to self-laudation, when all the world knows that the intellectual or material wares that are proclaimed are of far less value than their possessor supposes; but when, on the contrary, these wares are represented in all fairness, much of the offensiveness of the "tooting" above referred to vanishes. We suppose the same rule holds with nations as with men, in this respect. The people of the United States, for example, are fond of sitting off and admiring themselves, and telling themselves what a wonderful nation they are; and we confess that we are ever ready, ourselves, to sit on the front seat of the grand stand, and applaud as vociferously as anyone. Foreigners tell us that this is bad taste — that the people of this country admire themselves too much, and that if we had better judgment we should do less "tooting." But the question naturally arises, if the progress of the United States has not been, in fact, so wonderful that all of this self-admiration that we indulge in is justifiable; and we are of the opinion that history and statistics show that such is the case. Some suggestions that tend to substantiate this view are given in an interesting article by Mr. W. C. Dodge, in the July issue of *Cassier's Magazine*, from which the following paragraphs are taken.

In order to get a clear idea of the conditions under which the United States began their existence as a nation, says Mr. Dodge, one must also consider the restrictions placed upon the colonists by the mother country. England's policy was well expressed by Sir William Pitt, who said, "It is the destiny of America to feed Great Britain, and the destiny of Great Britain to clothe America." In other words, America was to remain for all time an agricultural country, furnishing the people of Great Britain with food and the raw materials for her manufactures, while she was to do the manufacturing. Her policy as to manufactures in the colonies was well expressed by Lord Chatham, who said, "I would not allow the colonists to make so much as a hob nail for themselves."

In accordance with this policy, Great Britain enacted laws prohibiting every species of manufacturing in the colonies. Even a hat factory in Massachusetts was declared a nuisance, and its existence ordered abated. When the colonists began to make iron and nails for their own use, the House of Commons resolved that "none in the plantations should manufacture iron wares of any kind, out of any sows, pigs, or bars whatsoever," and the House of Lords added that "no forge going by water, or other works, should be erected in any of the plantations for the making, working, or converting of any sows, pigs, or cast iron into bar or rod iron." A bill was also introduced in Parliament which prohibited the erection of any mill for slitting or rolling iron, for the manufacture of spikes or nails, or any plating forge to work with a tilt hammer, or any furnace for making steel, and also proposed to abolish the few which had been built; and by the act of 1750 the further erection of all such was prohibited.

It was the same with the textile industries. The colonies were prohibited not only from transporting any manufactured articles abroad, but also from one colony to another; and to still further cripple the growth of manufactures, an Act of Parliament forbade, under severe penalties, even to outlawry, the departure from Great Britain of any artificer in any of the various branches, and also the exportation from Great Britain of "any machine, engine, tool, press, paper, utensil, or implement, or any part thereof, which was then, or thereafter might be, used in the cotton, woolen, or silk manufacture, or any model or plan thereof," under penalty of forfeiture, a fine of $1,000, and a year's imprisonment, and the like penalty for any one "having, collecting, making, applying for, or causing to be made, any such machinery"; and when, in 1684, the colony of Virginia passed an act to encourage the manufacture of textile fabrics, the act was annulled by Parliament.

These laws were enforced long after American independence. As late as 1830, Hugh Wagstaff was imprisoned for putting on board the American vessel *Mount Vernon*, for New York, twenty-three boxes of spindles to establish a cotton factory in the United States, and the spindles were confiscated. And when the Hon. Tench Coxe, the coadjutor of Alexander Hamilton, entered into a bond with a party in London to send hither models of Arkwright's patented spinning frame, they were detected and confiscated.

As late as 1832 the model of a roller for printing calico, to be used at Lowell, was obtained only by concealing it in a lady's trunk; and, still later, when Messrs. Sharp and Roberts, of Manchester, England, who, in 1841, patented their self-acting spinning mule in the United States, sought to send the patterns to their partner, Bradford Durfee, at Fall River, Mass., they succeeded only by smuggling them through France. The laws prohibiting the emigration of artificers were not repealed until 1825, and that prohibiting the exportation of machinery, etc., not until 1845.

The Constitutional Convention of 1787 conferred on Congress the powers under which the United States have since grown to their present estate; and under the exercise of those powers America has grown and prospered as no other nation on earth has. What that growth has been may be epitomized by saying that from that little beginning in 1790, the United States have grown until to-day they do one-third of the world's manufacturing, one-third of its mining, and one-fifth of its farming, and they possess one-fifth of its wealth. Years ago, Gladstone, in his book entitled "Kin Beyond the Sea," said: "America will probably become what we are now,—the head servant in the great household of the world, because her service will be most and the ablest." Already America has reached that point, for as Mulhall, the British statistician, recently said:—"If we take a survey of mankind in ancient or modern times, as regards the physical, mechanical, and intellectual force of nations, we find nothing to compare with the United States in 1895. The physical and mechanical power which has enabled a community of wood-cutters and farmers to become, in less than 100 years, the greatest nation in the world, is the aggregate of the strong arms of men and women, aided by horse-power, machinery, and steam-power, applied to the useful arts and sciences of every-day life." And he adds: — "The intellectual power of the Great Republic is in harmony with the industrial and mechanical power. The census of 1890 showed that over 87 per cent. of the total population over ten years of age could read and write. It may be fearlessly asserted that, in the history of the human race, no nation ever before possessed 41,000,000 instructed citizens."

He also shows that the wealth of the United States is $23,000,000,000 more than that of Great Britain, seven times greater than that of Spain, nearly double that of France, and equal to the combined wealth of Russia, Italy, Austria, and Spain; and that America's productive capacity is not only greater than that of any other nation, but that, from 1860 to 1895, it has increased far more rapidly than that of any other, the increase per capita being at least 30 cents per day. In 1793 the gross receipts of the United States were but six and two-thirds million dollars, or a little over $20,000 per day. In 1898 they were over $758,500,000, or nearly two and one-half million dollars per day. In 1796 such was the credit of the United States that when the Commissioners, under authority of Congress, borrowed $200,000 to complete the public buildings, the State of Maryland, in loaning them that amount in United States stocks held by that State, required the Commissioners to give their personal obligations as additional security; and on that $200,000 of United States stocks they could realize but a trifle over 65 per cent.! Within a few years past the government has paid 130 per cent. for its own bonds in order to redeem them in advance of their maturity, — a thing that no other nation has ever done. And only recently, when an offer was made to sell $200,000,000 of 3 per cent. bonds, they were subscribed for seven times over by the people, and in less than six months they commanded 7 per cent. premium in the market. And now, under the recent act to fund the national debt by the issue of 2 per cent. bonds, $260,000,000 of them have been taken in three months. No other nation has bonds bearing so low a rate of interest, the lowest being a portion of British consols bearing $2\frac{1}{2}$ per cent., while the latest for the war in South Africa bear $2\frac{3}{4}$ per cent. The debt of European nations ranges from $75 to $115 per capita, while that of the United States, which was $52.96 in 1872, was but $13.81 in 1898.

The internal and coastwise commerce of the United States by water and rail amounts to more than the foreign commerce of Great Britain, France, Russia, and Belgium combined. Every year there are over 60,000 passages of vessels through the Detroit river, carrying over 40,000,000 tons of freight, and over 80,000 passengers, or nearly fifteen times as many as through the Suez Canal. In 1899 nearly 19,000 vessels arrived and cleared at Chicago, — very nearly as many as at London, which leads the world. The American people write 40 per cent. of all the letters in the world, and the American postal service is the greatest in the world; and there are more miles of telegraph and telephone wires in the United States than in all other countries combined. The annual gain in wealth is about $2,000,000,000; and last year the earnings amounted to $14,500,000,000, one-half of which was paid to labor. Each working day adds $6,000,000 to the nation's wealth. The capital has been multiplied more than threefold since 1870, and at that rate there will be added in the next ten years as much as the entire capital was in 1870.

Does not a showing like this make a reasonable exhibition of national self-admiration pardonable?

Boiler Explosions Since 1879.

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	11	8	10	13	18	132
1880	19	11	11	11	15	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	11	12	12	6	6	152
1885	14	20	11	7	12	12	10	9	11	11	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	21	20	25	13	15	23	246
1889	18	14	17	14	9	5	17	16	14	28	19	9	180
1890	21	26	22	13	18	20	8	21	15	20	18	21	226
1891	21	26	19	11	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

Total Number of Explosions, ... 5,199

TABLE 2.—SUMMARY OF DEATHS BY BOILER EXPLOSIONS.

YEAR.	JAN.	FEB.	MAR.	APR.	MAY.	JUNE.	JULY.	AUG.	SEPT.	OCT.	NOV.	DEC.	TOTAL.
1879	18	28	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	31	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	21	31	18	11	16	23	12	30	11	28	25	18	244
1891	23	35	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	29	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

Total Number of Persons Killed. 6,118

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	16	18	213
1880	44	23	59	46	59	132	41	21	35	28	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	19	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	21	33	24	20	17	27	28	314
1887	31	17	23	43	39	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	24	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
Total Number of Persons Injured,													8,651

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

YEAR.	EXPLOSIONS.	KILLED.	INJURED.
1879,	132	208	213
1880,	170	259	555
1881,	159	251	313
1882,	172	271	359
1883,	184	263	412
1884,	152	254	251
1885,	155	220	278
1886,	185	254	314
1887,	198	264	388
1888,	246	331	505
1889,	180	304	433
1890,	226	244	351
1891,	257	263	371
1892,	269	298	442
1893,	316	327	385
1894,	362	331	472
1895,	355	374	519
1896,	346	382	529
1897,	369	398	528
1898,	383	324	577
1899,	383	298	456
Totals,	5,199	6,118	8,651

The tables that we present herewith give summaries of the boiler explosions that have occurred in this country since the beginning of the year 1879, so far as we have been able to learn of them. According to Table 1 there were 5,199 boiler explosions during the twenty-one years between January 1, 1879, and January 1, 1900. These explosions, it will be seen from Tables 2 and 3, resulted in the death of 6,118 persons, and in more or less serious injury to 8,651 others; so that the total number of persons killed or injured during this time was 14,769. Many a thriving town has a less population than this. In Table 4 the number of explosions each year, and the number of persons killed and injured, are shown in such a manner as to facilitate comparisons. We see from the last line of this table that on an average 1.18 persons were killed per explosion, and 1.66 were injured. That is, 2.84 persons were disabled, on an average, by every boiler explosion.

An Experience with Pitted Tubes. — A correspondent sends us the following account of an experience with iron and steel tubes in a boiler, out in South Dakota: "When we came to Dakota, in 1883, we brought with us a new boiler made of iron, having iron flues. It was before the time of making everything of steel. This boiler we used ten years without a single repair. At the end of that time we put in two new fire sheets. In doing so it was necessary to remove twenty of the flues, which we replaced with steel. These new flues commenced giving out in about two years, and now we have removed all of the twenty except two. Now, remember there are in the boiler twenty of the original flues, apparently as good as new. Whenever a steel flue gave out we put back, in its place, the old one, which we had welded; and every one of the old ones, so replaced, is all right. The steel flues would pit right through in patches as large as a quarter of a dollar, and when taken out were worthless."

We are well aware that an action of this kind is sometimes observed, and we are not prepared to offer a rational explanation of it. It has sometimes been suggested that the iron and steel, being somewhat different in composition, act like a galvanic couple, producing an electric current which destroys the steel by electrolysis. We do not favor this hypothesis, for several reasons, the most obvious of which is, that it would prove too much. It would show that the steel tubes ought to pit in boilers where experience shows that they do not. An even more conclusive argument against the electrolytic theory is, that although a battery whose respective electrodes are of iron and steel will indeed produce an electric current, it will be a very feeble one, measurable only with refined instruments. The electromotive force of such a battery is far below that required for the continuous decomposition of water. It is highly probable, therefore, that any currents which might originally flow between the iron tubes and the steel ones would be speedily arrested and annulled by the phenomenon which is known to electricians as "polarization of the plates." It does not appear to us to be necessary to invoke the aid of the subtle electric fluid to explain the phenomenon in question. It is quite likely that the action is purely a chemical one, and that we should understand it if we knew all about the feed water, and the particular steel of which the troublesome tubes are made.

The Locomotive.

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Right-Angled Triangles and Branched Pipes.

The engineer makes constant use of geometrical principles. Some of these are so evident that he learns to conform to them by experience, even when he has never studied geometry; while others are of such an abstract nature that their truth would perhaps never even be suspected by anybody but a geometer, and the ordinary non-mathematical citizen needs to see a good proof of them before he can admit that they are actually true, or even probably so. In this last class is the celebrated "Pythagorean theorem," which states that the square on the hypotenuse of a right-angled triangle is equal to the sum of the squares on the other two sides.

The theorem just mentioned is called the "Pythagorean theorem," because it is supposed to have been discovered by the Greek philosopher Pythagoras, who was born about the year 582 B. C. It is sometimes called, colloquially, the "pons asinorum," or "bridge of asses." This name does not properly belong to the Pythagorean theorem, however, because it was first (and more properly) given to an entirely different theorem, — namely, to the fifth proposition in the first book of Euclid's geometry, which states that if a triangle has two of its sides equal, the angles opposite those sides are also equal. This is not a difficult proposition at all — in fact it is one of those whose truth is sufficiently obvious for the engineer to accept it as a fact, even without a formal proof; and yet is often found that the proof that Euclid gives bothers the student, who usually thinks the proposition is much worse than it really is. The name "bridge of asses" appears to have arisen from the real or fancied difficulty of coaxing an ass across a bridge, even when the bridge would bear up an elephant. He is fearing trouble that isn't there at all, and he is afraid of a bridge that he could cross with perfect ease and safety, if he would only make the attempt without any fear.

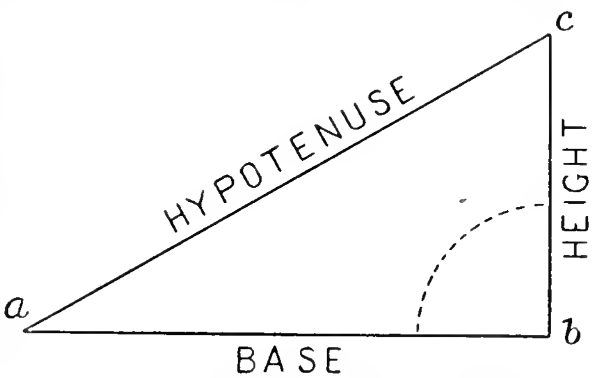


FIG. 1. — A RIGHT-ANGLED TRIANGLE.

The Pythagorean theorem concerning the right-angled triangle has been a favorite subject of contemplation among geometers, and since Euclid's demonstration of it is somewhat troublesome to students, attempts have been made to find some other proof which should be simpler, while remaining, at the same time, equally sound. The result is that something over four hundred proofs of this proposition are now known. We shall give one of the simplest of these.

First, however, let us explain the meaning of the several terms that are used in connection with right-angled triangles, in order that there may be no misunderstanding on account of the words that are used. A triangle is called a "right-angled triangle,"

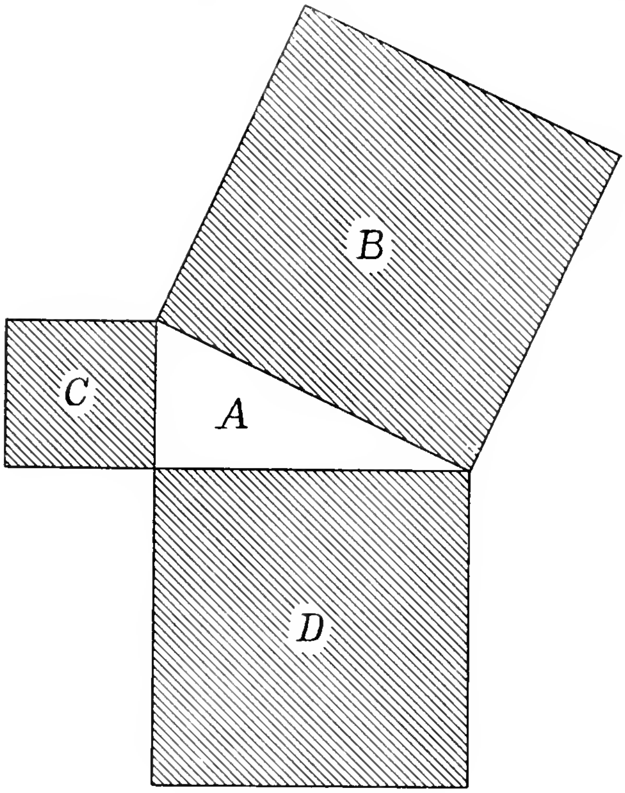


FIG. 2. — MEANING OF THE THEOREM.

when it has a right angle for one of its angles. In Fig. 1, for example, *a b c* is a right-angled triangle, because the angle at *b* (marked by the dotted quarter-circle) is a right angle. Either of the sides next to the right angle may be called the "base," and the other side adjoining the right angle may then be called the "altitude" or "height." In Fig. 1 we have called *a b* the base, and *b c* the height; the right angle being, as we have said, at *b*. The remaining side of the triangle is called the "hypotenuse," — a word which, like many another terrifying object, looks worse than it really is. The word "hypotenuse" comes from a Greek expression which means merely "the side opposite the right angle." In Fig. 1, *a c* is the hypotenuse of the triangle.

Having explained the terms that are used in connection with right-angled triangles, we are prepared to proceed with the discussion of the properties of such triangles. The theorem of Pythagoras states that if a square be drawn upon each of the three sides of a triangle such as is shown in Fig. 1, then the area of the square that rests upon the "hypotenuse" is equal to the sum of the areas of the squares that rest upon the "base" and the "height" of the triangle. In Fig. 2, for example, let *A* be a right-angled triangle; *B*, the square resting upon the hypotenuse of this triangle; *C*, the square resting upon its height; and *D*, the square resting upon its base. Then the area of the square *B* is equal to the area of the square *C* plus the area of the square *D*. As a numerical example of this, consider the diagram given in Fig. 3, where the base of the triangle is four inches, the height is three inches, and the hypotenuse is five inches. The square resting upon the height contains nine square inches; the square resting upon the base contains sixteen square inches; and the square upon the hypotenuse contains twenty-five square inches. The theorem therefore holds true in this particular case, because 9+16=25. (It is true that we have not proved that it is *possible* to construct a triangle whose sides shall be 3, 4, and 5 inches, respectively, and which shall have, at the same time, one of its angles a right angle. As we are using this triangle merely by way of illustrating

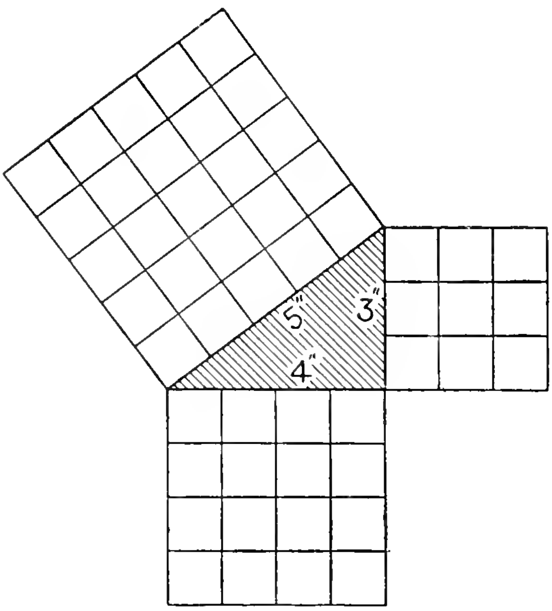


FIG. 3. — FIRST EXAMPLE.

the *meaning* of the Pythagorean theorem, this omission is not important, and we shall ask the reader to take our word for it that the construction *is* possible.)

In Fig. 4 another triangle is shown, which also illustrates the theorem that we are discussing. The base of this triangle is 12 inches, its height is 5 inches, and its hypotenuse is 13 inches. A triangle constructed with these sides will have a right angle at the corner opposite the longest side, so that the theorem must be true in this case. The square resting upon the base of this triangle contains 144 square inches; the square resting upon its height contains 25 square inches; and the square resting upon its hypotenuse contains 169 square inches. We see that 144+25=169; and hence the proposition is true for this particular triangle.

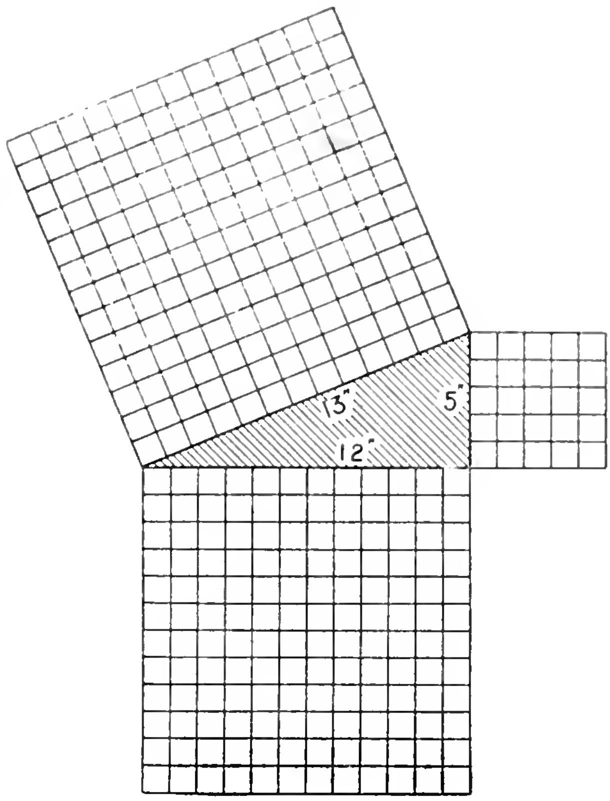


FIG. 4. — SECOND EXAMPLE.

As a third illustration, consider the triangle shown in Fig. 5. The base of this triangle is 15 inches, its height is 8 inches, and its hypotenuse is 17 inches. A triangle with these sides will have a right angle at the corner opposite the side whose length is 17 inches; and the reader may verify, if he pleases, that the theorem is fulfilled by this triangle.

In all three of the illustrations that we have given, the right-angled triangle has had its sides expressible in exact inches. Only a very small proportion of the possible right-angled triangles have this property; for, in general, when the height and base of a right-angled triangle are expressible in exact inches, the hypotenuse can be expressed only by a whole number plus a string of decimals which never comes to an end. A triangle which happens to have all its sides expressible in whole numbers is called an "integral," or "whole-

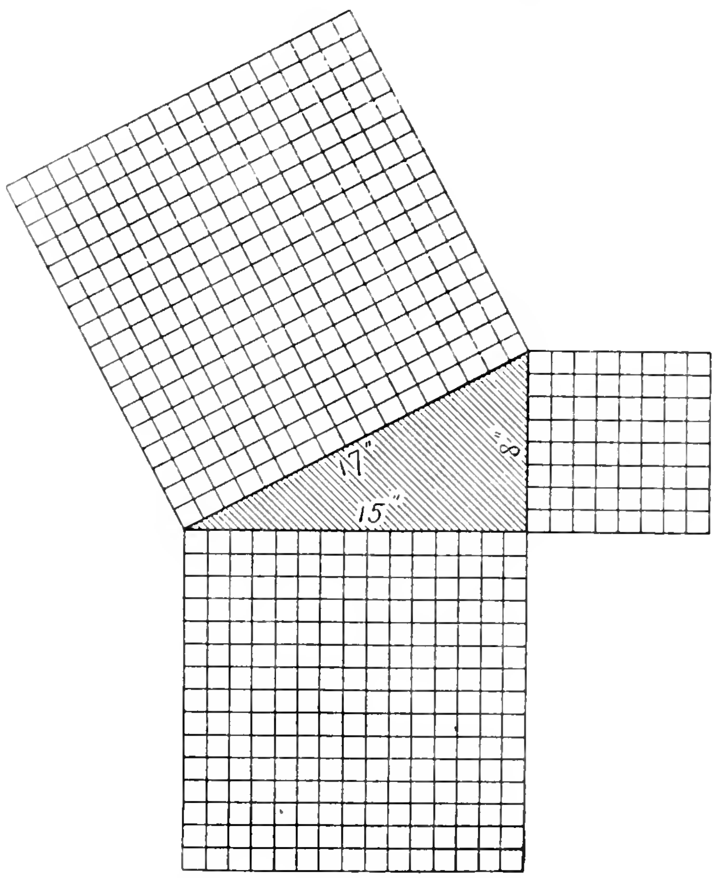


FIG. 5. — THIRD EXAMPLE.

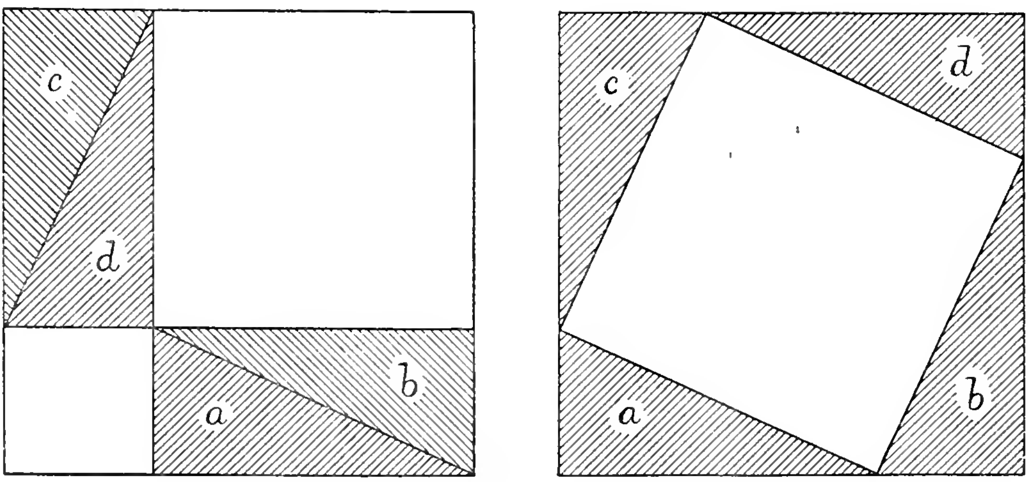
numbered" triangle. We append a table which gives the sides of every possible integral triangle whose least side does not exceed 20 inches. The theorem that we are discussing may be verified from any one of these triangles: but it is important to note that the theorem is equally true of *all* right-angled triangles, whether their sides are expressible in whole numbers or not.

Suppose a right-angled triangle is given, and that we wish to prove, without reference to whether it is an "integral" triangle or not, that the square on its hypotenuse is equal to the sum of the squares upon the other two sides. Let *a*, in Fig. 6, be the triangle in question, and let *b*, *c*, and *d* be three other triangles, exactly like it. Arrange all four of these triangles as shown in Fig. 6, and draw a square around them,

TABLE I.—LIST OF ALL INTEGRAL, RIGHT-ANGLED TRIANGLES WHOSE LEAST SIDES DO NOT EXCEED 20.

Height.	Base.	Hypotenuse.	Height.	Base.	Hypotenuse.
3	4	5	15	20	25
5	12	13	15	36	39
6	8	10	15	112	113
7	24	25	16	30	34
8	15	17	16	63	65
9	12	15	17	144	145
9	40	41	18	24	30
10	24	26	18	80	82
11	60	61	19	180	181
12	16	20	20	21	29
12	35	37	20	48	52
13	84	85	20	99	101
14	48	50	. .		. .

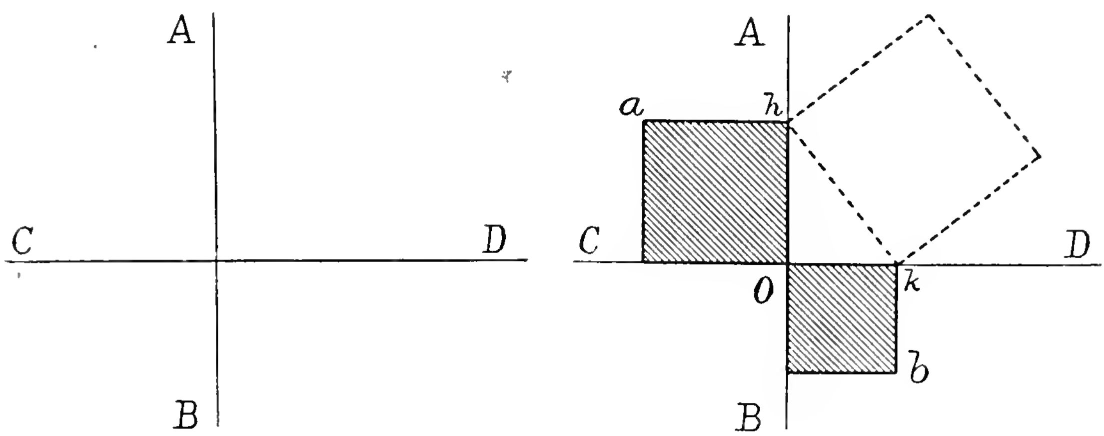
so as to just include them all, as shown. The upper, right-hand blank square is then the square on the *base* of the given triangle, and the lower, left-hand blank square is the



FIGS. 6 AND 7.—PROOF OF THE THEOREM.

square upon the *height* of the triangle. These two squares, together with the four shaded triangles, exactly make up the big, outside square. Now let all the four triangles be shifted about, within the same big, outside square, until they come into the positions shown in Fig. 7. (The reader can easily satisfy himself that this is possible.) The vacant square in the middle of Fig. 7 is then the square on the *hypotenuse* of the given triangle; and since this vacant square, together with the four shaded triangles, just fill the same big, outside square as before, therefore the vacant square in Fig. 7 is equal to the two vacant squares in Fig. 6. In other words, the square on the hypotenuse of a right-angled triangle is equal to the sum of the squares on the other two sides; and this is the Pythagorean theorem, which was to be proved. (Its truth, it will be perceived, is entirely independent of any supposition with regard to the expressibility of the side of the given triangle in whole numbers.)

Of the various applications of this theorem to practice, we will consider only one. When, in engineering practice, two steam pipes or two water pipes come together and merge into a third pipe which is to carry all the steam or water which is delivered to it by the two branch pipes, it is desirable that the sectional area of the main pipe shall be equal to the sum of the sectional areas of the two feeders. For simplicity, let us first



FIGS. 8 AND 9. — THE THEOREM APPLIED TO SQUARE PIPES.

suppose that the pipes are square instead of round. The Pythagorean theorem then enables us to find the diameter of the main pipe very simply, when the diameters of the two feeders are given. For draw two straight lines, *AB* and *CD*, at right angles to each other, as shown in Fig. 8; and in the upper left-hand angle formed by these two lines draw a square, *Oa* in Fig. 9, representing, on some definite scale, the cross-section of one of the feeder pipes, and in the lower right-hand angle draw another square, *Ob*, representing, on the same scale, the cross-section of the other feeder. Then join the corners *h* and *k*, and on the line *hk* draw a square as indicated by the dotted lines. The area of this dotted square is then equal to the sum of the areas of the two shaded squares, since *O h k* is a right-angled triangle. The dotted square therefore represents (on the same scale as that on which the feeders are drawn) the size that the main pipe should have, in order that its sectional area may be equal to the sum of the sectional areas of the two feeders.

If the pipes are circular instead of square, the construction is very similar; for let a square be drawn about the circle which represents the pipe, as shown in Fig. 10. Then the area of the circle so inscribed is always 0.7854 times the area of the square which just contains it. Hence if squares are drawn around the circles representing the feeder pipes, we may proceed with the construction just the same as we did before, as indicated in Fig. 11, using the squares that are drawn around the circles. Then, when the dotted square has been obtained, just as we obtained it before, we draw a circle (also shown dotted) which just touches this square on the inside; and this dotted circle will represent the main pipe, on the same scale as that on which the shaded circles representing the two feeder pipes are drawn. For the dotted square is equal to the square *Oa* plus the square *Ob;* and hence 0.7854 times the dotted square is equal to 0.7854 times the square *Oa*, plus 0.7854 times the square *Ob*. That is, the area of the dotted circle is equal to the sum of the areas of the two shaded circles.

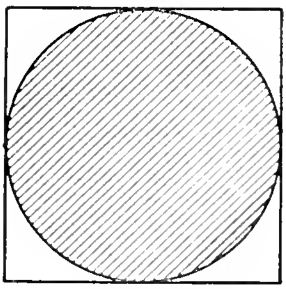


FIG. 10. — SQUARE DRAWN AROUND A CIRCULAR PIPE.

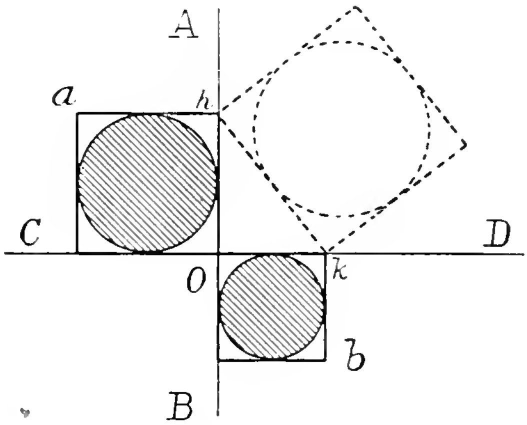


FIG. 11. — THE THEOREM APPLIED TO ROUND PIPES.

In proportioning pipes in practice, we have to be governed by the sizes of pipe that are available in the market; and therefore we cannot always choose a main pipe which shall have *precisely* the cross-section of the two feeders which empty into it. The ac-

TABLE II. — GIVING THE PROPER TRADE SIZE OF A MAIN PIPE, WHICH RECEIVES TWO GIVEN BRANCH PIPES.

SIZE OF LARGER BRANCH PIPE.		TRADE SIZE OF SMALLER BRANCH PIPE.											
Nominal or Trade Size.	Actual Internal Diameter	1″	1¼″	1½″	2″	2½″	3″	3½″	4″	4½″	5″	6″	7″
1″	1.048″	1½	..	..	..	..	..	..	..	..	..	..	..
1¼	1.380	2	2	..	..	..	..	..	..	..	..	..	..
1½	1.610	2	2½	2½	..	..	..	..	..	..	..	..	..
2	2.067	2½	2½	3	3	..	..	..	..	..	..	..	..
2½	2.468	3	3	3	3½	3½	..	..	..	..	..	..	..
3	3.067	..	3½	3½	4	4	4½	..	..	..	..	..	..
3½	3.548	..	4	4	4	4½	5	5	..	..	..	..	..
4	4.026	..	..	4½	4½	5	5	6	6	..	..	..	..
4½	4.508	..	..	5	5	5	6	6	6	7	..	..	..
5	5.045	..	..	..	6	6	6	7	7	7	7	..	..
6	6.065	..	..	..	..	7	7	7	8	8	8	9	..
7	7.023	..	..	..	..	..	8	8	9	9	9	10	10
8	7.982	..	..	..	..	..	..	9	9	9	10	10	..
9	9.000	..		..	..	..	..	..	10	10	..	..	..

companying table (Table II) will be of assistance, however, as showing within practical limits what trade size of pipe is equivalent in cross sectional area to any two given feeders that are to empty into it. This table was constructed by the aid of a diagram like that shown in Fig. 11, except that we have varied from the results given by the diagram just enough to bring them out in some trade size of pipe than can be bought in the market.

The use of Table II will be readily understood from one or two numerical examples. Suppose, for instance, that a 3-inch pipe and a 4-inch pipe are to discharge into a common main, and that we wish to know the proper size of this main. The 3-inch pipe is the smaller of the two given ones, so we look for 3″ in the top heading of the table, and having found it we look down the column under it until we come opposite 4″. We find 5″ in the table at this point, and hence the main pipe should be a 5″ one.

Again, suppose the two branch pipes are to be 3″ and 6″ in diameter, respectively. We first find 3″ in the top heading of the table, and we run down the column below it until we come opposite 6″ on the left-hand margin. Here we find 7″; and therefore a 7-inch main will be ample to receive the discharge from two branch pipes which are 3″ and 6″ in diameter respectively.

We have not carried the table beyond 10-inch pipe; but any problem of this sort which involves pipe-sizes that are not given in the Table can be readily solved by the aid of the diagram suggested in Fig. 11. R.

Obituary.

Mr. James Evans.

We record, with sorrow, the death of Mr. James Evans, which occurred at his home at Troy, N. Y., on July 28th. Mr. Evans was a good friend of the Hartford Steam Boiler Inspection and Insurance Company, and his son, Mr. E. W. Evans, is an inspector in our New York department. We extract from the Troy *Budget* the following notice, which gives some account of his life: "His demise was not unexpected, as he had been critically ill for a long time, and yet the announcement was a shock to his many friends, who had hoped against hope for his recovery. Mr. Evans was one of the old sterling type of men, who regard duty as part of their religion, and friendship as a virtue, and not a mere formality. He was born in Wales, but came to this country in early boyhood. He has lived at Troy the greater part of his life, and it is safe to say that he has not left an enemy behind him. He entered the employ of the Burden Iron Company early in life, and has been with it for thirty years, serving it with fidelity and efficiency, his loyalty and ability being repeatedly recognized by the company, and rewarded by promotion. He was superintendent of the 'Water Mill' until that branch of the great plant was abandoned, when its work was transferred to the upper factory. Mr. Evans was also superintendent of the rivet and horse-shoe departments, and had under him, in each position, large numbers of employees, who entertained for him the highest respect and good will, and who will sincerely regret his death. His health, which had been robust for all his previous life, first began to fail last fall. It was then learned that he was afflicted with cancer of the stomach, and that there was little hope for him. An operation was performed upon him a few months ago, but the relief that was hoped for was not secured. He passed away peacefully, leaving an honorable name, which guarantees to his family the respectful sympathy of all."

Mr. Evans was 55 years of age.

The Locomotive.

HARTFORD, AUGUST 15, 1900.

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

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

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The Big-Word Mania among Scientists.

Herbert Spencer, in his "First Principles," the first volume of his masterly Synthetic Philosophy, says that "Evolution is an integration of matter and concomitant dissipation of motion; during which the matter passes from an indefinite incoherent homogeneity to a definite, coherent heterogeneity, and during which the retained motion undergoes a parallel transformation." I can remember many years ago hearing an acquaintance reel off a remarkable paraphrase of that good old saw, "People who live in glass houses should not throw stones." This is the way he put it: "Individuals inhabitating domiciles of crystalline structure should refrain from the projection of missiles of granitic formation."

Why will scientific men persist in using such big words? Of course there are places where nothing but polysyllables will do, but they are few. In scientific literature generally the now omnipresent Greek and Latin derivatives could just as well give place to the simple Anglo-Saxon. The true scientist, and surely the true scholar, will use the shortest words he possibly can, for in all his writings he strives to instruct, to make his meaning plain; not to confound the intellect and wear out the dictionaries of his readers. The simpler his style the more popular will be his writings and the more good he does. It is this that has made the scientific writings of Huxley, Tyndall, Arabella Buckley, Thoreau, Burroughs, and some others so popular.

And again, in the tendency of scientists to use long words may be found the root of some of the antipathy so many people have for everything scientific. They refrain from reading scientific books for fear of the unpronounceable words, and thereby deprive themselves and others of the many benefits to be derived from scientific studies. So prevalent is this idea that to many the very mention of scientific subjects repels them and they turn from them on the first opportunity with a sigh of relief, glad to escape contact with such laborious books. But the true language of science is not polysyllabic. Your simple man of science does not say on a stormy day that "a condensation of aqueous substance has taken place in the circumambient atmosphere, and precipitated itself upon the surface of our planet." He says instead, "It is raining." He says boiling water is water heated to a temperature of 100 degrees Centigrade, not that it is "hydrogen monoxide elevated to the temperature of ebullition."

But there are so many scientists of the highest rank who take delight in these big words. Take Herbert Spencer's remarkable definition of evolution, quoted in the first paragraph of this article, for instance. Mr. Spencer's language is perhaps very scholarly and all that, but for any one to understand what he means, it is necessary to read the first 400 pages of his book. The late George John Romanes was another scientist who fairly reveled in big words. He played with them, juggled them into sentences, and the average reader cannot help losing himself in the bewildering maze. Two examples from his "Examination of Weismannism," his best known work, will illustrate the point. They are selected at random. Romanes, in speaking of plant life, says: "All the multicellular organisms propagate themselves not exclusively by fission or gemmation but by sexual fertilization." Which translated into common English means that the higher plants multiply not only by division and buds, but by seed. A little further on Mr. Romanes speaks of the "undifferentiated idio-plasm of the first ontogenetic stage." Such words are simply staggering.

The other day I met with the word "idiodactylae." The Standard Dictionary defines it thus: "A phalanx of coliomorphic oscine birds." Of course, the meaning of the word was at once made clear. In some readings on entomological subjects I meet with the word "planipennia," which the Standard says is a name given to "a suborder of neuropterous insects with multinervate wings and multiarticulate antennae." The definitions of scientific words in the Standard Dictionary, as may be inferred by the examples cited, are not characterized by extreme simplicity of language. The reader is informed that the "acanthocephala" is the name given to an order of "nemathelminth worms without a mouth or intestinal canal, but with a retractile proboscis covered with hooks, comprising echinorhynchidae." The "arcturidae are a family of isopods with inferior operculiform uropods and with the anterior (4) pairs of legs ciliated and the posterior (3) ambulatory." Taking up the study of shell-fish, one finds that the rhopalodinidae are a "family of diplostomidean holothurians, having a flask-shaped body." Thanks for the last three words. Most people know at least what a flask is.

Prof. Hyatt in an article on the nautilus in *The American Naturalist* tells us that "the leading characteristic of parallelism in all genetic series of nautiloids is a tendency toward closer coiling and greater involution in the more specialized forms of each separate series, and a correlative increase in the profundity of the impressed zone." Pause, gentle reader, and carefully examine this sentence. It is truly frightfully and wonderfully made.

Prof. Cope, in his "Primary Factors of Organic Evolution," is nearly as bad. He kindly advises his reader that "in the first case, that of the human elbow, the cubitus was luxated posteriorly, so that the humeral condyles articulate with the ulna, anterior to the coronoid process." The translator of Ribot's "Psychology of Attention" tries to say that when we are very happy we forget our surroundings. He puts it in this way: "Intense enjoyment produces a momentary unity of consciousness."

Campbell, in his "Ferns and Mosses," states that "the young sporophyte of the pteridophyte, like that of the bryophyte, lives, for a time, parasitically on the gametophyte." Being translated into English, this means that the young ferns, like the mosses, live for a time as parasites on the several organisms that produce them. O tempora! O mores! O verba!

A man of science, a physician, criticises a modern novel, and tries to convey the idea that it is immoral. He calls it: "A paean pubescent; the study of a peccant pair; an immund study of stercoraceous souls."

The scientific reporter on our daily paper writes up an account of a runaway accident in which the driver was thrown out and broke a leg. He puts it this way: "The unfortunate individual was projected transversely from the vehicle, fracturing the tibia and fibula and luxating the tibio-tarsal articulation." It was probably the same reporter who described a farmer's weed-killing machine as an "aberuncator." All this is about on a par with the barber whose advertisement reads: "Come and repose recumbent, artistically in our piscatorial boudoir, and a physiognomical hair dresser will dexterously manipulate your cranium, abridge your capillaries, and shampoo you with ambidextrous facility on philological principles satisfactorily."

Nowhere do we find bigger words used than in medical science, and nowhere is there better reason for them; but there are times when it does seem as if fewer syllables might fill the bill. For instance, a physician invents a new surgical instrument, but what earthly reason is there for describing it as a "new apparatus for the armamentarium of the clinician?" Another writer wishes to say that cancer is an unnatural growth. He takes a long breath and proceeds as follows: "Carcinoma arises from any subepithelial proliferation by which epithelial cells are isolated and made to grow abnormally." Dr. Edmund Andrews of Chicago Medical College relates a number of such instances, among them the following definition by an insanity expert: "The prodromic delirium is a quasi-pananoiac psychosis in a degenerate subject." Another person tries to say that certain microbes produce the poison of erysipelas. He writes: "The streptococcus erysipelatosus, proliferating in the interspaces of the connective tissue, is the etiologic factor in the secretion of the erysipelatous toxins." A post-mortem examination shows a diseased condition of the liver. The learned operator reports as follows: "A colossal carcinomatous degeneration of the hepatic mechanism." A bullet in the leg does not, to one of these polysyllabic physicians, make a hole in his patient. It is simply a "perforation." He never sees any bleeding. It is only a "hemorrhage" or "sanguineous effusion." If an artery is shattered and he finds it impossible to save the limb, he does not cut it off. That would be too simple. He gets out his "armamentarium," and amputates it.

Max Nordau in "Degeneration" tells us that these are degenerate days. Perhaps these long-worded scientists are degenerates. But listen to this from Nordau himself: "The leading characteristic of the hysterical is the disproportionate impressionability of their psychic centers." Yes, these are degenerate days. Time was when a word to the wise was sufficient. Nowadays it must be a mighty *long* word, or it will not do. Time was when the schoolboy could recite with satisfaction both to himself and his teacher:

Little drops of water,
Little grains of sand,
Make the mighty ocean
And the pleasant land.

Nowadays, to meet the full requirements of polysyllabic science, he must paraphrase it thus:

Infinitesimal particles of saline humective fluidity,
Minute corpuscles of discrete, non-adhering silicious matter,
Conjointly cause to exist the immeasureable expanse of hydrogen monoxide,
And the resplendent superficies of dry solidity.

—ARTHUR T. VANCE, in the *New York Times Saturday Review*.

[Our opinion is, that Mr. Vance's idea is quite correct, in the main. Scientific men are certainly prone to use words that are unnecessarily long and unfamiliar. There can be no possible excuse, for example, for the critical doctor describing a dirty novel as "an immund study of stercoraceous souls," when he might have said, just as well, that it is rotten. On the other hand, unfamiliar words are occasionally required, when an exact shade of thought is to be expressed with all the precision possible — especially if this thought is itself an unfamiliar one. Herbert Spencer's definition of evolution (with which Mr. Vance begins his article) is a case of this kind. It expresses with great accuracy the precise idea that Mr. Spencer has in mind when he uses the word "evolution"; and if he had used any less exact words, he would undoubtedly have been attacked by hosts of critics for giving a definition which did not fit his system of philosophy with the requisite nicety. We observe that although Mr. Vance paraphrases some of the other sentences and phrases to which he takes exception, he does not attempt to paraphrase this particular one. In fact, it would be exceedingly difficult to do so, without losing the precise force that Mr. Spencer wished it to have. If Mr. Vance will take the trouble to read Spencer's "Philosophy of Style," in the second volume of his *Essays, Scientific, Political, and Speculative*, he will find that Mr. Spencer has given a good deal of thought to this matter of big words, and that he does not approve of their use in any case, unless they are absolutely needful, in order to convey a writer's idea with definiteness and precision.— EDITOR.]

More "Magazine Science."

In the issue of THE LOCOMOTIVE for April, 1899, we had something to say about the kind of "science" that the high-class magazines give us. That was over a year ago; and since that time there has been as goodly a crop of pseudo-science in these same magazines as one could wish to see. It would be tiresome to go over the list and discuss it from one end to the other: and moreover it wouldn't do any good, because the magazines, in their superior enlightenment, would go on publishing the same sort of things, in just the same way.

Almost simultaneously with our criticism of last year, a fine specimen of "magazine science" was given us by Dr. T. J. J. See, now (and perhaps then) connected with the United States Naval Observatory, at Washington. It appeared in the *Atlantic Monthly* for April, 1899, and was entitled "The Solar System in the Light of Recent Discoveries." Dr. See announced, in this article, a "discovery" that he had made, concerning the temperature of the sun and other heavenly bodies. He was not at all modest about his claims, and he cheerfully states that his "law of temperature bids fair to do almost as much to explain the mysterious processes of celestial evolution as the law of Newton did to illuminate the older and more celebrated problem of the heavenly motions."

Dr. See states his "law," and proceeds to defend his claim to its discovery by stating (1) that Helmholtz first taught, in 1854, that the sun's heat is maintained by that body's steady contraction; (2) that Lane, in 1869, discussed the theory of the sun, and showed that the temperature of the sun may *rise*, as its bulk shrinks; (3) that in 1881 Ritter discovered exactly what See discovered seventeen years later, and that Ritter published it in Wiedemann's *Annalen*; and (4) that in 1898, See discovered the same thing himself, and magnified its importance, and talked about it so much, that surely he ought to have the entire measure of whatever credit is due to anyone for it. "By scientific usage," he says, "he is recognized as the discoverer who finds, makes known, and renders useful and effective the products of his labors." There is something sublime in the 1, 2, 3, 4 process by which the Doctor mounts his self-erected pedestal; something equally sublime in the way in which he "turns down" Ritter, because that gentleman saw fit to publish what he wrote in the foremost physical journal in the world, instead of where Dr. See thought he ought to have published it; and when we reflect that See has done absolutely nothing beyond what Lane and Ritter did, except to draw a lot of erroneous conclusions from his "law," the whole article has such a charming air of assurance and self-laudation that we are glad, on the whole, that he wrote it. One doesn't often get a chance to study this particular kind of a literary style, and the change is refreshing. Still, it would be well for Mr. See to remember a passage in the *Autocrat of the Breakfast Table.* "Nothing is so commonplace," says the good Dr. Holmes, "as to wish to be remarkable. Fame usually comes to those who are thinking about something else,— very rarely to those who say to themselves, 'Go to, now, let us be a celebrated individual!' The struggle for fame, as such, commonly ends in notoriety."

This matter of See's "law" is ancient history now, and we do not need to go into it further. Those who wish to follow it up are referred to the discussion of it that appeared in the *Astronomical Journal* (published at Cambridge, Mass.,) a year or more ago. In particular the reader is referred to No. 463 of that publication, which contains a passage from which the editor's views concerning Dr. See may be inferred. The *Astronomical Journal,* let us add, is one of the most accurate and authoritative astronomical publications in the world. Perhaps the editor of the *Atlantic Monthly* could not be expected to know whether Dr. See's "law" is sound or not; but he ought to be able to find somebody who could inform him on that point. Anyhow, his suspicions ought to be aroused by a contributor practically arrogating to himself the title of Newton the Second.

One of the most striking of the recent examples of "magazine science," is Nikola Tesla's article in the June issue of *The Century Magazine*, entitled "The Problem of Increasing Human Energy." This article fills about thirty-six pages of the magazine, and consequently we cannot review it in any great detail. It contains some striking photo-engravings of apparatus which Mr. Tesla has used in his electrical experiments, and these engravings are likely to hypnotize the unscientific reader into the belief that certain things in the accompanying text are gospel, when as a matter of fact they are nothing but arrant nonsense. Perhaps the best way to treat this article will be to quote opinions concerning it from a couple of standard periodicals, in widely different fields; because this will perhaps free us from the imputation of being in a chronically bad humor towards the magazines.

Let us first see what *Marine Engineering* has to say — for Mr. Tesla touches upon all subjects, from signaling to the planets, to steamboat propulsion. "This dazzling contribution to modern unscientific research," says that journal, "reads like nothing so much as an essay on Christian Science, so profound is it in the ambiguous nothingness whereby it leads through the intricacies of incoherency unto the climax of absolute asininity. This climax is reached (for us) in the following statement, which occurs on page 198 of the June *Century:* 'Steamers and trains are still being propelled by direct application of steam power to shafts or axles. A much greater percentage of the heat energy of the fuel could be transformed into motive energy by using, in place of the adopted marine engines and locomotives, dynamos driven by specially designed high-pressure steam or gas engines, and by utilizing the electricity generated for the propulsion. A gain of from fifty to one hundred per cent. in the effective energy derived from the coal could be secured in this manner.' It is no doubt beyond the comprehension of the literary gentlemen who publish *The Century Magazine* to understand that progress in marine propulsion is slow, very slow, and that there is nothing in the entire domain of scientific research that promises any hope of being able to transform a much greater percentage of the heat energy of fuel into motive energy by employing dynamos driven by specially designed high pressure steam or gas engines. It is to be expected, however, that as those responsible for the statements made in what has been considered one of the foremost literary magazines of the country, they should appreciate their lack of expert knowledge, and by procuring suitable editorial assistance, safeguard their readers, the reputation of the magazine, and their own sense of right. Under the circumstances, we most unqualifiedly pronounce the statement here reproduced from *The Century Magazine*, regarding marine propulsion, to be a crude and ignorant 'fake.'"

This is strong language, but we think the editors of *The Century* would have hard work to answer it. Elsewhere in the same issue (namely the July issue) of *Marine Engineering*, Professor William F. Durand, of Cornell University, makes a few observations along the same line, which might set the editors of *The Century* a-thinking, if they would give themselves the trouble to read what he says.

Turning now from technical journalism to the field of pure science, we propose to quote a few remarks about Mr. Tesla's article which appear in a communication published in the July issue of *The Popular Science Monthly*, under the heading "Science and Fiction." "Mr. Tesla has enjoyed considerable excellent repute as a gifted student of certain electrical phenomena," says this writer, "and one expects a good deal from his 'electrical experiments, now first published.' Mr. Tesla, too, expects a good deal from them. It would take too long to even note here all the important scientific discoveries which Mr. Tesla expects to make, or all the benefits which he expects to thereby confer upon mankind in general, and in particular upon those who exploit his inventions. Some samples may be given. War will be rendered harmless by being reduced to a sort of game between 'telautomata,'— machines which will behave 'just like a blindfolded person obeying instructions received through the ear,' any one of which machines is 'enabled to move and to perform all of its operations with reason and intelligence. . . . It will be able to follow a course laid out, or to obey orders given far in advance; it will be capable of distinguishing between what it ought and what it ought not to do. . . . In fact, I have already conceived such a plan.' Inasmuch as the interest in this telautomatic warfare is to be purely æsthetic, it would seem as if international bull-fights, or kite-flying, or spelling-matches, or potato-races might do as well, and have the added advantage of leaving Mr. Tesla's expectations free to wander among the following prospective discoveries.

"New sources of energy, Mr. Tesla thinks, may be opened up, such as a wheel which shall perform work without any further effort on our part than that of constructing it. 'Imagine a disk of some homogeneous material,' he says, 'turned perfectly true, and arranged to turn in frictionless bearings on a horizontal shaft above the ground. This disk, being under the above conditions perfectly balanced, would rest in any position. Now it is possible that we may learn how to make such a disk rotate continuously, and perform work by the force of gravity without any further effort on our part. . . . To make the disk rotate by the force of gravity we have only to invent a screen against this force. By such a screen we could prevent this force from acting on one-half of the disk, and the rotation of the latter would follow.' Into further particulars concerning the nature of such a screen Mr. Tesla does not enter, though it would seem a matter well fitted to engage his peculiar gifts. The 'screen against gravity' idea has already entered into a popular story,* but scientific men have probably not given it much consideration [because its existence would imply the falsity of the conservation of energy, which is believed to be one of the most fundamental facts of nature].

* The story here referred to is doubtless one of Mr. Frank R. Stockton's.

"The golden age figures largely in Mr. Tesla's article; he offers us all that is entrancing and wonderful. He is generous. We ask for the bread of definite facts of science and intelligible evidence, but he gives us the amethyst and topaz and diamonds of an ambient medium doing all our work, and the atmosphere transporting all our motive power, and the tyrant gravity held powerless by a screen, and Mr. Tesla correcting Lord Kelvin's errors. Still, amethyst and topaz and diamonds are only stones. They may dazzle the magazine reader, but they do not nourish the student of science.

"The editorial department of *The Century Magazine* perhaps felt that these jewels were a bit too bright. We read there that 'much that must seem speculative to the layman can take its proper place only in the purview of the scientist.' Some conservative scientists will feel like growling, 'And much that must seem bosh to the man of science can take its proper place only in the purview of the editorial departments of popular magazines.' Leaving aside the present case, it is a fact that the same care which is exercised by editors to secure in their contributions excellence of style and syntax, a proper moral tone, and freedom from advertisement of business ventures, is not exercised to secure accuracy in statements of fact or decent credibility in matters of theory. The editors apparently impute to their readers a desire to be entertained at all costs. They descend to a footing with the Sunday newspaper instead of trying to rise to the level of such scientific literature as Huxley or Tyndall gave us. They evidently often do not know science from rubbish, and apparently seldom make any effort to find out the difference. They should at least submit their scientific literature to competent men for criticism and revision."

We do not need to make further quotations about this article in *The Century*, nor do we need to add a single word of our own. We should like to commend to Mr. Tesla's attention, however, the same extract from the *Autocrat* to which we referred Dr. See, earlier in the course of this article.

A Pennsylvania "Glacier."

The North Mountain glacier, near Wilkes Barre, Pa., is gradually disappearing. The thinning of the deep forest has let in the sun, and in a short time there will be nothing left of one of the most curious phenomena of that part of the country. This glacier is on the summit of North Mountain, in one of the wildest and until recently most deeply wooded regions of the state. It is about four miles from Lake Ganoga, but is known to but few, the journey through the heavy forest being too arduous to entice summer guests to the spot. Consequently few but the hunters and woodsmen have seen it. It occupies a swale-like place of several acres on which there were for years only a few inches of water and where the only vegetation was rank grass, ferns, and moss. Underneath this is a thin layer of sand and then ice. How thick the ice is no one knows. A few years ago some hunters chopped a hole five or six feet deep in it, but found no sign of its ending. Now, however, instead of a few inches of water there are seven feet. Last year the water was four feet deep, the year before that hardly a foot. Next year there may be no ice at all, as the glacier is evidently melting fast, and the ice-cold water which has refreshed many a hunter and animal will disappear.

This is the explanation once given by a geologist. Ages ago the glaciers filled all the valleys of the land to about this parallel of latitude and perhaps the southernmost limit reached was North Mountain. One branch pushed itself down the valley of the Loyalsock, but the big mountain barred the way of the great glacier, which gradually disappeared after leaving a tooth on the mountain. This tooth is the present glacier and it made a valley for itself on the mountain top. This was done by plowing the earth with an immense bowlder which to-day marks its end. This bowlder is of entirely different formation from the other rocks on the mountain and there is no telling from whence it came. As the big glacier gradually melted, this tooth, protected by the mass of vegetation on the mountain, remained intact, only a little of its surface melting during the summer, only to freeze again during the winter. But in the last five years the dense growth of trees has been gradually thinned by the woodsman's axe until now the sunlight streams in in a thousand places where it never before penetrated, and the damp and shady forest ground catches glimpses of the sky. The woodsman is still busy chopping down the great trees and letting in the light. All winter he will labor, and next summer the relentless sun may reveal for all time the secrets of the glacier. If not next summer, then the next or next. It will be slow but sure. — *New York Sun.*

Inspectors' Report.

JUNE, 1900.

During this month our inspectors made 10,392 inspection trips, visited 18,141 boilers, inspected 8,926 both internally and externally, and subjected 1,033 to hydrostatic pressure. The whole number of defects reported reached 15,715, of which 1,347 were considered dangerous; 113 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,099	53
Cases of incrustation and scale,	2,857	64
Cases of internal grooving,	172	59
Cases of internal corrosion,	1,151	102
Cases of external corrosion,	775	87
Broken and loose braces and stays,	156	47
Settings defective,	428	31
Furnaces out of shape,	484	17
Fractured plates,	296	73
Burned plates,	357	40
Blistered plates,	288	132
Cases of defective riveting,	1,810	144
Defective heads,	111	9
Serious leakage around tube ends,	3,026	231
Serious leakage at seams,	408	24
Defective water-gauges,	277	54
Defective blow-offs,	236	50
Cases of deficiency of water,	11	5
Safety-valves overloaded,	70	30
Safety-valves defective in construction,	124	32
Pressure-gauges defective,	577	48
Boilers without pressure-gauges,	14	14
Unclassified defects,	988	1
Total,	15,715	1,347

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

Vol. XXI. HARTFORD, CONN., SEPTEMBER, 1900. No. 9.

Feed Water and Boilers.

One of the most important factors to be considered in connection with the generation of steam is the quality of the feed water that is available, for this has a large influence, both upon the consumption of fuel, and upon the durability and cost of maintenance of the boiler. Durability and cost of maintenance are specially important elements to consider, when the water contains a large amount of solid matter.

Practically all waters contain mineral matter in greater or lesser amount, and those which contain lime and magnesia in considerable quantities yield a hard, stony scale, which can be removed only with difficulty. When chemical substances are introduced into the boiler to prevent the formation of this stony form of scale, the solid matter in the water is often deposited in the form of a sludge, which, although it has the advantage of being much more readily removed from the boiler, is nevertheless likely to cause overheating, leakage, and distortion and even fracture of the boiler.

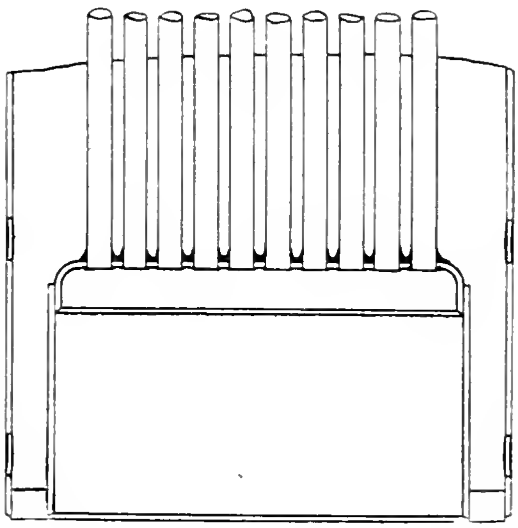

Fig. 1. — Hard Scale on Tube Sheet.

We hardly need to say that the quality of water varies greatly in different parts of the country. Some localities are favored with very pure water; others have water which contains considerable organic matter, but is nevertheless well adapted for use in steam boilers; in other places we may find water which makes scale quite slowly, so that the deposit can be controlled by the introduction of solvents, and frequent cleaning and washing of the boilers. Again, we have found localities, in our experience, where the water is so bad that it is more economical to use the plain cylinder boiler than any other type, the formation of scale being so rapid and abundant that the accessibility of every part of the heating surface, for cleaning, becomes the paramount consideration in the selection of a boiler.

The nature of the water supply receives far too little attention, in general, from those who have to determine what type of boiler shall be used in any given place. The conditions may be such that one type of boiler, with good care, may be operated for a long term of years without injury or accident, while some other type, when used under the same conditions, may show distress in a few months, or a few weeks, or even in a few days, according to the character of the water, and the duty required of the boiler. Many cases have come under our observation, in which the horizontal tubular boiler has been successful when some other type has proved unsatisfactory, or perhaps could not be operated at all. The reason for this is not hard to find. When properly proportioned, with wide spaces between the tubes, and between the tubes and the shell, the horizontal tubular boiler is accessible in nearly every part for cleaning, while most of the other types are not.

To illustrate this point, we will compare the vertical and the horizontal tubular boilers. As a concrete example, let us consider a horizontal tubular boiler 72 inches in diameter and 18 feet long inside, having a total heating surface (or surface in contact with water) of some 1,500 square feet; and let us compare it with a vertical tubular boiler having substantially the same heating surface. If these two boilers take their feed water from the same supply, and evaporate the same quantity per hour, the total solid matter deposited in any given time, either as scale or sediment, will be the same in each. Scale formed upon the tubes in either boiler is constantly loosening and falling down, so that it collects at the bottom of the boiler. In the vertical tubular type some scale and sediment will pass over into the water leg around the firebox, and lodge there. A great deal, however, — especially in the larger sizes, — will be retained by the tubes, and lodge upon the tube-sheet, directly over the fire. The surface upon which the scale can lodge here is limited, of course, to the spaces between the tubes; and if we consider a vertical tubular boiler having substantially the same heating surface (1,500 square feet) as the horizontal tubular one whose dimensions we have already given, we shall find that the total area of the tube sheet is about 28 square feet. The tubes remove some 6 square feet of this, and there remain but 22 square feet upon which the scale and sediment will accumulate. In the equivalent horizontal tubular boiler the deposit may lodge anywhere on the lower half of the shell. Now it is easily shown that the area of the lower half of the shell of the horizontal boiler is 170 square feet. The surface upon which the deposit may collect is therefore eight times as great in the horizontal tubular boiler as it is in an equivalent boiler of the vertical type. It is true that the shell of the horizontal boiler is so steep at the sides that loose scale is not likely to collect there to any great extent, until the lower parts are pretty well covered. Making all due allowance for this, however, the fact remains that the effective area for the lodgment of sediment and loose scale is

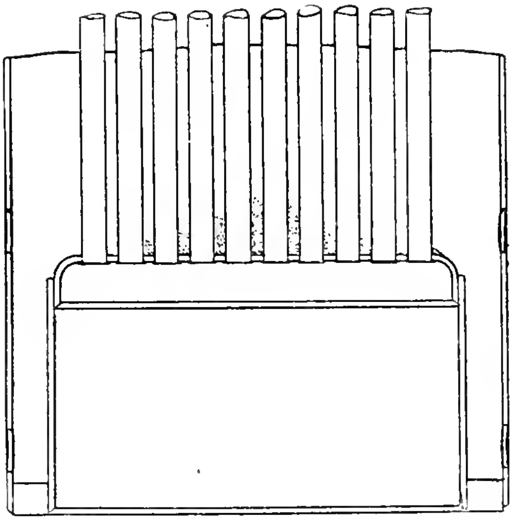

FIG. 2. — LOOSE DEPOSIT ON TUBE SHEET.

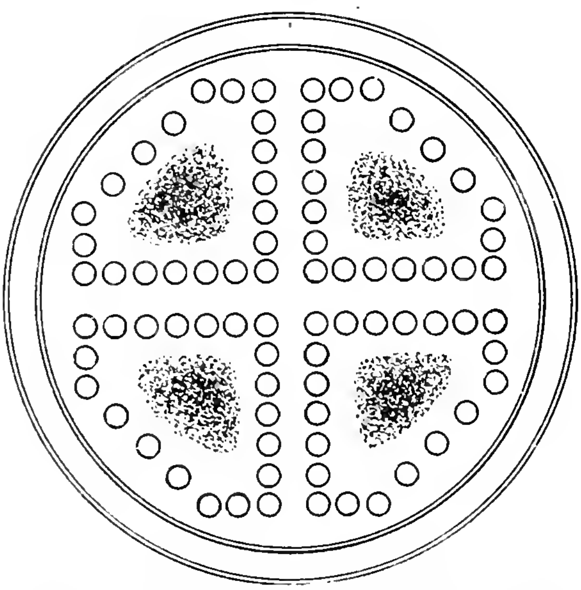

FIG. 3. — DEPOSIT ON TUBE SHEET WHEN SPACES ARE KEPT FREE.

several times as great in the horizontal tubular boiler, as it is in a vertical tubular boiler of equal evaporative power.

The point of all this argument is, that when a horizontal tubular boiler and a vertical tubular boiler of the same evaporative power are run side by side at the same duty and with the same water, the sediment and loose scale which collect at the bottom in any given time will be several times as thick in the vertical type as it is in the horizontal one.

Continuing our comparison of these two types, we may remark that the greater thickness of the deposit in the vertical boiler is of far more importance than its mere numerical measure would indicate. For in the horizontal type the deposit does not cover anything except the shell plates and the girth joints; whereas in the vertical type it buries the tube ends, and keeps the water away from the expanded joints by which they are secured to the tube sheet. These expanded joints are very sensitive to abnormal increase of temperature, and a slight degree of overheating will often start them and cause them to leak badly.

Our illustrations indicate the way in which scale may be expected to collect in a vertical boiler, when using bad water. In the first place, since the tube sheet and the lower ends of the tubes are exposed to the most extreme heat of the furnace, there will be a deposit of scale upon these parts, directly from the water, on account of the rapid evaporation there. If the water contains lime and magnesia, this scale will be likely to be hard and stony. It may cover the spaces on the tube sheet, between the tubes, to a thickness of from $\frac{1}{16}$ to $\frac{3}{16}$ of an inch (and perhaps more), building rings around the tubes at their junction with the tube sheet. This action is indicated by the dark spots between the tubes in Fig. 1. Scale deposited in this way is a common cause of obstinate leakage at the tube ends, and of injury to the tube sheet. The removal of such scale is always exceedingly difficult, and it is often impossible without removing the affected tubes.

Passing now to the source of trouble upon which we have especially dwelt in comparing these two types of boiler, — namely, to the accumulation of loose scale and sediment upon the fire sheets, — we shall find that this deposit will tend to collect, in the vertical boiler, somewhat in the manner indicated in Fig. 2, the deposit being heaviest in the middle of the tube sheet, and gradually lessening in thickness towards the edges. The tubes near the middle will leak worst, in case of a deposit of this kind, because the water is kept away from them most effectually by the greater depth of the deposit. When care is taken to keep the spaces in front of the handholes clean, the deposit can no longer collect in a single mass, as represented in Fig. 2, but will be massed in four smaller heaps, among the tubes which are separated by the spaces that are kept clean. It is difficult to represent this state of affairs in an illustration, but the attempt to do so has been made in Fig. 3, which represents the tube sheet of a vertical boiler. Most of the tubes have been omitted in the cut for the sake of clearness, and the four regions of heaviest scale deposit are indicated by the four shaded regions. In cases of this kind there is usually little or no leakage along the spaces in front of the handholes, but the tubes leak in clusters of from six to twenty, around the middle of the shaded areas in the cut.

It should be clearly understood that this article is not intended as a condemnation of the vertical tubular boiler, for this type often gives excellent service when it is run with a suitable feed water, and receives proper care. Moreover, there are many other types of boiler that are poorly adapted for waters that contain considerable quantities of solid matter, and which form scale rapidly. We have selected the vertical tubular boiler for the comparison because it is a type familiar to everybody, and because it was necessary to select *some* particular kind of boiler, in order to illustrate our general proposition, — the proposition, namely, that under certain conditions one type of boiler may prove entirely satisfactory, both as to economy and as to durability, while other types may not be adapted to these conditions, and perhaps cannot be run in the same place without considerable waste of fuel, and frequent bills for repairs. Constructing engineers, mill owners, and steam users generally would do well to consider this point carefully, when designing or installing steam plants.

Boiler Explosions.

MARCH, 1900.

(70.) — On March 2d a boiler exploded in the Warnell Lumber & Veneer Company's mill, at Plant City, Fla. R. W. Smith and W. Williams were badly injured. The plant was damaged to the extent of about $2,000.

(71.) — On March 2d a boiler exploded at an oil well at Ansonia, Tioga County, Pa. Several men were hurt.

(72.) — A boiler exploded, on March 2d, in the Rose-Morgan Company's coal works, at Bellaire, Ohio. Nobody was hurt, and the property loss was small.

(73.) — A boiler exploded, on March 2d, in Merchant & Hanson's sawmill, at Wake, near Stormont, W. Va. George Steurer was instantly killed, and Henry Garland was fatally injured. Two of Mr. Steurer's sons were also badly injured. The boiler-house was completely wrecked.

(74.) — The boiler of a steam launch belonging to the transport *Hancock* exploded, on March 3d, at the dock in San Francisco, Cal. Two of the crew were seriously injured.

(75.) — On March 5th a boiler exploded in J. T. Waters' planing mill, at Carson City, Mich. Erwin Waters was instantly killed. The mill was wrecked, and E. H. Brower's workshop, which adjoined the mill, was also completely demolished.

(76.) — On March 6th a misplaced switch at Old York Road, on the Reading Railway, near Philadelphia, Pa., caused a shifting engine to collide with a coal train. The boiler of the shifting engine exploded. Seven cars were wrecked, and a hundred yards, or so, of track were torn up. Nobody was injured.

(77.) — A boiler exploded, on March 8th, in Wright's cotton gin, at Lytton Springs, near Lockhart, Tex. Nobody was hurt.

(78.) — A boiler in Jonathan Grawall's planing mill, at Rockwood, some ten miles south of Somerset, Pa., exploded on March 12th, totally destroying the mill, and fatally injuring Frank Grawall, a son of the proprietor. The proprietor himself received slight injuries.

(79.) — A boiler exploded, on March 15th, in the Fay-Egan plant, at Cincinnati, Ohio. Engineer Charles Harris was badly scalded about the neck and back, but it is believed that he will recover.

(80.) — On March 17th a boiler exploded in Knight & Thompson's sawmill, at Shapleigh, near Sanford, Me. The mill was demolished, but as nobody was near the building at the time, there are no personal injuries to record.

(81.) — The boiler of locomotive No. 129, of the Southern Railway, exploded, on March 17th, at Brownsboro, near Huntsville, Ala. Fireman George T. Heinman was blown from the cab, and scalded so seriously that he may not recover.

(82.) — A boiler exploded, on March 19th, in Chandler's fruit-crate factory, at Southern Pines, N. C. Engineer Robert Taylor was killed, and John Monroe was fatally injured. Angus Kelly and William Shaw also received minor injuries. The factory was badly damaged

(83.) — On March 22d a boiler exploded in the E. Tremaine Lumber Company's plant, at Jensen, Sebastian County, Ark. The damage was slight, and there were no personal injuries, so far as we are aware.

(84.) — On March 23d a boiler exploded in James Nickum's sawmill, six miles southwest of Muncie, Ind. Thomas Sullivan, Clifford Van Buskirk, and Marion Carey were killed, and Alonzo Van Buskirk was fatally injured. James Dragstrim, James M'Creary, and William Green were also badly hurt. The mill was blown to fragments.

(85.) — A boiler exploded, on March 24th, in John Neubauer's sawmill, near Lancaster, Ohio. John Neubauer was instantly killed, and Clay Neubauer was fatally injured. Charles and William Neubauer (both sons of the proprietor of the mill), were injured so badly that it is feared that they cannot recover. Theodore Neubauer and William Young were also badly hurt.

(86.) — On March 25th a hot water boiler exploded in the Golden Eagle Pharmacy, North Avenue and Clark Street, Chicago, Ill. A soda fountain valued at $5,000 was wrecked, but nobody was hurt.

(87.) — Robert Kiefer's grist-mill, situated near Selvin, in Warrick County, Ind., was wrecked, on March 28th, by the explosion of a boiler. Engineer Robert Day was badly scalded, and several other employees received lesser injuries.

(88.) — On March 28th the boiler of locomotive No. 300, on the Norfolk & Western Railroad, exploded while opposite Breeden, near Huntington, W. Va. Engineer Samuel C. Buck was blown into Twelve Pool River and instantly killed. Fireman David Sharp was also fatally injured.

(89.) — On March 28th a boiler exploded in Daniel Bros.' sawmill, in Quemahoning Township, Somerset County, Pa. David Berkey and George Mosteller were severely injured, and the mill was blown to pieces.

(90.) — A boiler exploded, on March 28th, in H. M. Law's sawmill, at Woodland Park, near Cripple Creek, Colo. Engineer Willard Heisey was killed, and another man was injured. The mill was wrecked.

(91.) — On March 28th a boiler exploded in R. E. Vanarsdale's sawmill, some five miles southeast of Ingalls, Okl. Frederick Vanarsdale (son of the proprietor) was injured so badly that he died within a few hours.

(92.) — A boiler exploded, on March 30th, in the C. W. Rutledge Lumber Company's plant, at Pullman, a station in Sevier County, Ark., on the Pittsburg & Gulf Railroad, about fifty miles north of Texarkana, Texas. John Smith was killed, and four other employees were injured. The plant was wrecked. [Readers of The Locomotive may remember that a boiler explosion occurred in the Pullman Lumber Company's plant, at Pullman, Ark., on February 24, 1900. The present explosion is distinct from the one which we recorded in our list for February. The two plants were in sight of each other.]

(93.) — A boiler exploded, on March 30th, in Henry Kraver's distillery, on the Louisville & Nashville Railroad, near Henderson, Ky. Fireman Michael Roland was fatally injured, and died a few hours later. Walter Ross was injured so badly that he may not recover. Engineer Martin Spalding and William Warren were also badly scalded. The plant was considerably damaged.

(94.) — A heating boiler exploded, on March 31st, in the Hartz & Bahnsen Company's building, at Rock Island, Ill. Augustus Lundberg was slightly injured by flying fragments of glass. The building was not badly damaged.

April, 1900.

(95.) — On April 2d a boiler exploded in the G. O. Williams Lumber Co.'s brickyard, at Atlanta, Ga. John M. Smith, Walter Evans, and James Perkins were killed, and Charles Hardeman, Thomas Glass, Rufus Glass, Samuel Banks, and Edward Hardeman were seriously injured. The building in which the boiler stood was badly wrecked.

(96.) — A boiler exploded, on April 2d, in R. E. Cogbill's sawmill, situated some two or three miles from Boydton, Va. Joseph Webb was severely injured. We have seen no estimate of the property loss.

(97.) — On April 3d a boiler exploded in a sawmill belonging to Charles Burr, at Balls Mills, near Williamsport, Pa. Engineer John Engle was badly scalded, and John Douty was also injured to a lesser extent.

(98.) — A locomotive boiler exploded, on April 4th, in the Delaware, Lackawanna & Western railroad yards, at Binghamton, N. Y. Engineer Charles Veeder and Fireman George Ritzheimer received slight injuries.

(99.) — A boiler exploded, on April 4th, in the Ohio Stave Co.'s mill, at Millersburg, a small station on the Lake Shore railroad, about nine miles from Goshen, Ind. George Morris was slightly injured. The property loss was about $5,000.

(100.) — A boiler exploded, on April 6th, in Ham & Co.'s fertilizer works, at Washington Court House, Ohio. One side of the large building was torn out, and débris was scattered in every direction. Mr. Ham and an employee by the name of Miller were injured.

(101.) — On April 7th a boiler exploded in McQuillan's flouring mill, at Harriston, Ont., wrecking the boiler house and doing considerable damage to the mill. One man was slightly scalded.

(102.) — A safety boiler exploded, on April 7th, in the power house of the Watertown Paper Co., at Watertown, N. Y. There were only three men in the building at the time, and these escaped injury.

(103.) — A boiler exploded, on April 7th, in E. V. Walls' sawmill, situated about four miles south of Grant City, Mo. Herbert Walls, a son of the proprietor, was instantly killed, and the mill was totally wrecked.

(104.) — A boiler exploded, on April 10th, in the round house of the Grand Trunk Railway, at Niagara Falls, Ont. The property loss is estimated at $3,000. We have not learned of any personal injuries.

(105.)—On April 10th a boiler exploded in Frederick Hyde's sawmill, at Sanborn, near Lockport, N. Y. Ralph Dodge was severely, and probably fatally, injured, and a son of Mr. Hyde was severely scalded. Six other men received minor injuries. The building in which the boiler stood was wrecked, and the roof was thrown thirty feet into the air.

(106.)—On April 10th a boiler exploded in R. Tuttle & Co.'s flouring mills, at Columbia City, Ind. Fireman Henry Landon and Oliver Young, a teamster, were killed. The plant, which was valued at $35,000, was totally wrecked.

(107.)—A boiler exploded, on April 11th, on the German tank steamer *Cutheil*, Captain Shroeder, while she was anchored near Regla Wharf, at Havana, Cuba. Two of the crew were badly hurt.

(108.)—A boiler exploded, on April 11th, in the Louisville Bottle Manufacturing Co.'s plant, at Louisville, Ky. Clarence McNally was instantly killed, and David Wing was injured very seriously and may not recover. The boiler house was entirely demolished and strewn about over a radius of one hundred yards.

(109.)—A boiler exploded, on April 12th, in John S. Reiter's sawmill, at Sylvester, near Big Rapids, Mich. David Zimmerman and James Moffat were killed. Frank Maxwell and Oscar Zimmerman were injured, and the mill was completely demolished, parts of it being thrown to a distance of thirty rods.

(110.)—Two boilers exploded, on April 13th, in the furnace department of the Riverside Plant of the National Tube Co., at Wheeling, W. Va. Richard K. Satterfield was injured so badly that he died about three weeks later. George Spindle, Wm. Hile, A. F. Hodgkiss, Thomas Burk, Wm. Frazier, James Mitchell, Julius Schellenberger, W. M. Tehschabach, Alexander Zarohur, S. E. Mason, John Weinochi, George Borswich, George Frazier, Walter O'Neil, and a man whose name we have not learned, were also injured. The buildings composing the steel works and water works were destroyed, and three thousand workmen were thrown out of employment for a time. It is said that the property loss was $50,000.

(111.)—On April 18th a boiler exploded in Reuben Short's sawmill, on Tavern Creek, three miles south of Iberia, Mo. Elmer Short and W. R. Short were badly injured.

(112.)—The boiler of locomotive No. 102, of the Boston & Albany railroad, exploded, on April 18th, while going east on the West Shore tracks at Canastota, near Syracuse, N. Y. Fireman Julius Kampfer was badly scalded and bruised. The explosion consisted in the failure of the crown sheet.

(113.)—Walter Cogswell was scalded to death, on April 18th, by the explosion of a boiler on Atlantic Avenue, Boston, Mass.

(114.)—A portable boiler belonging to Drake & Stratton exploded, on April 25th, at Rankin, Pa. Joseph Wright and Siley Sarb were injured so badly that they will probably die. Julius Siedle, John Flaherty, and Genneron Faraso were badly injured. Eight men also received lesser injuries.

(115.)—A boiler exploded, on April 26th, in Tupper Bros'. creamery at Eaton, N. Y. Paul Stillman was badly burned about the face, neck, and arms.

(116.)—Edward Wheeler and Edward Leonard were severely injured, on April 27th, by the explosion of a boiler at the Wheeler lime beds, near Huntington, Ind.

(117.) — On April 27th a boiler exploded in W. K. Noble's hop pole factory, at Convoy, near Van Wert, O. Nobody was in the factory at the time, and hence there are no personal injuries to record. The entire plant was destroyed, and its site is marked only by a hole in the ground. The property loss was about $5,000.

(118.) — A hot water boiler exploded, on April 29th, in the Smith flats, at Syracuse, N. Y. The basement of the building, and some of the apartments on the lower floor, were badly damaged. Nobody was injured.

(119.) — Two boilers, belonging to J. N. Bray & Co., exploded, on April 30th, at Cecil, near Tifton, Ga. Luther Clair, Hugh Chambers, Augustus Nicholson, John Cashen, and Wm. Houston were killed. J. C. Raines, Sebastian Allen, Wesley McPhaul, Frank Sims, Z. T. Agee, and Octavius Smith were badly hurt. The mill house and machinery were badly wrecked, and the property loss was said to be between $10,000 and $15,000.

Inspectors' Report.

JULY, 1900.

During this month our inspectors made 10,068 inspection trips, visited 19,046 boilers, inspected 10,090 both internally and externally, and subjected 867 to hydrostatic pressure. The whole number of defects reported reached 16,705, of which 885 were considered dangerous; 55 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,364	52
Cases of incrustation and scale,	3,319	70
Cases of internal grooving,	196	12
Cases of internal corrosion,	1,462	43
Cases of external corrosion,	870	37
Broken and loose braces and stays,	193	59
Settings defective,	504	37
Furnaces out of shape,	540	27
Fractured plates,	330	49
Burned plates,	425	63
Blistered plates,	183	8
Cases of defective riveting,	2,002	48
Defective heads,	108	17
Serious leakage around tube ends,	2,452	93
Serious leakage at seams,	420	19
Defective water-gauges,	258	52
Defective blow-offs,	210	65
Cases of deficiency of water,	16	9
Safety-valves overloaded,	66	23
Safety-valves defective in construction,	85	22
Pressure-gauges defective,	637	36
Boilers without pressure-gauges,	36	36
Unclassified defects,	1,029	8
Total,	16,705	885

The Locomotive.

HARTFORD, SEPTEMBER 15, 1900.

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

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WE desire to acknowledge the twenty-fifth report (for the year ending March 31, 1900) of the Märkischer Verein zur Prüfung und Ueberwachung von Dampfkesseln, of Frankfurt, Germany.

IN the July issue of THE LOCOMOTIVE we stated that the inspectors of the Hartford Steam Boiler Inspection and Insurance Company made 9,120 inspection trips during the month of May, 1900. This is incorrect owing to a clerical error in the returns as received at this office. The true number was 10,120.

The "Lake Serpent."

A variation on the sea-serpent story appeared a few weeks ago in the *Boston Globe.* We reprint it below, for the benefit of those who may be interested.

The *Otetiani* (says the account), a sidewheel steamboat belonging to the Seneca Lake Steam Navigation Company, officered by Capt. Carleton C. Herendeen and pilot Frederick Rose, was between Dresden and Willard, near Geneva, N. Y., a few minutes before seven o'clock, when pilot Rose saw, about 400 yards ahead, what appeared to him to be an overturned boat. He called Capt. Herendeen, who examined the object with the glass. It appeared to be about 25 feet long, with a very sharp bow and long, narrow stern. Amidships it was much broader and higher than at either end. A number of passengers gathered around the pilot-house and discussed the supposed boat. Among them was President F. A. Malette of the board of public works, editor and publisher of the *Saturday Review;* Commissioner of Public Works Albert L. Fowler, and D. W. Hallenbeck, Police Commissioner George C. Schell, Fred. S. Bronson, manager of the Geneva telephone company, and Charles E. Coon, a commercial traveler for a Philadelphia house, all residents of Geneva, and Prof. George R. Elwood of Guelph, Ont., a geologist who has been studying the country around the lake. When Capt. Herendeen completed his examination of the object, the pilot signaled the engineer to slow down. The steamboat approached to within 100 yards and preparations were made to lower a boat. As the davits were swung outward the supposed upturned boat turned and began to move away. "Full speed ahead," shouted the captain. The object was moving slowly and the steamboat gained on it rapidly. The object again turned, this time toward the boat, raised a head, looked in the direction of the boat and opened a mouth, displaying two rows of sharp white teeth. The captain said that he would ram the creature, wound it, and take it alive if possible. Otherwise he would kill it and either take it aboard or tow it to Geneva. The boat was turned so that the creature would be approached from the side. The deck was crowded with passengers. These the captain ordered amidships, in order to avoid any accident should the creature attempt to come aboard after the attack was begun. The captain cautioned everybody to get a life-preserver and keep cool, because, he said, he did not know what would happen when the boat struck the monster. Some of the women, who were in tears, retired to the cabin; the others showed as much interest and excitement in the chase as the men. The boat fell away some distance and turned to make the attempt to ram the creature. The captain signaled full speed ahead, and in a moment the *Otetiani* was under way. Every eye on deck was fixed on the monster, and hardly a person was breathing normally. While the steamboat was yet some distance from it, the monster again looked at the boat, sank out of sight, and the boat passed over the spot where it had been. Some of the passengers declared that they could see the dark outline of the creature's body. The steamer prepared to continue her course to this city. "There it is," suddenly exclaimed one of the women passengers who was standing on the after deck; "the thing has come up!" The passengers, with the captain in advance, ran to the stern of the vessel, and within 50 yards the long, lithe body of the monster was lying on the surface, in practically the same position as when discovered. The captain ordered the boat put about and the attack was renewed. Instead of trying to strike the creature full in the side, the boat was maneuvered so that the starboard paddle-wheel would strike it about midway between its head and tail. The boat went ahead under full steam, the monster paid no attention to it, and with a thud which all on board heard and felt, the steamboat struck the spot at which it was aimed. The force of the impact threw every one off his feet, and the vessel careened violently to port, but quickly righted. For an instant, in which everybody wondered what would happen next, there was not a sound on board except the engine. Then the men cheered and some of the more timid of the women, recovering from their fright, screamed. Lying close beside the steamer, with a gaping wound in his side, was the monster. It raised its head, gave what sounded like a gasp, and lay quiet. Its spinal column had been broken and it was dead. The lifeboats were quickly lowered and rowed to its side, and with the aid of boathooks ropes were passed around the carcass. Other ropes which were fastened on board the steamer were then passed down and attached to the improvised swings. All helped to haul the monster in. The carcass was clear of the water when the rope near the tail slipped off, and the tail dropped into the water. The weight on the other rope then became so great that it began to slip through the hands of those holding it. They were compelled to let go or go overboard. As soon as the body struck the water it began to sink and disappeared. At the point where the carcass was lost the lake is over 600 feet deep, and, as is well known, bodies of persons who have been drowned in that part of the lake never again rise or are recovered. When the steamer arrived in this city shortly before midnight the stories told of the monster were about the same, although in some the imagination had rather free play, and the length of the monster was estimated at from 25 to 90 feet. The most careful and perhaps the most trustworthy account was given by Prof. George R. Elwood, who was in one of the lifeboats that made a rope fast around the carcass. "Do you know what a clidastes was?" the professor asked. "Well, that is exactly what the creature we saw last night seemed to be. It was about 25 feet long, with a long tail, which tapered until within about five feet of the end, when it broadened out and looked much like a whale. The creature weighed about 1,000 pounds. Its head was perhaps four feet long and triangular in shape. Its mouth was very long, and was armed with two rows of triangular white teeth as sharp as those of a shark, but in shape more like those of the sperm whale. Its body was covered with a horny substance, which was as much like the carapace of a terrapin as anything else of which I know. This horny substance was brown in color, and of a greenish tinge. The belly of the creature, which I saw after the rope slipped and the carcass was going down, was cream-white. The eyes were round, like those of a fish, and it did not wink."

This story is pretty evidently a hoax, but it is told in such detail that we took the trouble to write to several of the gentlemen mentioned in it. The uniform reply was, that there is no word of truth in the whole thing. Still, the story is perhaps worth preserving, as a masterpiece of circumstantial mendacity.

We note, in the issue of the *Journal of the Franklin Institute* for August, an interesting article by Dr. William H. Greene, entitled "Prismatic Lighting for the Illumination of Dark Interiors." Up to a few years ago, architects had no idea of using any kind of glass in windows except the ordinary, flat kind with which we are all so familiar. This gives entire satisfaction when the light can enter from the outside in a horizontal direction, or nearly so; but when the window is at the bottom of a tall shaft (for example), so that the only light available for the illumination of the room is that which comes vertically down the shaft, the ordinary sheet of plane glass is not all that could be desired. "Prismatic glass" was devised in order to make the light turn a corner — in other words, to deflect it from a vertical direction to a horizontal one, or to bend its course in some other analogous way. Most of the glass that is used for this purpose is flat on one side, and has prismatic ridges on the other side, so designed as to turn the incident light through the desired angle, and cause it to enter the room in the proper direction. Sometimes, however, the ridges are upon both sides of the glass, as this construction possess certain advantages which may warrant the extra expense. Those wishing more detailed information concerning prismatic glass will find Dr. Greene's article of great interest.

Twentieth Century Energy.

Beyond doubt coal exerts the widest and most important influence on humanity. Coal constructs and drives the steamship, locomotive, and electric car, lights the gas flame and the electric lamp, turns the wheels of industry, and makes habitable the factory, the office, and the home. It brings to us a great store of energy from the sunshine of former ages. Unfortunately, our methods of using this product of Nature's laboratory are so wasteful that the greater part of the stored energy escapes without performing any useful work. The supply of coal is limited, how limited we do not know; but a just regard for people yet to be, bids us use with reasonable care this substance, for which science has thus far discovered no substitute.

The losses that occur in the application of the energy of coal to our purposes result partly from a direct escape of heat during the process of combustion, but often to a greater degree when the heat is changed to motion, electricity, or light. In house stoves, furnaces, hot water and steam heaters it is variously estimated that from one-half to three-fourths of the energy of the coal burned escapes with the flue gases. The steam boilers of large power plants are more efficient than domestic heating devices; and the chimneys of such plants usually receive from one-fifth to one-third of the energy of the coal put into their furnaces. In the very general use of steam for the production of mechanical motion much energy is lost. The steam contains from one-half to three-fourths of the heat developed by the combustion of the coal used; but the steam engine is able to deliver as mechanical power only from five to fifteen hundredths of the coal's energy. The generation of electricity on a commercial scale is at present entirely dependent on mechanical power, and the dynamo is a very efficient machine, delivering usually in the form of electric current as much as nine-tenths of the energy supplied to it. Unfortunately, however, the steam engine has been the only prime mover available for the general operation of dynamos, and the electricity delivered has been seldom more than one-tenth of the energy of the coal burned.

The production of gas from coal is a process of rather low efficiency. What is known as coal-gas contains about one-fourth of the heating power of the coal from which it is generated; but along with the gas, coke is produced to the amount of five or six tenths of the coal's total heating capacity. Where the coke can be used or sold to advantage, therefore, the gas and coke together are a fairly efficient product. Nowadays water-gas is largely displacing coal-gas, because its production is cheaper. This water-gas has from five to six tenths of the energy in the coal consumed for its output; but there is no coke remaining to raise the total efficiency. Coal-gas is suitable for either light, heat, or power production, without additions of other substances; but water-gas is available for heat and power only, except when treated with mineral oils.

The gas-engine, whose development has now reached a stage that renders it of great importance as a prime mover, shows a marked improvement over the steam engine in the matter of efficiency. For example, the best steam engines deliver in mechanical work only about fourteen-hundredths of the heat energy in the steam entering them, while fair gas engines convert into motion two-tenths of the heat energy of the gas they consume. This higher efficiency of the gas-engine is more than offset, for plants of fairly large size, not only by the difference in contained energy between coal and the coal-gas or water-gas it produces, but especially by the prices at which these gases are commonly sold. At one dollar per thousand feet, coal or water-gas costs as much for power production as would coal at fourteen dollars per ton in a good steam plant. In small steam-power plants the consumption of coal is relatively very large, and this, together with the small amount of labor necessary for the care of a gas-engine, gives the latter a place where only a little power is wanted, in spite of the high price of fuel in the gaseous form.

For general heating purposes coal and water-gas make a poorer showing than coal. At one dollar per thousand feet, the cost for a given quantity of contained heat is about equal to that of good coal at forty dollars per ton. As more than one-half of the heat energy of coal usually escapes up the chimney in house-heating, and as there is a smaller loss of heat in this way when gas is the fuel, the probable cost of general gas heat is that of coal at from thirty to twenty dollars per ton, when gas costs one dollar per thousand feet. For many special purposes, where a small amount of heat is wanted during a short time, gas is, no doubt, the cheaper fuel, because it can maintain a very small fire, which can be started or extinguished immediately.

For a given illumination, the amounts of energy consumed at the lamp differ greatly between gas and electric service. The ordinary gas flame consumes about sixteen times as much energy to produce the same amount of light as does an incandescent electric lamp, and about sixty times as much as produces an equal illumination in the electric arc. In spite of the low efficiency of the gas-engine, when coupled to a dynamo, the gas used to drive it for the production of electricity yields three times as much light in incandescent lamps and about eleven times as much in arc lamps as the same amount of gas would give off if burned directly at gas jets. The electric heater is one of the very few devices for the transformation of energy that have a perfect efficiency, in that it sends out as heat the equivalent of all the electricity consumed by it. Notwithstanding this perfect efficiency, it can never play an important part in general heating, so long as the production of electricity depends upon heat-driven prime movers of low efficiency. But little more than one-tenth the energy of coal can be delivered to the electric heater, while coal-gas brings one-quarter and water-gas about one-half to the gas stove. While the gas-heater is not as efficient, considering the losses by imperfect combustion and escape of heat through the chimney, as the electric type, it still renders useful a much larger part of the heat-energy of coal. All of the conditions and operations that require heat, mechanical energy, electricity, and light thus rest on coal for their production. Heat-energy from coal is more economically applied to power production, and in many cases to heating purposes, through the medium of gas, but coal and water gas contain so small a part of the energy in coal, and are sold at such prices, that their advantages over steam at the engine, or over coal at the heater, are largely vitiated. Electricity shows great economy over gas for illumination: it is much cheaper for a given amount of light to use gas in the gas-engine to drive a dynamo and thus supply electric lamps.

A gas produced at a moderate cost, and charged with nearly all the heat-energy from its coal, would materially reduce the coal consumption and cost of heating, power production, and electric lighting. Investigations looking to the cheap production of such a gas have for some years been in progress, and at recent dates the desired results have been obtained in both Europe and America. This comparatively new product, known as "producer" or fuel gas, contains fully eight-tenths of the heat energy of the coal from which it is made, and, moreover, this coal may be of the cheapest grade. This producer gas can be economically made in even small amounts, such as might be required for a private power or heating plant. It is also adapted for distribution on an extensive scale. The expense of the plant for the production of fuel-gas is moderate, being about the same for a small equipment as that of a first-class steam boiler plant of equivalent power capacity. As the gas-producer shows an efficiency that is rarely reached in actual practice by the steam-boiler, and as the gas-engine requires only about two-thirds of the heat-energy in gas that the steam-engine does of steam for a given amount of mechanical work, a power plant or factory can save at least one-third of the coal necessary in a steam-plant by the use of a producer and gas-engine. Moreover, the gas-plant is at a decided advantage as to its ability to begin power production at the maximum rate or stop entirely, on a minute's notice, which cannot be done with the steam boiler and engine. In plants for the supply of electric energy to the public, for which the fuel consumed is a very important item, the properties of the gas producer and engine make them of especial value, and their use in electric stations should reduce the price for electric current. In large, private heating-plants, the gas-producer effects a saving over the ordinary steam or hot water equipment, though the gain is not so marked as where power is required. When used in a large plant for general heating, the producer-gas will be burned in a suitable steam or hot-water heater, and the saving will result largely from the cheap grade of coal used. The low heating power of coal and water-gases, compared with the energy of their coals, the expensive plants necessary for the production of these gases, and their preparation for purposes of illumination, have all tended to make their general use for heating purposes impracticable. Producer or fuel gas, containing four-fifths of the energy from the cheapest grades of coal, instead of only one-quarter to one-half of the heating power from the more expensive grades, as do the illuminating gases, is available for the general supply of heat in towns and cities, at a rate comparing favorably with coal.

One ton of anthracite buckwheat coal in the gas-producer yields on an average from 160,000 to 170,000 cubic feet of gas, which contains fully eight-tenths of the heating power of the coal. The total cost of manufacture for this gas on a large scale is certainly not more than three cents per thousand feet; doubling this amount to cover distribution, charges, and profit, would give the fuel-gas a selling price of six cents per thousand feet. Fuel-gas has about one-fifth of the heating energy per cubic foot that is contained by the coal and water-gases, and at six cents per thousand cubic feet would be equivalent in cost of heating capacity to either of these gases at thirty cents per thousand feet, or to coal at about twelve dollars per ton. Gas in house-heaters will give from two to three times as much of its contained heat-energy in useful effect as coal commonly gives, and would really equal coal at from four to six dollars per ton at the rate mentioned. The great economy of fuel to be effected by the reduction of coal to gas before its general use for heat and power, and the substitution of glow lamps for the open flame, seem certain to make gas and electricity the forms of energy which will prevail in the twentieth century.— ALTON D. ADAMS, in the *Scientific American.*

A New Era in American Ships.

American ship building has passed through many discouraging periods of evolution, and the height of its remarkable development in the middle half of the present century can hardly be measured by the period of stagnation that has fallen upon it for the past two decades. Of this latter we have had enough, and no fruits of our war in Cuba and the Orient are better appreciated as a whole than the new interests that have been stimulated in ship-building circles. A part of the present activity in the shipping interest is due to the general prosperity of the country and to the withdrawal of some ships from the paths of commerce for war purposes; but, after due allowances are made for these, the fact remains that the American ship-building industry is entering upon a new era that may carry it to the high-water mark of half a century ago. Abundant and indubitable facts point toward the promising future of American ship building of war vessels, ocean steamers, yachts, and coasting vessels.

There are certain tendencies in this new movement that show the changes in the commercial needs of the country. The day of the small vessel has nearly passed, and those from 4,000 tons up are the universal favorites. A vessel of this size can be handled with the same number of men as required for one of half the tonnage, and its earning capacity is thereby materially increased. Hand in hand with the growth of larger vessels of enormous carrying capacity will go the reduction in speed. The fast vessels, which are built primarily to carry passengers and the mails, and incidentally to break records, are not profitable investments. They do not pay, whether flying under the American or British flag, unless heavily subsidized. There is sentiment in the thought of owning these handsome grayhounds of the ocean, but they are costly luxuries and their number will be limited. On the Pacific, where trade with the Orient is to develop, the new vessels will all be of large size and immense carrying capacity, and of comparatively slow speed. It is promised that over twenty-five of these large steamers will be engaged in the Oriental trade with our Pacific coast within the next five years. Every shipyard on the Atlantic and Pacific to-day is busy, and it is impossible to place new contracts for a vessel anywhere in this country. Within the next six months a large fleet of ocean steamers, coasters, wooden ships, and war ships will be launched.

This is not a matter of guesswork or of prophecy, but is an actual fact, based on the returns of the different ship-building plants and the investigations of the Commissioner of Navigation. Our own new navy furnishes considerable work for the plants, and the agitation for keeping one ship in the process of construction, in each of the important navy yards all the time, is likely to meet with a favorable outcome. There are fifty war vessels, of an aggregate displacement of 140,813 tons, in the course of construction or under contract in the various seacoast shipyards, and, besides these, Congress has authorized six other war ships, of 76,500 tons displacement, the contracts for which have not yet been let. These war vessels run all the way from the small torpedo boats up to the magnificent battle ships of the *Kentucky* and *Kearsarge* type. The growing needs of our navy tend to stimulate competition in the construction of vessels of every type, for, after the ship-building plant is once thoroughly equipped, it can accept orders for widely different types of vessels. It may be said that our new navy consequently gave the first incentive to the present movement in American ship building and induced builders to equip large and expensive plants at favorable points along the two coasts. Otherwise the present demand for American ships could not have been met in even a partially successful way. On the Pacific coast, the large steamers in the course of construction represent an immense tonnage in the aggregate. For the Hawaiian trade alone there are four steamers on the stocks with an aggregate gross tonnage of 26,500. The Pacific Mail Steamship Company has two large steamers partly finished, and The International Navigation Company has two more, while the Oceanic Steamship Company (Spreckles) have three building. On the Atlantic coast there are three large steamers in the yards for the Cuban trade. These ten steamers represent over 81,000 gross tons, and they do not include the new coasting traders.

There are over forty-five vessels of the latter class in course of construction or under contract in this country, and as their gross total tonnage is over 76,000, their average size must be decidedly larger than the average coaster built in former days. In this list are included some small vessels of not much more than local importance, and their small size increases the average capacity for the larger number of big ships. The large four- and five-masted sailing vessels are in great demand, and one at least is being built of 5,500 tons and with six masts.

The rates for ocean freight are higher by 25 per cent. to-day than they were a year ago, and the cost of construction has advanced proportionately because of the higher cost of lumber and structural iron and steel. These two offsetting factors do not seem to influence the course of the trade to any appreciable extent, and, from present indications, we may look for new fleets of American ships on the water by next summer, while others will take their places on the stocks of a score of different Atlantic and Pacific shipyards. Those who have the interest and glory of the American flag on the high seas at heart will find these harbingers for a new era of American ship building good reasons for being satisfied at the course of history in the past two years. — GEORGE E. WALSH, in *Science and Industry*.

WE have received, from Mr. A. Lincoln Hyde, a copy of his pamphlet on *The Inidikil System*, which is a system of decimal weights and measures proposed by him for the English-speaking people. He states that "the only just opposition to the metric system has come from the machine shop"; and he proposes a system of weights and measures which is based upon the same ideas as the metric system, and differs from it chiefly in taking the *inch* as the unit of length, instead of the meter. The unit of mass is the mass of a cubic inch of water. Mr. Hyde's system is thoroughly logical and consistent, and his pamphlet is a suggestive contribution to metrological literature. (See also the July, 1900, issue of the *Journal* of the Association of Engineering Societies, published at 257 South Fourth street, Philadelphia; price, 30 cents.)

The Locomotive.

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Boiler Explosion in an Ice Factory.

Our illustrations, this month, relate to a boiler explosion which occurred recently in a big ice-manufacturing plant in Texas. Unfortunately they do not convey to the eye a very clear idea of the extent of the damage that was done, but they are the best that we have been able to obtain.

The plant where the explosion occurred was a large one, and occupied an entire block. Like most other large plants of its kind, it included a cold storage department, and a department for the manufacture of ice. The cold storage portion was not seriously damaged as the direct result of the explosion, though there was undoubtedly a

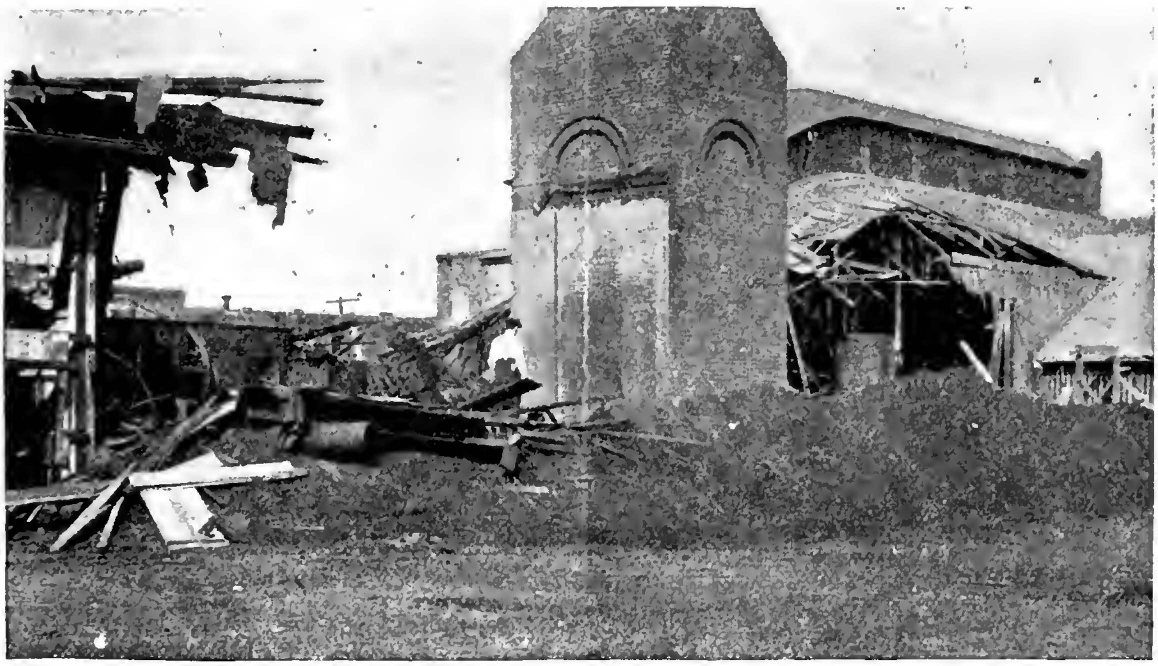

Fig. 1. — General View of the Ruins.

considerable indirect loss in the perishable merchandise that was stored there, when the temperature of the building rose above the point at which decay thereof could begin. The portion of the plant which was concerned in the manufacture of ice, however, was badly wrecked, and the property loss was undoubtedly from $25,000 to $30,000. Two men were also killed, and four others were more or less seriously injured. The ruins took fire, but the flames were soon controlled by the fire department.

The plant was operated by six 60-inch horizontal tubular boilers, 18 feet long, which were set in two batteries of three boilers each, one of these batteries lying on either side of the brick stack which appears in our illustrations. Boilers Nos. 1 and 2 of the south battery exploded, both giving way at exactly the same point. They were of the single sheet type, each having one sheet on the bottom and three sheets on the top. The fracture started at or just above the longitudinal seams and extended the entire length of each boiler, from the front to the rear head. The upper or top shell plates of both boilers were thrown entirely out of the grounds on which the boilers stood, and lodged on the railroad tracks, some 200 feet from their original positions.

According to one of our inspectors, who visited the place shortly after the explosion, the shell plates showed a muddy cast, and there were no indications of low water. Above the water line, these plates were badly corroded in both boilers, so that their original thickness of $\frac{5}{16}$ of an inch had wasted away until there were considerable

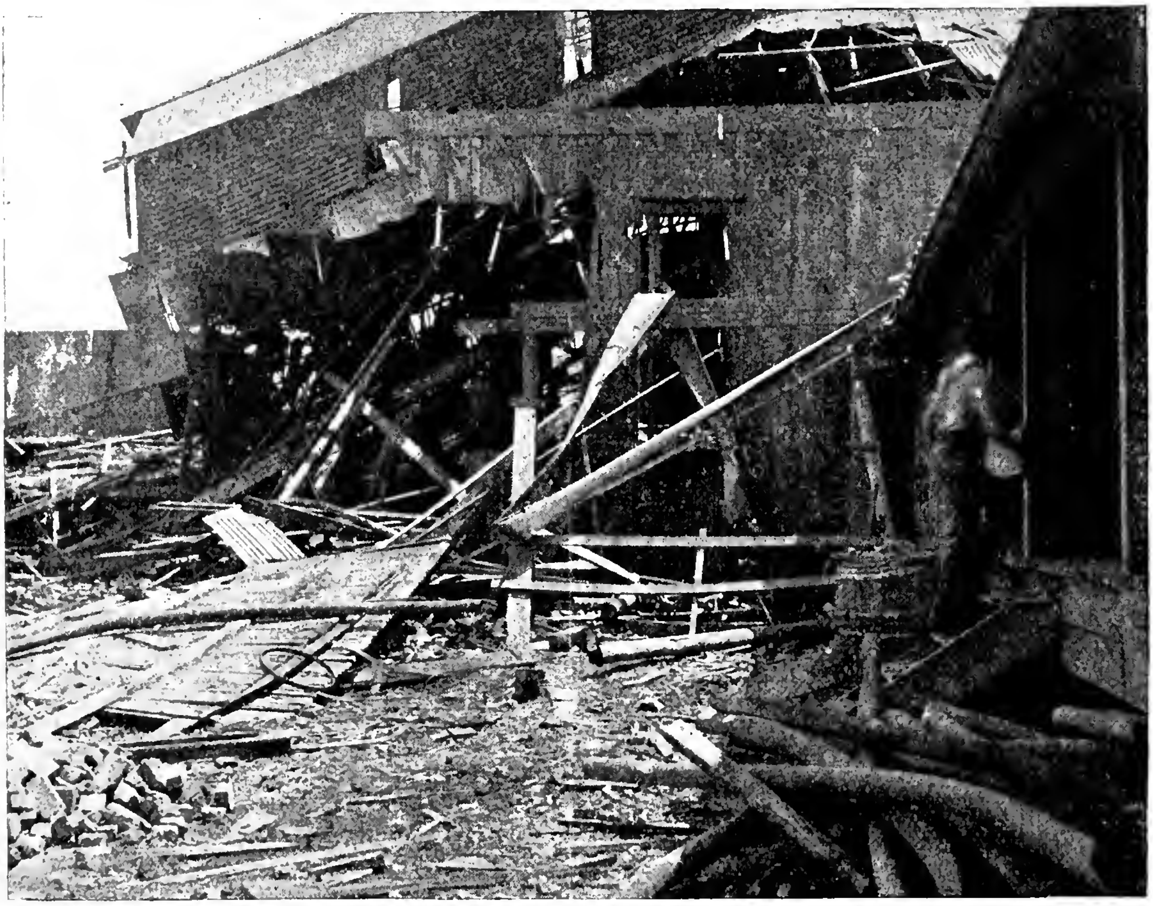

FIG. 2. — GENERAL VIEW OF THE RUINS.

areas where the thickness was only $\frac{1}{8}$ of an inch. In some places the corrosive action had been still more severe, so that hardly more than $\frac{1}{16}$ of an inch of metal was left. We cannot say positively that this corrosion was the cause of the explosion, because we were unable to make a very thorough examination of the fragments; but inasmuch as the line of fracture was certainly *near* the corroded areas, we suspect that the wasting of the plates was responsible for it in some measure, at least.

This particular explosion was selected for publication largely because it affords such a fine though expensive illustration of the emptiness of a certain argument against boiler insurance which is sometimes urged. The plant in question was practically the only large one of any sort, in that vicinity, which was not insured with us. Three of our representatives had called on the manager of this plant repeatedly, urging him to insure his boilers, and he had persistently refused to do so, saying, "I have a good engineer, and do not need any insurance." If the manager's decision had been in favor

Fig. 3. — Showing the Exploded Boiler.

of insurance, our inspectors would doubtless have detected the weakness and called his attention to it, with the result that the ice company would have been spared a loss of $25,000 or $30,000, to say nothing of a suit for $15,000 damages which we understand has been instituted by the heirs of one of the men who were killed.

Boiler Explosions.

May, 1900.

(120.) — One of the boilers of the Booth-Kelly Lumber company exploded, May 2d, at Saginaw, near Cottage Grove, Ore. Otto Frederickson was instantly killed, and Otto Anlauf and H. Rudolph were seriously injured. A new boiler was being installed, to take the place of the one which has exploded; and steam was kept up on the old one merely to aid in getting its successor into position.

(121.) — On May 3d a boiler exploded in the factory of Joseph Stern & Son, wholesale butchers, on West Fortieth street, New York. Thomas McGuire is missing, and as he was seen near the boilers just before the explosion, he was no doubt killed and buried beneath the wreckage. Henry Maninger was badly scalded. The three story brick building in which the boiler stood was about half demolished.

(122.) — On May 4th a boiler exploded in Hildrich & Heiller's sawmill, at Fayetteville, Tenn. The engineer was fatally injured, and several other men were injured to a lesser extent.

(123.) — On May 4th a boiler exploded in the Pacific Power company's plant, on Stephenson street, San Francisco, Cal. Fireman James H. Shea was scalded so badly that he died within an hour.

(124.) — A boiler exploded, on May 4th, in Arne's sawmill, at Prohibition, near Kimbolton, Ohio. Fireman Jasper Peoples was scalded so badly that he may die. Simeon Murphy, George Mercer, Joseph Huffman, and a man named Ames, were also scalded and bruised.

(125.) — A boiler used to operate a well-drilling machine exploded, on May 4th, on the Good-Hopper farm, near Federal, Pa., where the owners of the boiler, Messrs. Crane & Craig, were drilling a well for the Trust Coal company. Nobody was injured.

(126.) — On May 8th a boiler exploded in Smith & Co.'s feed mill, at West Cornwall, Conn. The small building in which it stood was blown to atoms, but nobody was injured.

(127.) — On May 10th a boiler exploded on the tug *Pioneer*, of Philadelphia, while she was towing barges off Nuevitas, Cuba. The *Pioneer's* crew were rescued by the crew of the barges.

(128.) — A boiler exploded, on May 10th, in Jonas Saner's grist mill, back of Raven Rock, about eight miles from St. Marys, W. Va. Samuel Bennett had his skull crushed, and will die. Jonas Saner, Fred Saner, and John Bennett were also badly scalded and otherwise injured. The building was wrecked.

(129.) — On May 11th a boiler exploded in D. L. Lockhart's sawmill, at Lockhart, on the F., C. & P. railroad, about eight miles from Orlando, Fla. The mill, which was three hundred feet long and two stories high, was completely wrecked, but only one of the thirty men who were about the place was seriously injured. Christopher Beck was caught under one corner of the falling roof, and three of his ribs were fractured.

(130.) — A boiler belonging to the Cook Transportation company exploded, on May 12th, at Whitehall, Washington county, N. Y. Louis Jandreau and Horace A. Stevens were severely injured, but will recover. The building in which the boiler stood was blown to atoms, and the boiler was hurled over the machine shop, falling at a point more than 100 feet from its initial position.

(131.) — A small boiler used for heating water exploded, on May 13th, in the basement of the Hotel Fensmere, Boston, Mass. Nobody was hurt, and the damage to property will not exceed $250.

(132.) — The boiler of the locomotive attached to south bound passenger train No. 21, of the Illinois Central railroad, exploded, on May 17th, at Dubois, near Ashley, Ill. Charles Fricke and Thomas Wright were killed outright, and Fred Crawford, John Hampton, and Samuel Ascoff were fatally injured. Henry Holtall, Frank Johnson, Charles Novack, and William Scherer were also scalded. The locomotive was completely demolished.

(133.) — A boiler exploded, on May 21st, in John Ryan's stone quarry, at Whitehouse, Ohio. The south side of the building in which it stood was demolished. Nobody was injured.

(134.)—A hot-water heating boiler exploded, on May 21st, in the basement of the building occupied by L. M. Smith & Bro., on Drexel and Oakwood boulevards, Chicago, Ill. Some damage was done to the basement, but nobody was hurt.

(135.)—A boiler exploded, on May 24th, in Capt. James A. McFerrin's sawmill, at Burleson, ten miles west of Covington, Tenn. Capt. McFerrin, James York, Samuel Burkett, Moses Hunley, and one other man were killed. The mill was completely wrecked. The body of one man was driven through the walls of a cotton gin, some distance away.

(136.)—On May 29th the boiler of locomotive No. 1, of the Baltimore & Sparrows Point railroad, exploded between Sollers and Turner's stations, near Baltimore, Md. Engineer William H. Faulds was killed, and Fireman August Heise was seriously injured. The locomotive was blown to pieces.

(137.)—On May 31st a boiler exploded in the Anchor mills, at Mt. Gilead, near Cincinnati, Ohio. Augustus Stevens was killed outright, and Fireman James Carter was fatally injured. The boiler-house was blown to pieces.

June, 1900.

(138.)—A boiler exploded, on June 1st, at the Lester Coal and Transfer Company's plant, at Fort Smith, Ark. The boiler was internally fired, and as nearly as we can gather from the somewhat meager information received, the explosion consisted in a rupture of the water leg, on the inside surface, below the grates. It does not appear that anybody was hurt.

(139.)—A boiler explosion occurred, on June 1st, on the steamship *Bolivar*, as she was preparing to sail from Key West, Fla. Our accounts say that the explosion "almost lifted the vessel out of the water," but they do not give technical particulars. Chief Engineer John Thompson, Fireman Pablo Feal, and a boy named Willie Hancock, were scalded so badly that they died shortly afterward.

(140.)—On June 4th a small boiler exploded in J. J. Wells' ice-cream house, at Athens, Mich. The explosion was apparently due to corrosion of the boiler. Mr. Wells was badly burned, but will recover.

(141.)—A boiler exploded, on June 4th, in the Dominion Iron and Steel Company's plant, at the George's River quarries, near Sydney, Cape Breton. Engineer Parry was killed.

(142.)—On June 8th, two boilers exploded in Anderson & Klein's distillery at Anderson, a station on the L., St. L. & H. railway, a few miles from Cloverport, Ky. The greater portion of the mill was destroyed and the property loss was large, though we have seen no estimate of its exact amount. The plant had recently been fitted out with new machinery, and everything was supposed to be in good order. Thomas Parley was killed.

(143.)—A small boiler exploded, on June 9th, in O. T. Roberts' tinsmith shop, at Southeast Allentown, Pa. The building was considerably damaged, but nobody was hurt.

(144.)—On June 9th a boiler exploded in Kay's Ice Factory, at West Point, Miss., completely demolishing the building and all the machinery. The fireman, whose name we have not learned, was thrown to a distance of more than 100 feet, and received injuries from which he will die. Two other men were also badly injured. The shell of the boiler fractured from end to end, and opened out into a flat sheet. Bricks and fragments of iron were hurled a quarter of a mile.

(145.) — A boiler exploded, on June 9th, in C. F. Reed's sawmill, five miles west of Fife Lake, Grand Traverse County, Mich. Alvin J. Cole and Manford Smith were killed outright, and Charles H. Cook was injured so badly that he died shortly afterwards. Edward Price, Frank Canute, and five other men, also received injuries, from which, however, they will recover. The mill was completeiy destroyed.

(146.) — John C. Ryan, William Storey, and L. Baker were killed, on June 9th, by the explosion of a boiler in the Duke brick works at West Anniston, Ala., and George W. Wetzell, Asa Wilkerson, Hosea Williams, B. Ullman Reeves, Lee Simpson, William Knight, Charles Strong, Daniel Morgan, and Martin Huntley were seriously injured. Wilkerson and Williams cannot recover. Both heads of the boiler were blown out, and the works, which were extensive, were wrecked.

(147.) — William H. Rumple was instantly killed, on June 11th, by the explosion of a boiler in his sawmill at Howesville, near Brazil, Ind. Claude Rumple, his son, was also injured so badly that he will probably die. The other workmen were outside at the time, and escaped injury. The mill was wrecked.

(148.) — A small boiler, said to have been "attached to a freight engine," exploded, on June 11th, in the subway at Fifteenth and Callowhill Streets, Philadelphia, Pa. Engineer John Hovey was slightly injured.

(149.) — A small boiler exploded, on June 12th, in the Adams wagon works, at Paris, Ont. Andrew Stapleton received a severe scalp wound, but otherwise nobody was injured.

(150.) — A boiler exploded at Bunnel, near Daytona, Fla., on June 12th. Mr. Frank Reddick was burned so badly that he died on the following day. We have not learned further particulars.

(151.) — On June 13th a boiler exploded in the Home Steam Laundry, at Ruston, La. Fireman Larkin Risinger was the only one near the boiler at the time, and was the only person injured. He was thrown twenty yards, and was badly scalded and cut. His injuries are very serious and may prove fatal. Portions of the boiler were found 650 feet from the scene of the explosion.

(152.) — A boiler exploded on June 15th in Putnam & Gross' sawmill at Francisco, Jackson county, Ala. The mill and machinery were totally wrecked, but nobody was killed.

(153.) — On June 16th a boiler exploded on William Bender's pleasure yacht, on the Black river, near Carthage, N. Y. Fortunately nobody was injured.

(154.) — A boiler exploded on June 17th at the Commonwealth gold mine, at Pearce, near Tucson, Arizona. Fire followed, and the fifty-stamp mill was soon in flames. The fire spread to the great tanks which held the oil that was being used as fuel, and the entire plant was quickly destroyed, together with half the camp. The mill was one of the largest and best arranged in Arizona. The output of the mine in May was $140,000.

(155.) — A boiler exploded on June 18th in the Dunn & Marcia lumber mill at Cohasset, near Grand Rapids, Mich. The engineer was scalded so badly that it was thought for a time that he could not recover. At last accounts, however, he was improving rapidly.

(156.) — On June 19th a boiler exploded at Lewis Bros.' milk receiver, at Burnham Corners, near West Potsdam, N. Y.

(157.) — A boiler exploded on June 19th in J. H. Dare's sawmill, about eight miles north of Charleston, Miss. William Sheely, Samuel Word, and James Newman were scalded so badly that it is believed they cannot recover.

(158.) — A boiler exploded on June 20th in the Anniston Lumber Company's plant, at Lincoln, near Anniston, Ala. The property loss was small, and we have not learned of any personal injuries.

(159.) — On June 20th a boiler exploded in the Cleveland Paper Manufacturing Company's plant, at Newburg, Ohio. Newburg is a part of "Greater Cleveland.") The explosion demolished the power house, and seriously injured John Borrick and Andrew Woteski, though they will both recover. The property loss was large, but we have seen no estimate of its amount.

(160.) — A boiler exploded on June 20th in the town of Boston, two miles from Clarksburg, N. Y. John Flamary, Alexander Flamary, and Lawrence Mamoser, were instantly killed. Four other men who had been in the mill a few moments before escaped death by precipitate flight, as the boiler gave some premonitory evidences of its condition shortly before it burst.

(161.) — Sidney Daley was fatally injured on June 21st by the explosion of a boiler in James K. Woodman's mill at Deerfield Parade, Deerfield, N. H. He died on the following day.

(162.) — A boiler exploded on June 20th, in Riley Broyles' grist mill, near Williamstown, Ky. Mr. Broyles and his daughter Carrie, aged 15, were killed.

(163.) — On June 24th a boiler, used to operate a merry-go-round, exploded at Edwards' Grove, Rye Beach, N. Y., near Port Chester. L. Nelson, Charles Halett, and John Wood were badly injured, and it is believed that Wood will die. The injured men were all connected with the merry-go-round. None of the twenty-five women and children who were on the horses at the time were hurt. The stack and the upper part of the boiler were blown into Long Island Sound.

(164.) — On June 25th a boiler exploded in the basement of Reymer & Bros.' confectionery factory, at Pittsburg, Pa. Engineer Jacob Geyser was seriously scalded, but it is believed that he will recover. The basement was considerably damaged, and the sidewalk on Wood street was torn up.

(165.) — A boiler exploded on June 26th near Mountville, Laurens county, S. C. William P. Fuller and Marshall Owens were instantly killed, and I. Donnom Witherspoon and Evans Floyd were seriously injured.

(166.) — On June 26th a boiler exploded at the Talladega furnace, Talladega, Ala. Henry Brown was scalded to death.

(167.) — A boiler exploded on June 27th in the Ayden Lumber Company's plant, at Ayden, N. C. Two men were badly scalded and otherwise injured. The boiler house and the settings of the remaining boilers in the battery were destroyed.

(168.) — On June 29th a boiler exploded in H. F. Brockman's Model Bakery, at Jerseyville, Ill. Thomas Coats, who was doing some repairs on the boiler at the time, was badly scalded. (We have not received very full particulars of this explosion, but from what we can learn we judge that it may be regarded as one more example of the folly of trying to repair a boiler while it is under steam.)

(169.) — On June 29th a boiler exploded in Charles E. Bartholomew's Beaver Creek sawmill, on Pine River, near Durango, Col. Neil Campbell, Edward Farmer, and a man named Dalton were seriously injured, and Campbell may die. The mill and machinery were totally destroyed.

(170.) — A boiler, used for heating water, exploded on June 30th, at the almshouse at Adel, Iowa. Robert Kimrey was badly scalded, and the building was somewhat damaged.

(171.) — A boiler exploded, on June 30th, in the McQuag rice and grist mill, at Eureka, Fla. Fortunately nobody was hurt, and the property loss was not large.

(172.) — Alexander Sawyer, E. L. McKinney, and Marvin Clausen were badly scalded on June 30th by the explosion of a boiler in the Park Rapids Lumber Company's plant, at Park Rapids, Minn.

Inspectors' Report.

AUGUST, 1900.

During this month our inspectors made 9,380 inspection trips, visited 17,623 boilers, inspected 7,580 both internally and externally, and subjected 862 to hydrostatic pressure. The whole number of defects reported reached 13,624, of which 827 were considered dangerous; 32 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	997	28
Cases of incrustation and scale,	2,399	40
Cases of internal grooving,	148	3
Cases of internal corrosion,	920	31
Cases of external corrosion,	600	32
Broken and loose braces and stays,	114	17
Settings defective,	400	21
Furnaces out of shape,	334	26
Fractured plates,	354	30
Burned plates,	292	15
Blistered plates,	114	6
Cases of defective riveting,	2,129	30
Defective heads,	96	15
Serious leakage around tube ends,	2,750	321
Serious leakage at seams,	416	17
Defective water-gauges,	217	34
Defective blow-offs,	180	40
Cases of deficiency of water,	16	9
Safety-valves overloaded,	73	18
Safety-valves defective in construction,	51	24
Pressure-gauges defective,	443	28
Boilers without pressure-gauges,	14	14
Unclassified defects,	567	28
Total,	13,624	827

The Locomotive.

HARTFORD, OCTOBER 15, 1900.

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

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

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

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

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

WE desire to acknowledge a copy of the *Annual,* for 1899–1900, of the Polytechnic Engineering Society, of the Polytechnic Institute of Brooklyn, N. Y. It is very neatly gotten up, and its contents and general appearance are highly creditable to the society from which it emanates.

WE have received a copy of the twenty-ninth annual *Report* (for 1899–1900) of the Schlesischer Verein zur Ueberwachung von Dampfkesseln, of Breslau, Germany. The society is in a highly prosperous condition, and the report shows that it has 10,240 boilers and other similar steam apparatuses under its inspection. We desire to acknowledge, also, the twenty-seventh *Report* (for 1899) of the Hannover Verein zur Ueberwachung der Dampfkessel, and the thirtieth *Report* (also for 1899) of the Norddeutscher Verein zur Ueberwachung von Dampfkesseln, of Hamburg, both of which we have examined with interest.

The Metric System in Europe.

Some months ago (says the *Mechanical World*, of Manchester, Eng.), the government addressed a circular letter to our representatives in Europe asking for information relating to the metric system in the various countries. It appears from the replies which have just been published that the change to the metric system in Austria was made in 1876, and met with many difficulties, as the new scale bore no resemblance to that which it superseded. The alteration was facilitated, however, by wise concessions, the transition period was over in four years, and the method now gives complete satisfaction in Austria and Hungary. The metric system is firmly established in Belgium, where it came into general use in 1855, and the question of introducing it in Denmark is under consideration, the majority of the commercial and professional classes being in favor of the reform. In France, where the law was brought into force in 1837, all authorities are agreed that the metric system has been commercially beneficial, and the principle has also been firmly established in Germany, where it was brought forward in 1868, and has been of advantage to the trade of the country. Too much prejudice against the system exists in Greece, and the government has therefore refrained from making it compulsory; but in Italy its use was made uniform by legislation in 1890. The obstacles encountered in enforcing the principle in the Netherlands have gradually been removed, and it is now in operation throughout the country. In Portugal, where the method was introduced in 1852, little opposition was manifested, as about twelve years were occupied in carrying it into effect. Spain adopted the system in 1869, Norway and Sweden in 1879, and Switzerland in 1877. Taken altogether, the metric system appears to have proved beneficial, and no desire exists, in the countries that have adopted it, to revert to former methods.—*American Machinist.*

[The Hartford Steam Boiler Inspection and Insurance Company publishes a little book explaining the metric system, and containing a very extensive and complete series of tables for facilitating the comparison of metric measures of all kinds with those now in use in the United States. This little book has been received everywhere with great favor. The price charged for it is intended to merely cover the cost of type-setting, paper, and binding. For the edition which is bound substantially in leather, with red edges, we charge $1.25. A special edition was also printed on bond paper, with gilt edges, the price of this edition being $1.50. Orders should be addressed to the home office of the company, at Hartford, Conn.]

The November Meteors.

To the Editors of The Locomotive, *Gentlemen:* — Last October you published, in your journal, an account of the November meteors, in which you traced the history of these heavenly tramps back for 1,800 years or so, and pictured the glories of the celestial bombardment that was scheduled for the 16th of the following month. I was deeply interested, and I took some trouble to see the show, as I propose to relate in this letter. First, however, I want to explain that my long silence in regard to the matter has been due, in some measure, to the fact that my vocabulary of good English words was too limited to express my real sentiments with sufficient precision, while preserving a suitable regard for the proprieties. You will probably remember the story of the farmer who started up a hill a mile long with a big load of potatoes. When he reached the top he looked back and found that his wagon was empty. A small hole in the bottom of his wagon had allowed the potatoes to fall through, one by one, till they were now arranged in Indian file all the way up the hill. Yet deep as were the farmer's feelings, he spake him never a word, but contented himself with a few dumb gesticulations. He had no words in all his stock that seemed to fit the case. Well, I felt somewhat the same way; but I have cooled off some now, and I propose to narrate such portions of my experiences and reflections as are adapted to the eyes and ears of a pair of civilized and Christian editors. I had dragged myself forth into the cold, dark world without, on several occasions, each night before November 16th, so as to be sure not to miss the display, if it should be disposed to come along before it was expected. Of course, I was not disappointed on these nights, because no meteors were really due. But on the night of the 16th I made up my mind that I should have a great time watching the celestial pyrotechnics to which I had looked forward since I was eight years old. The early part of the night was cloudy; but as I didn't expect anything until after midnight, I didn't worry. Along after midnight somewhere, I dressed, and, with a companion, I sallied forth. (I may say that my companion was not my wife. She had more sense. She stayed at home and went to sleep again.) Well, we sallied forth, as I said, and made a bee-line for the Garden street reservoir, whose high banks we climbed, and on whose top we shivered in unison for several hours. The clouds gradually cleared away, and after a time we could see pretty well. That is, we could see the reservoir, and the moon, and the Asylum Hill church, and the reservoir watchman, and pretty much everything except the *meteors.* Of these, I suppose we saw a dozen, altogether,—a dozen little, measly, good-for-nothing ones, that came at long intervals, and were so faint that after one *had* come we chewed the rag together for ten minutes or so before we could both agree that we saw it at all. Well, to spare you the harrowing details, we eventually dispersed to our respective homes, and, so far as we were concerned, the show was over. The whole thing reminded me, somehow or other, of the man who thought what great fun it would be to frighten his wife, some night, by throwing bricks down the chimney. The more he thought about it the more he laughed; and one night, when he couldn't stand the strain of his mirthfulness any longer, he got up and proceeded to the roof of the house without going through the formality of dressing. He had thrown down a score or so of bricks, when, hearing no yells of terror from below, and finding that the cold wind wasn't half so enjoyable as he thought it would be, he concluded to give the experiment up and go back. But when he tried to do so, he found that his wife had stolen softly up and locked the skylight on the inside. So he was permitted to roost all night on the ridge-pole and think what a lot of fun he was having. Now, I don't know *why* my experience reminded me of this story, but it *did*. And now that the thing has so long gone by, and my homicidal instincts have yielded to a proper course of diet and exercise, permit me to ask what ever became of that meteor shower, anyhow? Only I beg you not to say that "perhaps it will come *this* year," because if you should throw out any such suggestion as that, I fear that my frenzy would come on again with all its primitive intensity. Sorrowfully yours,

A HARTFORD VICTIM.

[We don't know what became of that shower. All we can say, positively, is that we haven't got it. We will make affidavit to that, and we are also willing to be searched. If our unfortunate friend had not specifically requested us not to say it might come this year, instead of last, we might possibly have made some such suggestion; but of course, under the circumstances, that would be inexpedient.—THE EDITORS.]

Don't Touch the Valves!

Frank and Henry Dagger, who are employed as boiler repairers by the Lackawanna company, had a terrible experience, on June 24th, at the Holden mine, near Scranton, Pa. Finding one of the boilers to be in need of repairs, they caused it to be put out of service, and when it had cooled sufficiently they both entered it to make an inspection. When they were about to come out again somebody opened the valve between the boiler they were in and the main steam-pipe. The error was quickly discovered, and the valve was promptly closed again, but not until one of the men had been fearfully scalded. Henry, who was near the manhole, escaped without injury; but Frank, who was further in, could not reach the manhole in time to avoid the fiery blast of steam that came through the valve. At last accounts the injured man was still in a very serious condition.

Accidents of this kind happen every little while, and our inspectors have sometimes had narrow escapes of the same sort. There is no excuse for any man's opening a valve into an empty boiler, because the fact that he does so simply proves that he was careless and did not know what he was about. The only safe way to do, when a boiler is being inspected in a battery in which other boilers are still in service, is to let every valve alone till the job is done.

Never touch any valve whatever, until the inspector has come out of the boiler, *and has reported that he is through with his internal examination.* If that rule is faithfully followed, accidents such as the one noted above will never happen; and the inspector will not be scalded unless the stop-valve breaks of its own accord.

The World's Need of Coal, and the United States' Supplies.

[Note.— It is about thirty-five years since Professor Jevons predicted that, by the end of the century, England's commercial and industrial supremacy would be checked by inability to supply the ever-growing demand for fuel. The coal which gave her economic dominion — which, more than iron, was the basis of her material power — was even then evidently exhaustible. With its disappearance, apparently, her wealth and power would decline. Trade expansion, spreading further and faster than seemed possible to the most sanguine a third of a century ago, has hastened the condition upon which Professor Jevons based his sinister prophecy. But in the meantime other factors — material, economic, and political — have entirely changed the problem. New countries have opened up not only new markets for consumption, but new sources of supply; improved transport, particularly by sea, has brought far-off shores practically nearer than the distant portions of our own land; and above all, a broadened understanding of national and international relations has drawn the whole world closer and is ever enforcing the concept that the great storehouse of the world is a common one — that the funds of material, of energy, even of human skill and handicraft, are in reality and inevitably a joint possession, which it is the duty and destiny of mankind to utilize and to distribute to the uttermost for the good of all. The new world, which supplied to the overburdened old world first room and opportunity to labor, then bread and clothing, now opens to the underfed furnaces, mills, and workshops of Europe, almost limitless stores of the coal and iron which are the prime material necessities of modern life. These will prove as life-giving and as little to be considered menaces to England's prosperity as were the wheat of the prairies or the cotton of the Southern States.— *Editors of the Engineering Magazine.*]

Coal is heavy, both specifically and in its aggregate annual tonnage. It is by long odds the greatest item of the freight traffic on American railroads, constituting one-fourth of the total tonnage, and if we omit the duplication of tonnage resulting from the transportation of one shipment over two or more lines of railway, it will be found that coal constitutes one-third of all the traffic moved in the United States. And although all indications now point to the fact that American progress towards the achievement of a great international coal trade will be steady and continuous, yet at the same time those who are concerned in the industrial progress of the United States need not fear that the exportation of coal will result in a diminished supply at home and increased prices for the fuel needed by manufacturers. Taking up the coal fields of the United States as a whole,— that is to say, the bituminous coal fields, with which alone exporters are concerned,— it will be found that from the Atlantic to the Mississippi the country is well supplied; and though the quality gradually deteriorates as one progresses from east to west, it so happens that each section is (or can be) supplied with suitable coal from its own fields.

In spite of continued efforts to increase the efficiency of engines and boilers, the progress of invention is such that coal is becoming each year a more and more important article of commerce. So short a time ago, viewing the history of the world, as 1831, the annual coal production of Great Britain was 24 million tons; for the year 1901 the coal production will probably be 240 million tons,— an increase of 1,000 per cent. In 1831 the population of Great Britain was 24 million, and the next census, 1901, will probably show about 40 million in that country,— an increase of $66\frac{2}{3}$ per cent. in 70 years. Therefore the production of coal has increased from one ton per capita to six tons, and the rate of increase has been 15 times as great as the rate of increase in population. The earliest statistics of coal consumption in the United States are very incomplete — in fact, prior to 1860 the output can only be guessed at; but such figures as are available show that in the United States, as in Europe, the increase in the use of coal has been phenomenal. In 1840 the production of bituminous coal in the United States was between one million and two million tons, and the production of anthracite was one million tons — say a total of 2½ million tons. At that time the population of the country was 17 million, so that there was probably less than one-sixth of a ton used annually, per capita.

Compare that with the present tonnage of 220 million and a population of approximately 75 million, and it will be seen that America is now using, per capita, eighteen times as much coal as she did sixty years ago. In fact, since 1890 the per capita increase has been 50 per cent. In that year and for some time prior thereto the coal requirements of the average community could be stated at two tons per person, but now three tons is the average for the country at large, and in all large places except the southern cities the average is above that.

First and foremost of the factors leading to this great increase in coal requirement has been the growth in the railway mileage at home and abroad. Such progress has now been made in the building of large locomotives that, counting in all the engines laid up for repairs, those temporarily in the shops, those in switching service and similar light duty, and those regularly employed on the road, it is found that some 1,600 tons of coal per annum are required for each locomotive in a company's service, on the presumption that the coal is of good quality, and that the number of engines owned is great enough to make an average practicable. No more than ten years ago the average coal requirements of a locomotive did not exceed 1,000 tons a year. As there are now 40,000 locomotives in the United States and Canada,* it will be seen that at least 64 million tons of coal are annually required in this line of business, with the chances greatly in favor of a tonnage exceeding that amount. In fact, it has been claimed that one-half of the bituminous product of the United States (say 90 million tons) is used by railways and steam vessels.

It is plain to all who give the matter more than passing interest that coal has come to the front, that it is in great demand the world over, and that the United States is, at present, the coal *cellar* of the world. That it will also become the coal *seller* of the world at an early date is a matter capable of mathematical demonstration.

Coal has always been high-priced in England. With the great prestige in manufacturing that the British people had for two generations in this century, their manufacturers were ready and willing to pay high prices for their fuel. High prices were charged, and even though the business was conducted in a most crude and costly way, great fortunes were made by the coal proprietors of England, Scotland, and Wales. Properly conducted, the operations should have been comparatively economical, for the coal could have been easily obtained. From the year 1600 to date, 10,000 million net tons of coal have been extracted from the limited areas of Great Britain, and it has come to such a pass that the high prices hitherto prevailing are absolutely required to meet the expenses of production and transportation, for now it is necessary to go deeper into the ground. Thinner seams have to be worked, the more attractive deposits having been exhausted. All the entries now are long, comparatively few new mines having been opened in Great Britain in the last ten years.

A moment's thought will make it plain that underground haulage and hoisting are enormously expensive methods of transportation, and that a certainty that these factors will increase in importance every day, as the coal industry grows older, makes it plain

* The large Canadian lines buy in the United States.

that the United States' coal fields, almost untouched as many of them are, grow steadily in advantage as regards the supply of the world. Generally speaking, there is not a coal mine in the seaboard bituminous regions from which coal has to be hoisted. It can in every case be drawn out in cars, sometimes up a grade, it is true, but quite as often the cars run down grade. Then, too, the American mines are generally new. All devices are contrived with the view of handling a large tonnage as economically as possible, and the present shipper of bituminous coal is not hampered by arrangements made years ago, when trade requirements were less important. Very notable, too, have been the arrangements made by the railway companies for the transportation of coal. The roads leading into the coal regions are solid and substantial, with grades and curves modified as far as the formation of the country will permit, and over them are operated trains of fifty 50-ton cars, drawn by huge slow-steaming locomotives. Owing to the allowance for extra weight generally permitted, the cars are often loaded to nearly 10 per cent. more than their marked capacity, making a consignment of 2,700 tons moved to market at one trip.

Having seen that there is an abundance of coal in the United States, and that the facilities for transporting it to tide already exist, we find at present but limited facilities for ocean transportation. At this time, when the requirements of the United States government for transports to the East Indies and the West Indies have retired many American vessels from commercial pursuits, and when the great requirements of the British government for transportation to South Africa have taken 3,000,000 tons of vessel tonnage from the market, and general business activity has made miscellaneous freight plentiful for all vessels, it must be confessed that the average coal man,— the owner of a few comparatively small mines,— is at a decided disadvantage in regard to supplying the great export demand; but in so far as the large producing companies are concerned, the question is by no means serious. Having ample resources, they will boldly start in and build vessels designed expressly for coal-carrying. It has been ascertained, by interviews with gentlemen thoroughly well-posted in the ship-building and shipping business, that a vessel having a cargo capacity of 7,000 tons would be best suited for this line of business, and that a speed of ten knots is the most economical for such a vessel. Faster time means more coal burned, and slower time means fewer trips per year; so that ten knots, which in practice will allow for one round trip across the Atlantic and back each month, is found to be the most desirable speed.

It has been calculated by a careful compilation of figures that the expense of operating a 7,000-ton steamer to such an accessible port as Gibraltar would be such as to make a total cost of but 80.4 cents per ton for the actual transportation of the coal. Upon this basis the American product could be put in foreign markets at rates that would make competition simply impossible. Coal could be placed at Cardiff, the greatest coal-shipping port in the world, for $3 less than the present wholesale selling-price at that place, even supposing that the vessel was destined to return empty, and the producer doubled the above-mentioned freight. Yet that is an extreme instance. It is not probable that an American producer would offer the coal at such a close margin, but he would seek to compensate himself for his expenditure incurred in the development of foreign trade by adding a dollar or two per ton to the cost price abroad, as determined by cost, insurance, and freight. Even on this basis, which gives him a $14,000 margin on a single cargo, there is $1 in favor of the United States seller at Cardiff, and nearly as much at every other port in the northern portion of the eastern continent, and when it comes to supplying the trade of South Africa and South America, both important, there is also some 2,000 miles of sea travel.

Unfortunately there are but few shipyards in the United States capable of building 7,000-ton vessels. The reduction in the price of iron and steel during the present year, the improvement of facilities to meet the home demand, and the undiminished strength of the foreign demand, all combine, however, to strengthen the interest of American producers in the export trade; and undoubtedly the building of steam colliers will soon commence at all the shipyards capable of such work.— F. E. SAWARD, in *The Engineering Magazine* (Abstract).

Mr. T. W. Hugo.

Mr. Trevannion W. Hugo, who is a special agent for the Hartford Steam Boiler Inspection and Insurance Company for Duluth, Minn., and vicinity, was recently elected mayor of that city on the Republican ticket, defeating an opponent who had previously been twice successful, and who had carried the city in the earlier elections by 1,700 majority. Mr. Hugo entered the service of this company in 1888, when he was introduced to our patrons as "the new inspector for the Duluth district." Since that time the business of the company in that department has increased until we now insure about nine-tenths of the insurable boilers there. Mr. Hugo may be described, in familiar language, as "a good fellow, and a hustler." "I feel best when a lot of work is pushing me," he says, "and I have never taken work seriously. It has always been a good joke to me; and a good joke is a thing I dearly love, whether it is on myseif or on somebody else." In addition to his duties as mayor and as our local representative, Mr. Hugo is mechanical superintendent of the Consolidated Elevator System of Duluth. The following item, which is taken from the *American Elevator and Grain Trade*, gives some few particulars of his earlier life: "Mr. Hugo is an Englishman by birth, a Canadian by education, and an American by choice. Born in Cornwall in 1848, he was educated in the public schools of Kingston, Ont., and having graduated from the higher schools he entered a machine shop, where he served a five years' apprenticeship. He then became an engineer on steamers plying the Great Lakes. One of his constructive feats was superintending the cutting of an ocean steamer, purchased by his company, in order to get her through the canal locks into the lakes. Sailing as engineer on a line having Duluth as one of its termini, he attracted the attention of certain of her business men, who had use for that sort of a man. They offered him the supervision of the machinery of the Consolidated Elevator System, which he accepted. The system was then in its inception only, but it has since grown to be a plant of eight elevators, with an annual handling capacity of 40,000,000 bushels of grain. The machinery of the system has all been made and installed under the superintendence of Mr. Hugo, and largely from plans made by him; and it is of such a characte as to have attracted the attention of the American Society of Mechanical Engineers, of which he is a member, and which has honored his work by papers and discussions."

Our respects and best wishes to the Mayor of Duluth !

IN Buda-Pesth there is a "news telephone," the object of which is to keep its 6,000 subscribers supplied with the latest news. The service has a main wire 168 miles long, which is connected with private houses and with various public resorts. From 7:30 in the morning until 9:30 in the evening, twenty-eight editions of news are spoken into the transmitter by ten men possessing loud, clear voices, working in shifts of two. The news is classified, and the service has been eminently successful. — *Scientific American.*

The Locomotive.

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Electrical Terms in Common Use.

That powerful, yet mysterious and subtle servant of man, electricity, has come to play a very important part in the affairs of modern civilization. As it has come into use, a number of new words relating to it have also been added to our every day vocabulary, and we read and speak of "amperes," "volts," "ohms," and the like, very often. These familiar words have a clear and definite meaning to the electrician, for the ideas that they express are a part of his professional education, and he measures currents and electromotive forces and resistances in amperes and volts and ohms just as readily as the carpenter measures a stick of timber with a two-foot rule.

A man who never saw a boiler might know, in a general way, what a riveted joint is like; but we could not expect him to be able to sketch one out in reasonable proportions. In the same way, a man may know, in a general way, what these electrical terms

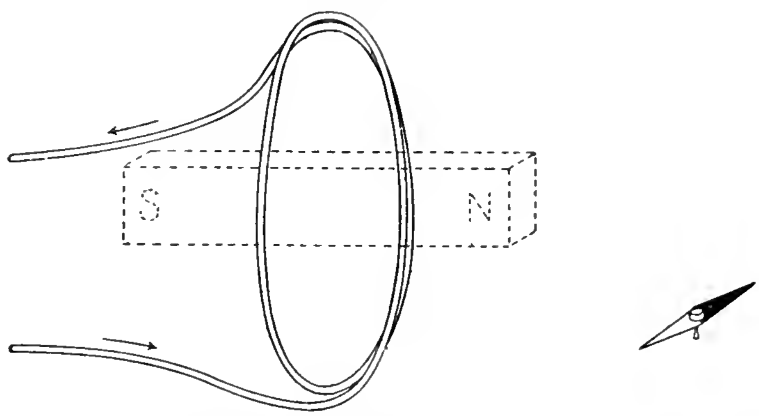


Fig. 1. — Illustrating the Principle of the Galvanometer.

signify, and may even use them intelligently in conversation and correspondence; but he might be unable, at the same time, to state with any precision what they mean. It could not be expected, for example, that a man could give an accurate account of an ohm or an ampere, if he never had any direct personal experience with electrical matters. It has appeared to us to be worth while, therefore, to give some account of the meaning of a few of the electrical terms that are most commonly used. Let us begin with the "ampere."

An electric current, as we all know, is capable of producing a great variety of effects. It heats the wire through which it travels, it magnetizes fragments of iron that may be near it, it attracts or repels other electric currents that may chance to exist near it, it may produce currents in neighboring coils of wire or masses of metal without touching them, and it is capable of producing chemical changes when it is caused to pass through suitable solutions. All these facts are well known. It is also well known that two different electric currents may give rise to any of these phenomena in different degrees, under precisely similar circumstances. One current, for example, may heat a piece of iron wire so hot that it shines in the dark, while another may heat a similar piece of wire so slightly that the rise in temperature is not apparent to the direct senses and can be detected only by the aid of delicate instruments. This difference in the intensity of the effects produced gives rise to the idea that some currents are bigger, or greater, than others, and suggests at the same time, that it would be possible to estimate the relative strengths of electrical currents, by comparing the effects that they produce. For this purpose we could select any one of the various kinds of effects that appeared to be convenient; and as a matter of fact, nearly every kind of effect that electricity can produce has been utilized in the construction of meters, or instruments for measuring the electric current. For example, the heating effect has been utilized for this purpose in several ways, one way being to arrange a little windmill over a flat coil of bare wire, so that when the wire is heated by the passage of the current a stream of hot air will rise from the wire and drive the windmill around. A big current of electricity will heat the coil hotter than a little one will, and hence, the ascending stream of air will work the little windmill faster.

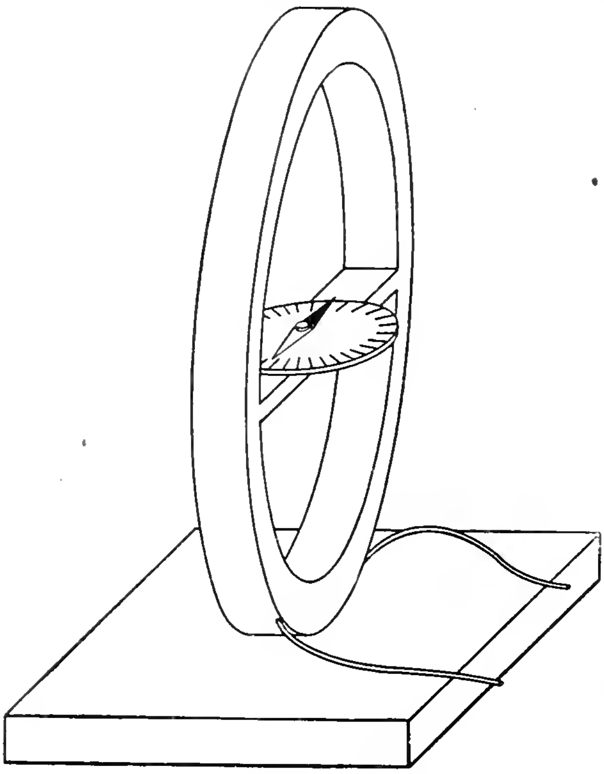


FIG. 2. — A GALVANOMETER.

The most familiar way of measuring an electric current, however, is by means of the *magnetic* effects that the current produces. If a coil of wire be traversed by a current of electricity as suggested in Fig. 1, the coil will act like a magnet upon any particles of iron in the vicinity. This is suggested by the dotted magnet marked "N S." (It should be understood that the dotted magnet is not supposed to be actually *present*. It is shown merely to make it clear what is meant when we say that the coil of wire, when traversed by a current, acts *like* a magnet.) In particular, if a compass needle be in the vicinity of the coil as suggested in the illustration, the needle will be deflected when a current passes through the coil; and as its deflection will be greater, the bigger the current, it is evident that two currents of electricity may be compared by passing first one of them and then the other, through the coil, and comparing the two resulting deflections of the needle. Instruments constructed on this principle are called "galvanometers," in memory of the early Italian electrician, Galvani. They differ a good deal in external form, but the general idea upon which they are based may be inferred from Fig. 2, which represents one of the commoner types. The needle is here placed centrally within the coil. The instrument is set so that when no current is passing, the needle lies parallel with the plane of the coil — that is, so that a person looking directly *down* upon the instrument from above would not see the needle at all. When a current is passed through the coil, the needle swings out towards a position at right angles to the coil. The amount of the deflection, in degrees, is read off by means of a graduated dial, placed immediately below the needle; and two currents are compared by comparing the respective deflections, in degrees, that they produce.

Another way of comparing electric currents is by means of the device shown in Fig. 3. This consists of a glass vessel containing a solution of (say) nitrate of silver, into which two silver plates are dipped. The current to be measured is caused to enter the solution through one of the silver plates, and leave it by way of the other one. When this experiment is tried, it is found that silver is gradually deposited upon one of the plates, an equal quantity of silver dissolving, meanwhile, from the other plate. This process goes on as long as the current flows, and the quantity of silver deposited upon one plate (or dissolved from the other) in two hours is just twice as great as the amount deposited (or dissolved) by the same current in one hour. In other words, the quantity of silver deposited (or dissolved) by a given current of electricity is proportional to the time that the current passes. It is also true that if one current is twice as big as another one, it will deposit (or dissolve) twice as much silver in the same time; or, expressed more exactly, the quantity of silver deposited (or dissolved) by a current of electricity in any given time (say one minute, or one hour.) is proportional to the strength of the current.

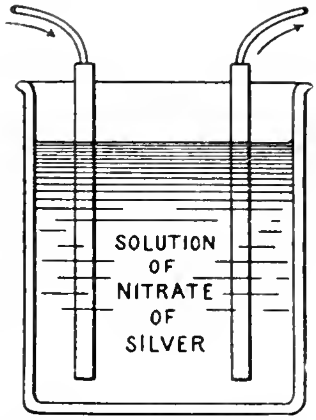


Fig. 3. — The Silver Voltameter.

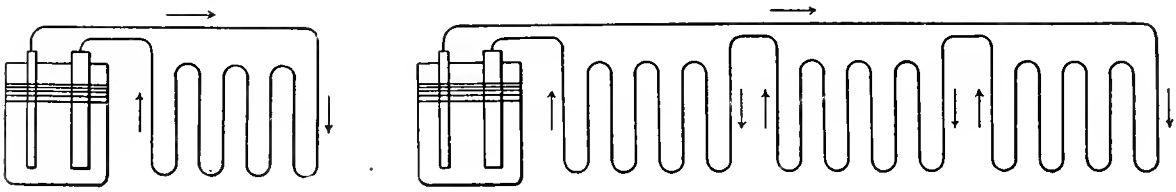
The instrument just described is called the "silver voltameter," the word "voltameter" being suggested by the name of another early Italian electrician, Volta. So far as the theory of the subject is concerned, we could use any metal we pleased for the plates, and we should then have a "gold voltameter," or a "copper voltameter," and so on, according to the particular metal selected; but for practical reasons that we do not need to discuss in this place, silver is preferred to the other metals, for use in this instrument.

The silver voltameter is a very accurate instrument for the measurement of electric currents, because we can determine the quantity of silver gained or lost by the plates with great precision, by weighing them before and after the experiment.

Having explained, in a general way, how electric currents may be measured, it remains for us to choose some one particular strength of current as a *unit*, with which to compare other currents, and to give this standard current a name. We can then specify other currents with precision, by stating how many times they exceed this standard current (or, if the current to be specified happens to be *smaller* than the standard current, we may state what fraction of the standard current it is equal to). Evidently we could choose any current we pleased as the unit. There is no theoretical reason, for example, why we could not take, as our unit of current, the current that would deposit one pound, or one ton, or one grain of silver, in an hour. There is no theoretical reason, as we have said, why any one of these currents should be taken as a standard, rather than any other; but it is desirable to choose our unit of current so that the equations that electricians sometimes have to handle shall be as simple as possible, and this practical consideration has led physicists to select, as their unit of current, the current that will deposit 4.025 grammes of silver per hour. A current of this strength is called an "ampere," this name being adopted for it in memory of the French electrician Ampère, who gave a great deal of study to the action of electric currents upon each other. An "ampere," then, is a current of such strength that it will deposit 4.025 grammes (or 0.142 avoirdupois ounce) of silver in one hour. If, when tested with the silver voltameter, a given current is found to deposit silver at the rate of 0.142 ounces per hour, we say that it has a strength of one ampere. If it deposits silver at the rate of 0.284 ounces per hour, we say that it has a strength of two amperes. If it deposits silver at the rate of 0.071 ounces per hour, we say that it has a strength of half an ampere; and so on.

A galvanometer cannot be used to determine the magnitude of a current *in amperes*, until we have found, for that particular instrument, how big a deflection of the needle corresponds to a current of *one* ampere. This can be determined either by comparing the proposed galvanometer with another one whose constant is known, or by putting it in the same circuit with a silver voltameter, and observing the deflection of the needle when the circuit is carrying a current which deposits silver at the rate of 0.142 ounces per hour. Then we shall know, in the future, that a current which gives this particular deflection of the needle has a strength of one ampere; and when the observed deflection is greater or less than this standard deflection, we can also determine the corresponding strength of the current, in amperes, by comparing the observed deflection with the standard deflection which corresponds to one ampere.

If two batteries, which are identical in all respects, are made to send a current through two precisely i lentical coils of wire, then the same current will be obtained in each circuit. But if the batteries are alike (as before), and the coils, while otherwise similar, contain different lengths of wire, then the observed currents will no longer be equal. (This state of things is suggested in Figs. 4 and 5.) It is found that the cur-



FIGS. 4 AND 5. — ILLUSTRATING "RESISTANCE."

rent through the short coil will be greater than that through the long one. This fact leads us to the idea of *resistance*. The battery, when sending a current of electricity through a wire, may be likened, in fact, to a steam pump delivering water through a pipe. If the length of the pipe be increased, the frictional resistance will also be increased, and the pump will not be able to deliver the same quantity of water per hour. The parallelism with the battery and wire is so evident that we do not need to dwell upon it further.

If we are going to measure electrical resistances, we must select some standard resistance as the unit with which others are to be compared, and we must give this unit a name. We must proceed, in fact, just as we did in connection with the measurement of *currents*, where we first selected a particular strength of current as our unit, and then named this unit the "ampere," in order that we might refer to it conveniently and definitely by a single word. We may select any kind of a resistance we please as our standard, so far as any theoretical objections are concerned; but here, just as in the case of currents, it is found that practical considerations limit our selection. For example, it would be natural to select, as our standard, or unit of resistance, the resistance of a certain length of wire of some stated diameter, the wire to be of copper, or silver, or platinum, or any other convenient metal. In practice, it is usual to actually construct standards in this way; but when we are *defining* our unit it is better to make a slight change. The resistance of a given piece of wire depends to some extent on the physical condition of the wire. It is found, for example, that a piece of freshly-drawn copper wire has its resistance slightly changed by annealing the wire; and as a definition is not good for anything unless it is exceedingly precise, physicists have endeavored to avoid such sources of possible error or misunderstanding as we have suggested in connection with the copper wire, by selecting *mercury* as the standard substance, instead of copper, or silver, or gold, or any other solid metal: for mercury, being a liquid, is presumably free from any of the uncertainties of physical state which exist in all solid substances.

Mercury being selected as the standard substance to be used in defining our unit of resistance, the next step is to determine what diameter and length the standard column of mercury, which is to be our unit, shall have. Here again we are at liberty to make an arbitrary selection; but for reasons very similar to those which led to the adoption of the actual *ampere* that is in present use for measuring currents, electricians have taken, as their unit of resistance, a column of mercury *one millimeter square*, and 106 centimeters long. A resistance of this magnitude is called an *ohm*, in memory of G. S. Ohm, a German electrician who contributed greatly to our knowledge of electrical laws. As the resistance of mercury (as well as that of other metals) is somewhat different at different temperatures, the standard mercury column which is defined as the *ohm* is supposed to be surrounded by melting ice, so as to be precisely at the freezing point.

An *ohm*, then, is the resistance of a column of ice-cold mercury, which is one millimeter square, and 106 centimeters (or 41.732 inches) long. (A millimeter is about the

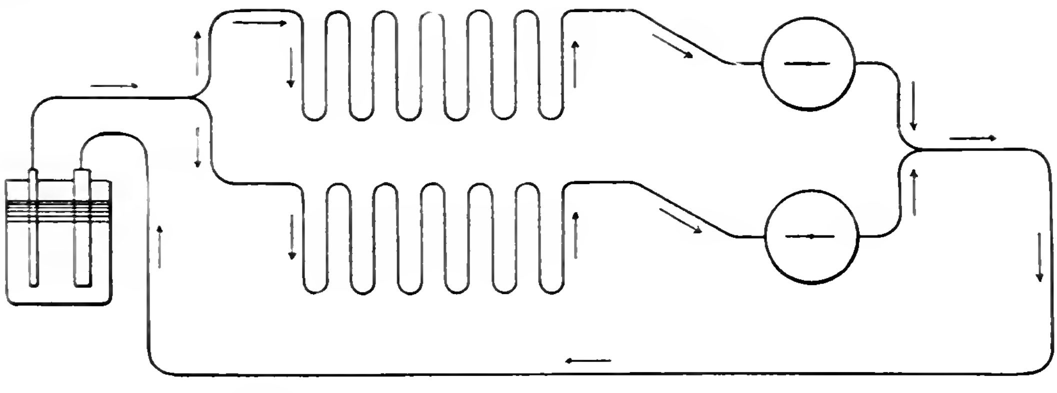


FIG. 6.—ILLUSTRATING THE PRINCIPLE OF THE BRANCHED CIRCUIT.

twenty-fifth part of an inch; so that the cross section of the standard column is about one twenty-fifth of an inch square, and its area is therefore about one 625th of a square inch.)

To understand how resistances are measured, consider, first, a circuit like that shown in Fig. 6. The current, as it comes from the battery, is here supposed to divide into two parts; and the two branches being of precisely the same resistance, it follows that the main current from the battery will divide into two precisely equal parts, one-half going through each branch. The circles on the right of the cut are supposed to represent galvanometers; and the point to be observed is, that if these two galvanometers show that the currents are precisely equal in the two branches, then we know that the resistances of the two branches are also precisely equal.

Let us pass, now, to the consideration of the apparatus shown in Fig. 7, which is identical in principle with that shown in Fig. 6. The resistance R is the one which is about to be measured, and we place this, as before, in one of the branches of the circuit. In the other branch of the circuit we place our standard column of mercury, whose resistance is one ohm for every 106 centimeters of its length. We arrange our mercury column so that the current enters it at the left-hand end; and we take the current away from the mercury column again by means of the movable wire P, whose point of contact with the mercury we can shift to the right or left, at will. The measurement consists in moving the point *P* until the two galvanometers, *A* and *B*, show that the currents in the two branches of the circuit are precisely equal. We then know that the resistances in the two branches are also precisely equal. In preparing the cut we have assumed that the two branch currents are observed to be equal when that part of the mercury column which is included in the circuit is 159 centimeters long, and therefore has a resistance of $1\frac{1}{2}$ ohms. If the galvanometers and the connecting wires are identical in both branches, it therefore follows that the resistance of the coil *R* is also $1\frac{1}{2}$ ohms. In practical work, the measurement of resistance is carried out by an apparatus a little more complicated than the one here shown. The method indicated in Fig. 7, however, is perfectly correct in principle, and only differs from the usual method employed (which we do not need to discuss here) in the way that measurement with a two-foot rule differs from measurement of the same thing with a micrometer calipers. The difference is one of refinement, rather than of principle.

Having now touched upon the measurement of currents and resistances, let us take up the one remaining quantity, of the three that are most often referred to by electricians.

Suppose that two circuits have precisely the same total resistance, and let one of them include one cell of battery, while the other includes two cells, each similar to the

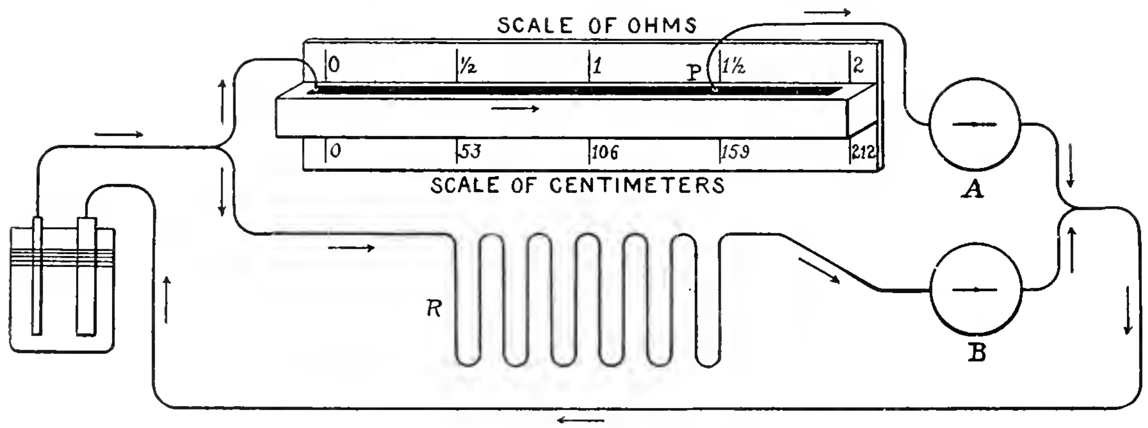


FIG. 7.—ILLUSTRATING THE MEASUREMENT OF RESISTANCE.

first one, and arranged in "tandem" fashion, so that the whole current goes through first one of them and then the other. In a case of this kind it is found that the *current* in the second circuit will be twice as great as that in the first one. In the same way, if two circuits have precisely the same total resistance, while one of them includes one cell of battery and the other includes ten similar cells, also arranged "tandem," the current in the second circuit will be found to be just ten times as great as in the first one; and so on.

These facts serve as a further justification of the comparison we have already made between a battery and a steam pump. A battery (or dynamo) is a device for forcing electricity through a wire, just as the pump is a device for forcing water through a pipe. Two steam pumps, set so as to operate "tandem," like our batteries, can overcome twice the resistance that either one of them can overcome separately. The steam pump gives rise to a certain *pressure* in the water, and it is this pressure which causes the water to flow onward through the pipe. In the same way we may think of a battery (or dynamo) as producing a sort of "electrical pressure," which tends to cause the electricity to flow onward through the wire. The "electrical pressure" that a battery exerts is called its "electromotive force." Formidable as it looks, this phrase, "electromotive force," means nothing but "a force tending to set electricity in motion."

It will be seen that "electromotive force" is a somewhat more abstract conception than either "current" or "resistance"; but there is nothing about it that is hard to understand if the reader will bear in mind the analogy of the steam pump. The main difficulty is, to see how such a thing can be measured, or estimated, in numerical units. In explaining this point, let us begin by calling particular attention to the fact that the "electrical pressure," or electromotive force, of a battery cell does not depend upon the *size* of the cell, but upon the materials of which it is composed. A big cell has the advantage over a little one of having a smaller internal resistance, and of having a longer life on account of the greater supply of material tha it contains; but the electromotive force that the cell produces is the same whether the cell is large or small.

Suppose, now, that we have a battery producing a current through a circuit whose total resistance (including the internal resistance of the battery itself, of course, since the current goes through the battery as well as the wire) is precisely one ohm. Then, if the battery is observed to produce a current of one ampere through this circuit, it is said to have one unit of electromotive force, or electrical pressure. If it is found to produce *two* amperes of current, the battery is said to have an electromotive force of two units; and so on. The unit of electromotive force thus defined is called a "volt," in memory of Volta, an Italian electrician who had a good deal to do with the establishment of the fundamental principles of electrical science. A "volt," then, is the electromotive force which will produce a current of one ampere in a circuit whose total resistance is one ohm. A battery whose electromotive force is 15 "volts" will produce a current of 15 amperes in a circuit whose total resistance is one ohm. A battery whose electromotive force is 15 volts will also produce a current of one ampere in a circuit whose total resistance is 15 ohms; or a current of 3 amperes in a circuit whose total resistance is 5 ohms, and so on. The general rule is, that if we multiply the resistance of a circuit (in ohms) by the current (in amperes) that we desire to produce in it, the product is the electromotive force (in volts) that will be required to produce the desired current. This simple rule is known among mathematicians as "Ohm's law," since it was first stated and proved by the G. S. Ohm for whom the "ohm" was named.

It is found that the "gravity battery," which is in favor among telegraphers on account of its simplicity and constancy, has an electromotive force of slightly more than one volt per cell. The ordinary sal ammoniac battery, which is used in connection with telephones, has an electromotive force of about 1.48 volts. The usual electromotive force (often called "voltage" for brevity's sake) which is used on incandescent electric lighting circuits, is 110 volts; although some circuits are run at 53 volts, and some at 220.

We have now explained the three chief units that are used by electricians; and for ease of reference we will repeat the definitions below: —

AMPERE. — The "ampere" is the unit in which electrical *currents* are measured. A current whose strength is one ampere will deposit silver in the silver voltameter at the rate of 4.025 grammes (0.142 avoirdupois ounce) per hour.

OHM. — The "ohm" is the unit in which electrical *resistances* are measured. A column of pure, ice-cold mercury, which is one millimeter square and 106 centimeters long, has a resistance of one ohm.

VOLT. — The "volt" is the unit in which electrical pressures, or *electromotive forces*, are measured. A volt is that particular electromotive force which will produce a current of one ampere in a circuit whose total resistance is one ohm.

OHM'S LAW. — Ohm's law merely states that if we multiply the total resistance of a given circuit (in ohms) by the current (in amperes) that we desire to produce in it, the product so obtained is the electromotive force (in volts) that will be required to produce the required current.

Boiler Explosions.

JULY, 1900.

(173.) — On July 2d the boiler of a threshing machine belonging to Talley Brothers exploded near Harper, Kans. Engineer Edward Talley was killed, and four other men were injured.

(174.) — A boiler exploded, on July 2d, in W. R. Pearson & Co.'s sawmill, near Fordyce, Ark. The boiler house was wrecked, and the property loss will be several thousand dollars. Fortunately, there was no one near the boiler at the time of the accident, so that there are no personal injuries to record.

(175.) — A boiler exploded, on July 3d, in Elder & Elder's creamery, at Allerton, Iowa. Claude Elder, a son of John Elder, one of the proprietors, was scalded so badly that he died later in the day. Matthew Elder, the other proprietor, was badly injured, but it is thought that he will recover. The plant was completely destroyed.

(176.) — A boiler exploded on the steamer *Peter Hontz*, on July 3d, at Clydetown, on the Tennessee River, six miles above Danville, Tenn. Alfred Mason was killed, and three other men were badly scalded, one of them fatally so. The damage to the boat is estimated at $3,000.

(177.) — On July 3d a boiler belonging to James Smith exploded between Rhome and Saginaw, in Wise county, Texas. The fireman and engineer were killed, and one other man was fatally injured.

(178.) — On July 8th a boiler exploded on a steam launch attached to the Flagship *New York*, just as the launch was going alongside of the cruiser. Three men on the launch were more or less injured by steam and flying splinters. It is said that one of the men cannot live. The upper part of the launch was completely wrecked.

(179.) — A boiler exploded, on July 10th, in Joseph Applebaker's sawmill, at Pittsville, Wis. Joseph Applebaker and Frank Murray were badly injured, and the mill was entirely wrecked.

(180.) — On July 10th a boiler exploded in the De Force Oil Works, near Astoria, Ore. Engineer Morris W. Moore was injured so badly that he died later in the day. John Shaw was also killed. Christopher Rentz is also believed to have been killed. The factory was totally destroyed.

(181.) — On July 11th a boiler belonging to Wm. H. Henley exploded at St. Jones' Neck, near Dover, Del. The fireman and four other men were severely scalded. The loss was about $1,000.

(182.) — On July 11th a boiler exploded on the Lenhart farm, a few miles northeast of Findlay, Ohio, in Cass Township. Fortunately, nobody was injured.

(183.) — Engineer R. Butler was painfully scalded, on July 12th, by the explosion of a boiler at Davidsonville, in Anne Arundel county, Md. We have not learned further particulars.

(184.) — The boiler of the locomotive drawing the north-bound express on the Fort Wayne, Cincinnati & Louisville division of the Lake Erie & Western Railway, exploded, on July 13th, near Beeson's Station, Ind. Engineer Robert Kelly and Fireman Otto Simmers were injured. The locomotive was converted into a pile of scrap iron.

(185.) — On July 13th a boiler exploded at the city wells, at Sulphur Springs, Tex William Merrett and a man named Felton were badly burned and scalded. One fragment of the boiler was blown more than half a mile, cutting down a five-inch tree in its course as neatly as it could be done with an axe.

(186.) — A power house on the Pinkerton farm, at Van Buren, near Marion, Ind., caught fire, on July 16th, and the debris held down the safety-valve of a boiler until the boiler exploded from the accumulation of steam. No one was injured. The power house belonged to Bettman, Watson & Bernnimer.

(187.) — A boiler exploded on the steamer *Queen City*, on July 16th, at Seaconnet Point, near Providence, R. I. The fireman was badly scalded, but the property damage was small.

(188.) — On July 17th a boiler exploded at the Pennsylvania Railroad Company's stone quarry, at Renovo, near Williamsport, Pa. George McEachron, William Bissett, and John Hickey were seriously injured. All the machinery was badly damaged, and the building was wrecked.

(189.) — A horizontal boiler over a furnace exploded, on July 19th, at the South 11th street mill of the Oliver Wire and Steel Company, at Pittsburg, Pa. Nobody was injured, and the property damage was small.

(190.) — On July 21st a threshing machine boiler exploded on George W. Earhart's farm, two miles southwest of Lima, Ill. James Higgins and his son, and Henry Holtman and Anges Meyer were scalded more or less severely, but it is thought that all will recover.

(191.) — The boiler of a threshing machine belonging to Falls & Alexander, exploded, on July 21st, near Shelby, Cleveland county, N. C. Blanche Alexander and Tilden Falls were killed. Alfred Falls, Shotwell Peeler, and five other men were injured. We have not learned further particulars.

(192.) — On July 23d a boiler exploded in the Kanawha Wood Turning Company's factory, at Charleston, W. Va. Assistant Engineer Henry Ronsey was badly scalded and otherwise injured, but he will recover. The main building of the factory, which was 90 feet long and 60 feet wide, was badly damaged. Nearly one-half of the roof was blown off, and the shafting and machinery were badly damaged. The property loss was in the vicinity of $7,000.

(193.) — A boiler exploded, on July 24th, on the steam yacht *Trilby*, owned by Fred. L. Spink, of Scriba, Oswego county, N. Y. Ivas Spink, Gladys Spink, and Fern Spink were killed. Fred. Spink, Mrs. Fred. Spink, Herald Spink, and Mrs. Jay Kelsey were seriously injured, and it is doubtful if Herald Spink recovers. The boat was badly damaged.

(194.) — A boiler exploded, on July 24th, in M. G. Gannon's steam sausage factory, on East B street, Belleville, Ill. John Fricke, a butcher employed by Mr. Gannon, was severely scalded. The building in which the boiler stood was destroyed.

(195.) — On July 25th a boiler exploded in the Waco Ice and Refrigerating Company's plant, at Waco, Tex. Henry Mercer and John Dorsett were killed, and James Sellers, Henry Bush, and Seth Robinson were injured. The mammoth plant, which covered an entire block, was torn to pieces. Nothing was left where the boiler stood but the brick smokestack. The damage to the property was probably $30,000.

(196.) — The boiler of a threshing machine exploded, on July 26th, on William Fitch's farm, at Caldwell, Kans. The outfit was wrecked, and Engineer William Smith was fatally injured.

(197.) — On July 27th a boiler exploded in Everett & Ikeler's sawmill, at Fishing Creek, near Benton, some eighteen miles from Bloomsburg, Pa. Charles Savage, Robert Evan, and Emanuel Bender were badly injured, and it is thought that all three will die. The force of the explosion was so great that many of the heavy timbers of the mill, as well as large fragments of the boiler, were thrown from one to two hundred yards.

(198.) — A boiler exploded, on July 30th, on the tug *Templar*, at Canton Hollow, near Baltimore, Md. Jeremiah Moore and C. E. Wood were killed. Captain Oliver Crowder and several others were also more or less injured, but it is thought that they will recover.

(199.) — On July 31st the boiler of a threshing machine exploded on Jacob Simpson's farm, nine miles south of Pana, Ill. Charles Simpson and Marion Sylvester were killed, and three other persons were severely injured.

When the Spanish cruiser *Infanta Isabel* was about to leave San Sebastian, Spain, on August 4th, one of her boilers gave way, and the escaping steam scalded twenty-one sailors. One of the men was killed, and six others were injured very severely. The cruiser postponed her departure.

Table of the Weight of Cast-Iron Balls.

[From the London Practical Engineer.]

Diameter in inches.	Weight in pounds.	Diameter in inches.	Weight in pounds.	Diameter in inches.	Weight in pounds.	Diameter in inches.	Weight in pounds.	Diameter in inches.	Weight in pounds.
1.0	0.14	3.0	3.69	5.0	17.1	7.0	46.9	9.0	99.6
1.1	0.18	3.1	4.07	5.1	18.1	7.1	48.9	9.1	103.1
1.2	0.24	3.2	4.48	5.2	19.2	7.2	51.0	9.2	106.6
1.3	0.30	3.3	4.91	5.3	20.3	7.3	53.2	9.3	110.2
1.4	0.37	3.4	5.37	5.4	21.5	7.4	55.4	9.4	113.7
1.5	0.46	3.5	5.86	5.5	22.7	7.5	57.7	9.5	117.4
1.6	0.56	3.6	6.38	5.6	24.0	7.6	60.0	9.6	121.2
1.7	0.67	3.7	6.92	5.7	25.3	7.7	62.4	9.7	125.0
1.8	0.80	3.8	7.50	5.8	26.7	7.8	64.9	9.8	128.8
1.9	0.94	3.9	8.11	5.9	28.1	7.9	67.4	9.9	132.8
2.0	1.09	4.0	8.75	6.0	29.5	8.0	70.0	10.0	136.7
2.1	1.27	4.1	9.42	6.1	31.0	8.1	72.6	......	......
2.2	1.46	4.2	10.12	6.2	32.6	8.2	75.5	......	......
2.3	1.66	4.3	10.86	6.3	34.2	8.3	78.1	......	......
2.4	1.89	4.4	11.64	6.4	35.8	8.4	81.0	......	......
2.5	2.13	4.5	12.46	6.5	37.5	8.5	83.9	......	......
2.6	2.40	4.6	13.30	6.6	39.3	8.6	86.9	......	......
2.7	2.69	4.7	14.19	6.7	41.1	8.7	90.1	......	......
2.8	3.00	4.8	15.11	6.8	43.0	8.8	93.3	......	......
2.9	3.33	4.9	16.08	6.9	44.9	8.9	96.5	......	......

Rule. — $(\text{Diameter in inches})^3 \times 0.1367 = \text{weight in pounds}$.

The Locomotive.

HARTFORD, NOVEMBER 15, 1900.

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

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

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

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

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

WE desire to acknowledge a copy of Mr. Rufus P. Williams' pamphlet entitled *The Metric System,* which is issued by The Decimal Association, of London. Mr. Williams favors the system, and his pamphlet should be in the hands of everyone who is interested in the metric question. Copies of it can doubtless be had of The Decimal Association, Botolph House, Eastcheap, London, E. C., England.

Inhabited Pop Valves.

Overalls, monkey-wrenches, hammers, loose rivets, and all sorts of things are sometimes found in boilers by our inspectors, as we have frequently related in THE LOCOMOTIVE. It may be mentioned, too, that pop safety-valves also frequently serve as receptacles for unexpected things, though in this case the foreign articles are usually deposited there by our friends of the world of fur and feathers. Pop valves, in fact, are growing to be quite fashionable places for birds' nests, and it is not uncommon to find that the English sparrow has utilized such a valve as a hatchery and nursery. When a number of boilers are always run together as a single battery, it usually happens that there are slight differences in the blowing points of the different valves, so that under ordinary circumstances only one or two of the valves blow, relief enough being obtained in this way to keep the pressure below the blowing points of the others. An enterprising sparrow may then rear her brood in a lazy way, by building her nest where the temperature is just right. All she has to do, then, is to turn the eggs from day to day, and the rest of the time she can go to picnics or attend circuses or grand opera, according to her taste, with the full knowledge that the proper temperature is being maintained at home. She has, in fact, quarters that are up to date. They are heated by steam, and the boiler is cared for by her janitor, the engineer, who is paid for this service by the otherwise soulless corporation that owns her flat.

Occasionally, however, she and her little family are evicted — literally "fired out." We hear, in the larger world, of the janitor giving a tenant "a good blowing up," and this is what happens, from time to time, to our little bird families, through no fault of their own. One of the inspectors from the Hartford office of this company recently had a pop valve blown in his presence, so that he might be satisfied that it was in good condition. A straight escape pipe led from the valve out through the side of the building, and when the valve blew, out through this pipe came nests and other things galore, and immediately there were flats to rent in that valve and pipe.

Squirrels, too, are coming to regard pop valves with increasing favor, both as nesting places, and as safe-deposit vaults for the storage of nuts. A few days ago one of the Hartford Company's inspectors found a pop valve that was filled almost solid full of hickory nuts by some industrious squirrel. It is not likely that these nuts would have prevented the valve from blowing, and yet, when considered from an engineering standpoint, they could not be regarded as an improvement to it. A pop valve loaded with hickory nuts and provided with a straight, horizontal escape pipe, would, when it blew, be likely to make the neighbors think the Spanish war was still with us!

The Engineer in China.

All the European newspapers are proclaiming that China must be civilized, quite regardless of the fact that there was a highly developed civilization in China at the time when the inhabitants of England were painted savages, and that the intervening centuries have seen no decline in the Celestial Land. The casual newspaper reader might imagine that there had been no civilization before the commencement of the nineteenth century, and that the inhabitants of Babylon, Nineveh, Heliopolis, Athens, and Rome had been only so many different varieties of barbarians. And yet a moment's reflection shows that the words "city" and "civilization" have the same roots. In the strict sense of the word, pastoral (and even agricultural) peoples are not civilized. Just as there are animals which can never be tamed to endure the companionship and dominion of man, so there are tribes which cannot, and will not, exercise the necessary self-control to accommodate themselves to the limitations and restraints of town life. It is perfectly correct to call them uncivilized, although the word is often used in a different sense.

There are, of course, degrees in civilization, and no nation has yet attained to finality in this matter. We are painfully aware of our defects, and of how much remains to be done before even the worst blots are cleaned off our social system. But, curiously enough, the remedies which are proposed here are quite different from those we are so ready to prescribe for China. Here the platform and the press ring with the praises of elementary education, secondary education, sanitation, temperance, improved dwellings, workmen's clubs, cookery classes, and the like. Every philanthropist has his own pet plan for making people less like the apes and more like the angels. But when the improvement of China is under discussion we hear nothing of these panaceas. Omitting the programmes of the missionary societies, the remedy which is universally put forward for the ills of that country is *engineering*. Its salvation is to be found in roads, harbors, railways, trolleys, sawmills, factories, and a thousand of the other products of the engineer's art and science. The coolie is to be converted from a beast of burden to a human being by machinery; the mandarin is to be rendered honest by machinery; the judge is to be converted to righteousness by machinery; and the Tsung-li-Yamen is to be reformed, if it be capable of reformation, by machinery. The regeneration of one-fourth of the human race is confided to the engineer, apparently with the full assurance that he is quite capable of effecting it in a short time, if he be not prevented by the obstinacy of those whom he is to benefit so greatly.

All this is exceedingly flattering to our profession; partly because there is a substantial groundwork of truth in it, but more particularly because it is so very far removed from the opinion of our work which is generally expressed. It is undoubtedly a fact that the engineer is seldom reckoned among the higher factors in the spread of civilization in Western countries. No statesman rises in his place in Parliament to proclaim that the crying need of the nation is labor-saving appliances, although of late years a few have preached the virtues of technical education, which is an admission of the value of manufacturing processes. It is not long that engineering has been reckoned among the professions, and even now it would raise a smile, or provoke dissent, to call it a learned profession. When the intellectual powers of an age are reckoned up, the names of eminent engineers are seldom mentioned. We hear of statesmen, authors, poets, teachers, and philanthropists, and the public imagines that they have furnished the motive force which has raised mankind to a higher plane, quite forgetful of the mechanics which rendered their achievements possible. In one of his great wars, Louis XIV said that victory would be secured by the side which could produce the last gold piece. There was a world of philosophy in the remark. The general can do nothing unless he has arms and a commissariat, and these are the result of labor, which must be paid for. If by mechanical appliances the output of a day's work in the manufacture of ammunition could be trebled in any country, then the military commanders of that land had, in the time we are speaking of, when there was little accumulated wealth, victory thrust into their hands. How little could the author do for humanity before the invention of the movable type. He might evolve soul-stirring ideas, but the knowledge of them was confined to an insignificant few. Great, however, as has been the effect of the printing press, it has only entered into the full development of its possibilities since every person has been able to read, and that result is distinctly the work of the engineer. At the first glance this assertion appears paradoxical, but a little reflection will show that it is literally true. Most middle-aged men can remember the time when it was exceptional for the lower classes to be able to read. It was quite a natural thing to ask a servant if he, or she, could read; and, oftener than not, the answer was in the negative. It is only since the institution of compulsory education that the art of reading has become universal, and it was not possible to pass a law of that drastic character when the working classes became so generally prosperous that they could dispense with the earnings of their children. As factories gradually displaced home industries, as railways decreased the cost of internal transit, as steamships brought grain from other lands where it could be grown under favorable conditions of climate, so wages rose, and the purchasing power of money increased concurrently. The labor of a man assisted by mechanical appliances, became equal to filling the mouths of his children, as well as those of his wife and himself. Then the philanthropist and statesman stepped forward to seize on the occasion, and to write their names on the pages of history as the authors of an epoch-making measure.

It would be quite possible to pursue the subject in many directions, but it is hardly necessary in these columns to lay further stress on the point that the inventor, the mechanic and the engineer lay the foundations of all social progress, and that without them society, particularly in the lower strata, must remain very imperfect. Nevertheless, it is a wonderful thing to find this truth fully realized by the public, although at present it seems as if the application of it were confined to China.

There are many points of resemblance between social customs in China and in England at the present day, while, if we carry our thoughts back 50 years, the resemblance becomes even more striking, with the exception that purely intellectual attainments have always been more highly regarded in the celestial land than here. In China the two qualifications which give social precedence are birth and educational attainments. The examination system was in full force there hundreds of years ago, and upon a man's success under it depends to-day very greatly his position in life. The studies are strictly classical; the Oxford don, who boasted that there was nothing useful taught at his university, would have been quite in his element in China. The writings of Confucius and of the poets furnish a great part of the mental pabulum of the students, but so keen is the competition, that it needs great mental powers to pass the higher examinations. Probably, as a means of training the intellect, and stimulating it to the highest activity, the Chinese system of education is equal to any in the world. It certainly bears a great resemblance to that which obtains in this country (England). Here the mental training held in the highest esteem is that which consists in the study of literature, and particularly in the literatures of Greece and Rome. Much of this is of about the same date as the classics of China, and is not much more in harmony with the sentiments and needs of the nineteenth century than are they. We might go further, and say that it produces much the same effects on many minds; in other words, it introduces a false and conventional standard of education. The fine old English gentleman of fifty years ago, who came of a county family and had received a university training, regarded the engineer very much as the mandarin regards the Englishman to-day. He admitted that the engineer was clever in his craft; that he could bend the forces of nature to his will, and that he could accomplish by his art things which formerly had been held to be possible only by magic. But not for one instant would he acknowledge him as an equal. If the engineer had asked his daughter in marriage, he would not only have refused him, but would have done so with contumely. He acknowledged only one kind of intellectual eminence, and that was the one stamped with a university degree.

The Chinese mandarin stands on much the same mental platform. The "complete gentleman," in his opinion, can be made only by one system, and all who do not follow that system are not gentlemen. It is not that he entirely despises the arts and inventions of the Westerns, but he would rather forego the conveniences attaching to them than endure the society of their authors. He recognizes the masterful and aggressive character of the European, and feels that the only method of safeguarding himself is to limit, and, if possible, to prevent, all intercourse with foreigners. The idea that such people can civilize *him*, that they can raise him in the social scale and widen the horizon of his mind, is too absurd for a moment's consideration. His contempt for them is even deeper than that of a vice-chancellor of an ancient university for a professor of engineering at a North County college.

It is no wonder, therefore, that the sudden and vigorous "civilizing" of China by Western nations, which has gone on since the Chino-Japanese war, has led to an outbreak. We can readily realize somewhat of the feelings of the Chinese if we imagine a number of Americans of the type set forth by Dickens in his "American Notes" — if such people ever existed — coming over here armed with the powers ascribed by the novelists to the inhabitants of Mars, and obliging us to admit overhead railways in Piccadilly, and to turn Westminster Abbey into a machine shop. Whatever might be the material advantages of such proceedings, it is certain that the strangers would have to demonstrate their magical powers very impressively before we should consent to their plans, and that we should nurture a deep, undying hatred for them forever. Such being the case, we shall be wise not to expect a too rapid civilizing of China by the engineer. No doubt he will effect a wonderful change in the long run, and that by machinery he will work all those reforms which in this country are ascribed to other means. But we have only to look back to the history of railways at home to realize the difficulties. No graves of ancestors were likely to be desecrated here. Yet there are many engineers now living who can remember when surveyors ran the risk of personal injury when laying out lines of railway in this country, so intense was the objection of land owners to having the iron roads on their estates. There are important towns which are off the direct route of main lines, because they offered too violent an opposition to their approach. It is only sixty years ago that such things happened, and at that time Englishmen considered themselves the most civilized nation of the world. It does not follow, therefore, that the Chinese are uncivilized because they entertain similar ideas now.

In spite of all opposition the engineer will, eventually, by the aid of machinery, create a moral revolution in China. The obstinacy of the mandarin and the ignorance of the coolie will be ineffectual to prevent it. Probably, the engineer will gain no more credit for it than he has gained here, all the fame being reaped by the statesman and the philanthropist. Nevertheless, when the steam tramp has supplanted the junk, piracy will become extinct; when wages have risen the way they are doing in Japan, owing to the introduction of machinery, infanticide will disappear; when railways have made communication easy and rapid, likin dues will become impossible, and one means of extortion by the governors will be removed; when newspapers have become general, the venality of judges will cease, either from the pressure of public opinion, or by means of a revolution. The engineer is the friend of the poor man all over the world, giving him cheaper food and better clothing, and rendering him more able to resist oppression and wrong. No wonder he finds small favor with the classes who desire things to remain as they are, either in England or in China.

The civilization of the Chinese by engineering methods carries with it a great danger which does not receive the attention it deserves. European capitalists may force railways and iron works on the Chinese, and instruct them in all the arts of peace, but they cannot guarantee that they will not turn their knowledge to account in the construction of war material. Civilization may grow there more vigorously than we desire, once we have succeeded in planting it. At present the military man is despised in China; he is regarded as the butcher is with us — something necessary, but objectionable. But the wily Oriental may follow our example, and exalt soldiering into an occupation of honor, both for princes and for common men. Then, when he has learned the art of gun-making, and has trained a million men or so, it will be his turn to dictate terms. The West will find itself face to face with the Yellow Peril, and will begin to consider whether its zeal for civilization has not outrun its discretion. Then its only safety will lie in its engineers furnishing it continually with weapons of greater potency than those produced in "Far Cathay." After being the creator of western civilization, the engineer will then become its guardian, and probably his merits will then be more freely acknowledged.— *Engineering* (London).

Housewife and Burglar. — The burglar had entered the house as quietly as possible, but his shoes were not padded, and they made some noise. He had just reached the door of the bedroom when he heard some one moving in the bed as if about to get up, and he paused. The sound of a woman's voice floated to his ears.

"If you don't take off your boots when you come into this house," it said, "there's going to be trouble, and a whole lot of it. Here it's been raining for three hours, and you dare to tramp over my carpets with your muddy boots on. Go downstairs and take them off!"

He went downstairs without a word, but he didn't take off his boots. Instead, he went out into the night again, and the "pal" who was watching and waiting saw a tear glisten in his eye.

"I can't rob that house," he said; "it reminds me too much of home." — *Lewiston Evening Journal.*

The Locomotive.

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On the Tubes of Water-Tube Boilers.

We are often asked how to calculate the force which tends to draw a tube, in a water-tube boiler, out of the header or tube sheet to which it is secured; and this article is intended as a general reply to the question. The problem is in reality extremely simple, and there should be no difficulty about it whatever, when the principle which underlies it is once correctly understood. Nearly every problem appears simple or diffi-

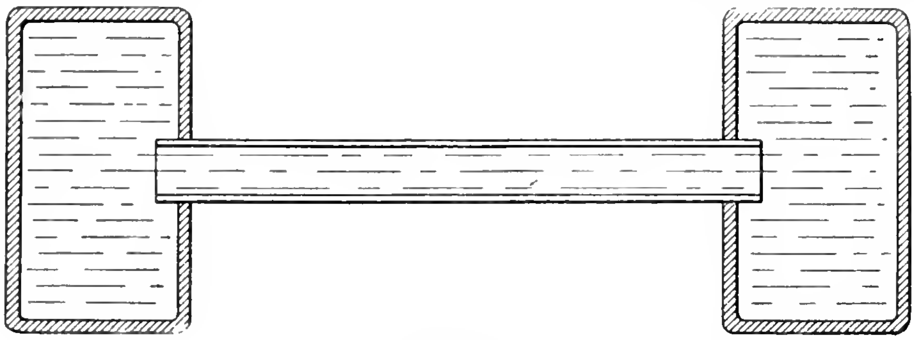

FIG. 1. — DIAGRAMMATIC PRESENTATION OF THE PROBLEM.

cult, according to the point of view from which we regard it; and the main thing to do in the present case, is to discover that particular point of view from which it will appear simplest of all.

The stress on the tubes of water-tube boilers is influenced (and sometimes very largely influenced) by the design of the boiler, as we shall show in the course of this

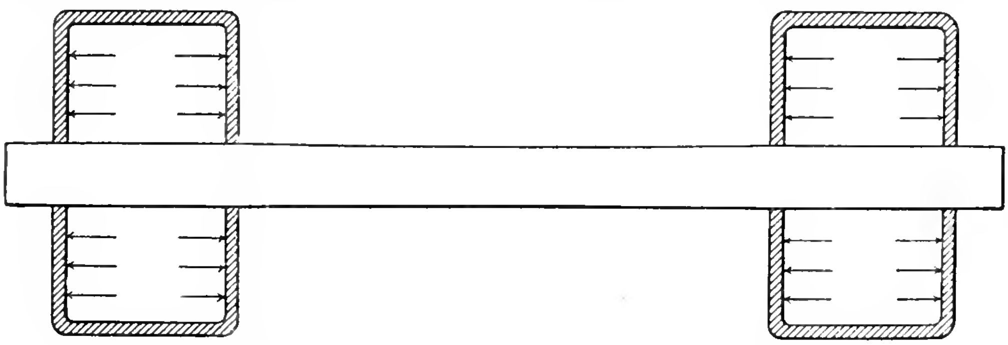

FIG. 2. — A PAIR OF BOXES (OR DRUMS) WITH SOLID SHAFT.

article; and in order to exclude all considerations except those of the most fundamental and elementary character, we shall first simplify the problem till it takes the following form: A pair of hollow boxes, made of cast-iron or other rigid material, are joined by a tube, as shown in Fig. 1. The whole apparatus is then filled with water, and a known hydrostatic pressure is applied. The problem is, to calculate the force which is acting upon the tube under these circumstances, tending to pull it out of the boxes.

Let us first take the case illustrated in Fig. 2, where a solid, round shaft of iron, of the same diameter as the contemplated boiler tube, is run completely through both sides of both boxes. Under these circumstances it is plain that there can be no pull lengthwise on the iron shaft, because the pressures on the boxes are balanced in all directions. If the shaft were cut in two at the middle, neither part would move either to the right or the left.

We have spoken of the shaft in Fig. 2 as being *solid;* but obviously it can make no difference whether it is solid or not, provided it is everywhere closed, so that the pressure in the boxes cannot find its way into the interior of the tube. Let us therefore

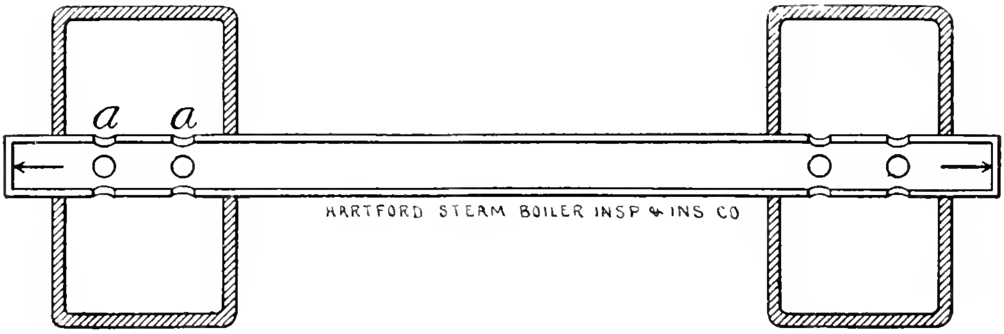

Fig. 3.—A Pair of Drums with Perforated Tube.

think of it, not as a solid shaft, but as a boiler tube, capped at the ends, and with no opening in it anywhere; and let us remember that when such a tube is arranged as in Fig. 2, there will be no lengthwise stress upon it at all.

Let us now make openings into this tube at each end (as shown at *a a* in Fig. 3), so as to admit the hydrostatic pressure in the boxes to the interior of the tube. The pressure upon the sides and ends of the *boxes* will not throw any stress on the tube in this case, any more than it did in Fig. 2; but it must be noted that Fig. 3 differs from Fig. 2 in the one important particular that the pressure now acts not only upon the boxes, but upon the ends of the *tubes* as well, as shown by the arrows; and hence, in the arrange-

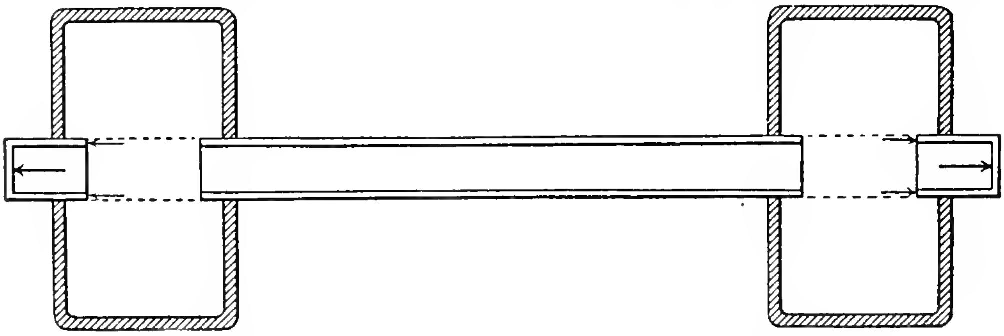

Fig. 4.—Showing the Tube Partly cut away.

ment shown in Fig. 3, there *will* be a lengthwise stress on the tube, and its amount will be just equal to the pressure exerted by the water against the end of the tube.

Let us now cut the tube entirely away, in the manner indicated in Fig. 4. By so doing we shall not alter the lengthwise stress (or pull) on the tube, except that by cutting the tube, we have exposed a small additional area to the action of the pressure, since the pressure now acts against the *cut end* of the tube, as well as upon the cap at the end. This difference is small, with boiler tubes of the usual diameter and thickness, and it is taken into account perfectly, by basing our calculation on the *external* diameter of the tube, instead of the internal one. Otherwise, as we have said, the lengthwise stress on the tube has not been changed by cutting it as suggested in Fig. 4. The most important difference between Figs. 3 and 4 is, that in Fig. 3 there is no necessary stress between the tube and the boxes — that is, there is no tendency to blow the tube out of the boxes — and we do not need to provide for any "holding power" between the tubes and the boxes, since the stress on the tube arises at the ends of the tube, and the pull is transmitted from one end of the tube to the other, without leaving the tube at all. In Fig. 4, however, this can no longer be true, because we have cut the tube, and the only way in which the stress can be transmitted from one end of the tube to the other, is by means of the boxes.

It is necessary, therefore, to roll the tube in, in Fig. 4, wherever it touches a box; or else to provide an equivalent holding power in some other way. The force that the water exerts against the end of the tube on the left (for example) is transmitted to the box, and through the box to the long section of tube in the middle. It is then transmitted to the right-hand box, and through this box to the tube end on the right, where it is balanced by the equal and opposite water pressure against this right-hand tube end. The total pull on the tube in Fig. 4 is plainly equal to the pressure that the water exerts against a circle whose diameter is equal to the external diameter of the tube.

The tube-ends in Fig. 4 may now be entirely dispensed with without affecting the

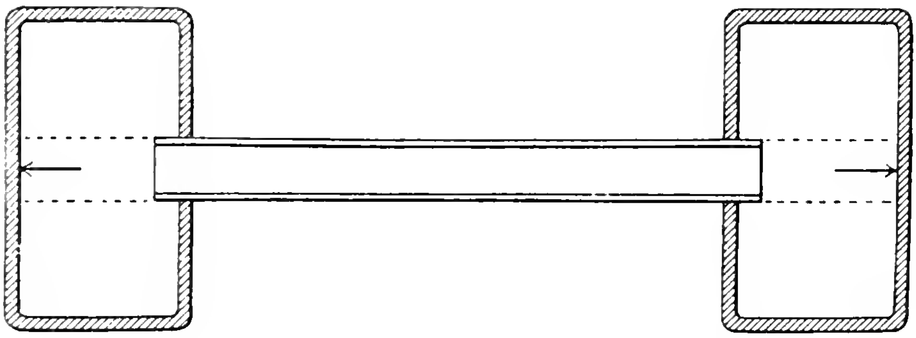

Fig. 5. — Indicating the Outcome of the Reasoning.

problem at all; for, as they stand in that view, they serve merely to receive the water pressure, and transmit it to the boxes. We may therefore consider them to be, for all practical purposes, a part of the boxes; and, as has been said, we may dispense with them altogether, and merely consider the pressure of the water against a region of the box of corresponding size. This is suggested in Fig. 5; and the final outcome of our argument is, that the only force which tends to strip the box from the tube, consists in the pressure of the water against the circle which is opposite the end of the tube as in Fig. 5, and whose diameter is equal to the external diameter of the tube.

This conclusion might have been reached much more simply, by merely imagining the tube in Fig. 5 to be *rolled* into one of the boxes, and fitted to the other one (say the left hand one) by a stuffing box. It would be evident, in this case, that the only force tending to separate the tube from the left-hand box would be the pressure against the end of the tube, and against the column of water within the tube — that is, it would be equal to the pressure exerted by the water against a circle of the same diameter as the outside of the pipe, just as we concluded in the preceding paragraph. The only objection to this simpler line of reasoning is, that it does not tell quite all of the story. It does not make it clear, for example, that the pull that the tube exerts upon the box is balanced by an equal and opposite water pressure against the opposite side of the box. For this reason we think the line of reasoning adopted above is preferable.

Let us take a numerical example. Let us suppose that the tube is 4 inches in diameter, externally, and that the pressure to be carried is 125 pounds per square inch, and that we wish to know the force which is acting between the tube and one of the boxes, tending to pull the tube out. We have seen that this force is numerically equal to the pressure sustained by a circle whose diameter is equal to the external diameter of the tube. In other words, we merely have to find the total pressure against a 4-inch circle. The area of a 4-inch circle is 12.57 sq. in.; and the pressure against each square inch being 125 lbs., the total pressure against the 4-inch circle would be 12.57 × 125 = 1,571 pounds. The force tending to draw the tube from the box, in the case in question, is therefore 1,571 pounds.

Now President J. M. Allen, in his experiments on the holding power of tubes, found that tubes of smaller diameter than this, when set in thinner plates than those customarily used in water tube boilers, and only expanded (without being flared or beaded), did not begin to draw out until the pull was from 5,000 to 7,000 pounds. Even at these figures the tube in our example would have a factor of safety of from 3.1 to 4.4. Making allowance for the greater thickness of the usual headers or tube sheets

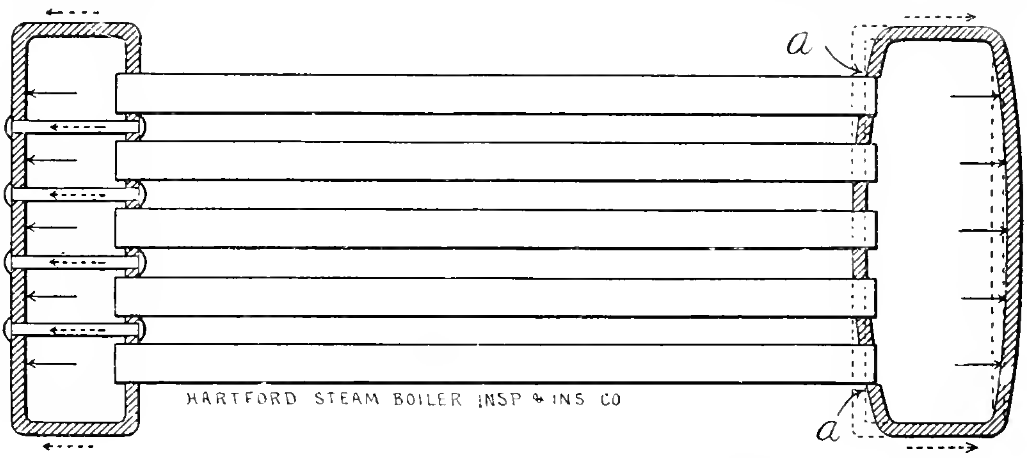

FIG. 6. — ILLUSTRATING THE IMPORTANCE OF CORRECT DESIGN.

of water-tube boilers, it is probable that in most cases the factor of safety, so far as the pulling out of an expanded tube is concerned, is from 5 to 7.

In order that there may be no misunderstanding in this matter, we desire to qualify this conclusion in certain ways. In the first place we have assumed throughout that there is no stress thrown on the tube except that which is due to the pressure of the steam. This condition, which is all-important, is probably very nearly fulfilled for the long tubes which, in most styles of water-tube boiler, furnish the greater part of the heating surface. It is *not* usually fulfilled, however, for the *nipples* which are often used for connecting the different parts or units of the boiler with one another. We devoted a special article to this subject in the issue of THE LOCOMOTIVE for July, 1900, where we pointed out the importance of properly flaring or beading over the ends of such nipples. A second condition for the applicability of the general conclusion given above is, that the material and workmanship must be of the best. The tubes must be of proper thickness, and the rolling must be done carefully and well. These are especially important points, as, if they are neglected, the holding power of the tubes will certainly fall below that assumed in our calculations, and hence it will be impossible to realize a proper factor of safety.

Another condition to be observed is, that the design and construction of the boiler must be such that the stresses are properly *distributed*, so that each tube may carry only its own fair share of the load. Consider, for example, the arrangement of things shown at the right-hand end of Fig. 6. Here we have a bank of tubes opening into a box or drum, which is originally flat, as indicated by the dotted lines. The pressure acts against the right-hand end of the drum in the manner indicated by the five short horizontal arrows within the drum; and the head of the drum will tend to bulge out, as shown. The pressure against the head of the drum produces a tension in the cylindrical part of the drum, as shown by the dotted arrows at the top and bottom. Now, if the tube sheet is not exceedingly rigid, it will yield somewhat to a severe pull like this, and it will tend to assume the form shown by the full lines, instead of remaining flat, as is indicated by the dotted ones. The result will be, that the joints between the tubes and tube sheet will be severely strained at the points marked *a a*, and the tubes may even pull out at these points, and give rise to a disastrous explosion. (An explosion which was very likely due to this cause is illustrated in the issue of The Locomotive for February, 1900.) Trouble of this kind is especially to be looked for, when there is any overheating of the tube-ends, and consequent lessening of their holding power.

The load carried by the outer end of the box or drum may be transmitted more equally to the tube sheet by the use of a sufficient number of properly distributed staybolts, as is suggested at the left-hand end of Fig. 6. Of course, all the sketches used in connection with this article are merely diagrammatic. They are intended merely to illustrate the *principles* under discussion, and are not to be understood in any other sense. The idea that we wish to illustrate in Fig. 6, for example, is merely that the *construction* of the boiler must be such that each tube-end receives its own fair proportion of the total load; for if this point is not attended to, then what we have said in the earlier part of this article about the stresses on the tubes is no longer true.

It appears fitting that we should close this article with the following sentence, which occurs also in the final paragraph of our leading article for last July: "To prevent misapprehension on the part of any reader who may fancy that our illustrations resemble some one particular sectional boiler, we desire to state that neither the illustrations nor the text of this article are intended to refer to any one make of boiler."

Inspectors' Report.

September, 1900.

During this month our inspectors made 10,712 inspection trips, visited 20,089 boilers, inspected 7,798 both internally and externally, and subjected 895 to hydrostatic pressure. The whole number of defects reported reached 19,655, of which 963 were considered dangerous; 53 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,005	34
Cases of incrustation and scale,	2,492	92
Cases of internal grooving,	132	5
Cases of internal corrosion,	812	31
Cases of external corrosion,	622	47
Broken and loose braces and stays,	169	21
Settings defective,	314	36
Furnaces out of shape,	363	15
Fractured plates,	292	51
Burned plates,	279	46
Blistered plates,	126	7

Name of Defect.	Whole Number.	Dangerous.
Cases of defective riveting,	5,040	16
Defective heads,	76	10
Serious leakage around tube ends,	5,344	252
Serious leakage at seams,	285	25
Defective water-gauges,	250	73
Defective blow-offs,	178	64
Cases of deficiency of water,	12	4
Safety-valves overloaded,	76	28
Safety-valves defective in construction,	82	35
Pressure-gauges defective,	380	38
Boilers without pressure-gauges,	9	9
Unclassified defects,	1,317	24
Total,	19,655	963

Boiler Explosions.

AUGUST, 1900.

(201.) — A boiler exploded on July 27th, at a place called "The Hauteurs," in St. Gabriel Parish, Rimouski county, Que. Mr. Edward Cloutier and a workman named Charles Landry were instantly killed. The mill was destroyed.

(202.) — On July 28th the boiler of a threshing machine exploded on William Melville's farm, in Hayes township, about five miles north of Sylvia, near Hutchinson, Kan. Henry Hibbert and a son of Mr. Melville were killed, and William Melville and Edward Jones were painfully injured.

(203.) — On July 28th a boiler exploded in Speice's sawmill, three miles east of Aylmer, Kan. Nobody was injured.

(204.) — On July 31st the boiler of a threshing machine exploded on the Swartz ranch, near Eltoro, Santa Ana county, Cal. Edward Rogers and a man named Jackson were badly injured. [The foregoing explosions were not brought to our notice soon enough to be included in the regular list for July.]

(205.) — On August 1st a boiler belonging to Guy Jack exploded at Scooba, near Meridian, Miss. Rudolph Stewart and three other men were injured, and the property loss was considerable.

(206.) — A boiler exploded, on August 1st, in Brocksmith & Warren's brick and tile plant, at Bicknell, near Vincennes, Ind. The building in which the boiler stood was blown to pieces, but nobody was injured.

(207.) — A boiler exploded, on August 3d, in Noah Pletcher's mill, some seven or eight miles south of Elkhart, Ind. Charles Crissner was seriously scalded, and the building in which the boiler stood was blown to atoms.

(208.) — On August 3d a boiler exploded in the flouring mills of the Paris Milling Company, at Paris, Tenn. Fireman Edward Haynes was killed, and W. C. Humphreys, R. A. Nash, Daniel Nanny, James Bruce, and Richard Haynes were seriously injured. The boiler passed through two brick walls in its flight, and landed 100 feet from its original position. The office and the west side of the main building were wrecked, and the property loss is said to have been $7,500.

(209.) The boiler of a steam automobile belonging to Dr. A. S. Hills exploded, on or about August 5th, at Peru, near North Adams, Mass. Dr. Hills lives at Somerville, and was making a tour of Massachusetts. Fortunately nobody was injured.

(210.) — Manuel Cuballo and Henry W. Christian were killed, on August 6th, by an explosion on J. J. Hill's new steam yacht *Wacouta*, in Washington harbor, Isle Royale (on Lake Superior).

(211.) — A boiler exploded, on August 7th, at the Fries gas well at Salem Church, near West Newton, Pa. The boiler was thrown 60 feet, and considerable damage was done, but nobody was injured.

(212.) — On August 8th the boiler of John Wymer's threshing-machine exploded at Claremore, I. T. Mr. Wymer was severely scalded, but will recover.

(213.) — A portable boiler exploded, on August 8th, while in use for drilling an oil well near Smithfield, Jefferson county, Ohio. A large fragment of the boiler passed over a tree sixty feet high, and eventually landed a quarter of a mile from its original position. Nobody was injured.

(214.) — The boiler of a steam fire engine, known locally as the "Mary Ann," exploded, on August 8th, during the course of a fire at Napoleon, Ohio. Nobody was injured by the explosion.

(215.) — On August 11th the boiler of Charles Flory's threshing-machine exploded at Marysville, Ohio. The men were at dinner at the time, and nobody was injured. The threshing outfit was ruined, and 800 bushels of wheat were destroyed.

(216.) — On August 14th the boiler of a portable sawmill belonging to Clevenger & Lamb exploded in Darby township, near Marysville, Ohio. Samuel Clevenger, a son of one of the proprietors, was seriously hurt. He was acting as fireman at the time.

(217.) — On August 14th the boiler of a threshing outfit exploded at Sonoma, Sonoma county, Cal. George Knox, George Didder, Aschel Callan, Charles Potter, and a man named Topple were more or less seriously injured.

(218.) — A boiler exploded, on August 14th, near Schellville, Tex. A man named Knox was fatally injured. We have not learned further particulars.

(219.) — A boiler exploded on August 14th, in the Carbolineum Wood Preserving Company's plant at New Orleans, La. John Koenig and Mrs. E. Schweitzer were killed, and Frederica Tilbert, Nicholas Bates, Viola and Harry Martinez, J. C. Williams, Julius Wirlein, and Roland Cole were injured.

(220.) — On August 15th, boiler exploded in Frederick Haugstorfer's Phosphate Works, Norristown, Pa. No person was injured, but the building in which the boiler stood was demolished, and fragments were thrown about to a distance of nearly a mile. A strange feature of the explosion is the disappearance of five horses, no trace of which can be found.

(221.) — A boiler exploded on August 16th, in Amos Hardin's sawmill, at Obion Hill, near Memphis, Tenn. Alfred McMillin was instantly killed, Willis Broyles was fatally injured, and six other men were injured in a lesser degree. (This is the fourth boiler explosion which has occurred in Hardin county within the last year, and each has been attended with fatal results.)

(222.) — A boiler exploded on August 20th, near Glass Rock, Perry county, Ohio. Three men were instantly killed, and another was fatally injured.

(223.) — A boiler exploded, on August 20th, in William Jarvis' wood yard, at Helena, Mont. (We hardly know whether or not this explosion should be included in our regular list, since it is stated, on what appears to be fairly good evidence, that the explosion was due to the intentional introduction of dynamite or giant powder into one of the flues of the boiler.)

(224.) — A boiler exploded, on August 21st, on the oil lease owned by Father McMahon, of Cleveland, Ohio. Timothy McMahon was seriously injured, and probably will not recover.

(225.) — A boiler exploded on August 21st, in Helser's sawmill, some two miles east of Glenford, Ohio. Saviga Dupleer, Eliza Weingartner, and James McLaughlin were injured.

(226.) — On August 21st a boiler exploded at Conesville, near Coshocton, Ohio. The Wheeling & Lake Erie railroad company is building a bridge across the Muskingum River at that point, and the boiler was used to keep the excavation from filling with water. No person was injured, although about twenty-five men were standing near.

(227.) — A boiler exploded on August 22d, in the Waycross Ice Factory, at Waycross, Ga. A large piece of iron was thrown through the roof of the building and landed one hundred yards away. Nobody was injured.

(228.) — On August 23d a boiler exploded in John E. Dilsaver & Son's feed mill, at Clinton, Iowa. Nobody was hurt.

(229.) — A boiler exploded on August 23d, in Behner's foundry, at La Grange, near Oberlin, Ohio. The boiler house was entirely wrecked, and the main building of the foundry was somewhat damaged. Nobody was injured.

(230.) — On August 23d a boiler owned by a man named Sequine exploded in the Swing Addition oil field, near Findlay, Ohio. Nobody was injured.

(231.) — A boiler exploded on August 25th in Thomas Drew's sawmill, at Geneva, Ind. Vernon Finkbone was seriously injured. The building and machinery were badly wrecked.

(232.) — On August 25th a boiler exploded in Benjamin Wheat's sawmill, at Palestine, near Sullivan, Ind. Mr. Wheat was fatally injured, and died upon the following day. Finlay Shears and Wise Stout were also seriously injured, but they will recover.

(233.) — On August 27th a boiler exploded at Ashton Bros.' mill, just across the river from Columbia, Tenn. Samuel Allen and Eugene Matthews were killed. James Paul was injured, but not seriously. The explosion wrecked the building in which the boiler stood, and tore the end out of a large mill adjoining it.

(234.) — A boiler exploded on August 29th, at Keith & Grube's shaft house on the Vindicator, at Cripple Creek, Colo. The building was badly wrecked, but, strange to say, not a man was injured.

(235.) — On August 30th a boiler exploded, in Reese & Adams' sawmill, at Cody, Halifax county, Va. One man was seriously injured, and the property loss was about $1,000.

(236.) — On August 31st a boiler exploded at Goalby's mine, at Percy, Ill. Nobody was injured.

Slow Building.

The first stone of Cologne Cathedral was laid on August 15, 1248, and the body of the edifice was not opened until August 15, 1848, 600 years later to the very day; and it was not until August 15, 1880, that the splendid structure was finally reported completed, having thus occupied, in building, the record time of exactly 632 years.

The castle of Kingsgoberg, which stands at the southern extremity of Jutland, took 204 years from the laying of the foundation stone to the rigging of its master's banner on its highest flagstaff. Its foundation stone was the skull of its builder's bitterest enemy. Three months after its laying Count Jhorsing, the builder of the castle, was killed. His son was then in swaddling clothes. He did not continue his father's work until aged 24. On his twenty-fifth birthday he was thrown into prison by the son of the man whose skull lay in the earth as Kingsgoberg's foundation stone. In this manner master after master of Kingsgoberg was stopped putting another stone toward the completion of the founder's work till civilization intervened.

Between Perth and Kingussie in Scotland, on the direct road from John o' Groats to Land's End, stands Murthley castle, a magnificent Elizabethan structure, designed in the early part of the present century. It is not likely to be finished, however, building experts declare, for at least another decade. Only a few miles distant, on the same main road, is the vast, unfinished palace of the Dukes of Athol. It was begun by the fourth Duke, who died in 1830, and who planned it in the most sumptuous style. When completed it will be one of the finest private residences in the Kingdom.

For over twenty years Lord Bute has been busily building a great mansion on the island bearing his name. It is not yet completed, nor is it likely to be for another ten years. At the end of that period Mount Stewart, as the place is to be called, will be one of the most gorgeous establishments in the world.

Restormel Castle, in Cornwall, took ninety years to build, of which period exactly one-third was occupied in excavating the foundations. The solid rock upon which it stands is almost as hard as iron. Indeed, "Restormel" means in Cornish, "the palace of the iron rock." Milan Cathedral was begun in 1386 and finished under Napoleon in 1805 — 419 years. The Duomo at Florence was commenced by Arnulfo in the year 1294, the last block of marble being placed in position in the façade in presence of the King on May 12, 1887, a period of 593 years.— *Stray Stories.*

We have received, with the author's compliments, a copy of Ing. Alberto Pacchioni's little book entitled *Il Tiraggio artificiale dei Focolari* ("On Forced Draft"). It contains a good deal of useful information, and might be translated into English with advantage to the engineering profession. The bibliography of the subject, which is appended to the body of the work, gives a copious list of references to previous papers on the subject in English, French, German, and Italian. The author's address is as follows: Ing. Alberto Pacchioni, Direttore dell' Officina a Gas del Popolo, Via Flaminia, Rome, Italy.

The Locomotive.

HARTFORD, DECEMBER 15, 1900.

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

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

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

THE *Index* to the 21st volume of THE LOCOMOTIVE, which is completed with this issue, will be ready shortly, and may be had gratis by those who preserve their files for binding, upon application, by mail, to the Hartford office of this company.

WE have received an exceedingly beautiful book of photo-engravings, issued by Messrs. Warner & Swasey, of Cleveland, Ohio, and illustrating some of the famous astronomical instruments that they have constructed, as well as the observatories in which they are installed. The observatory of the Syrian Protestant College, at Beirut, Syria; the Dudley Observatory, at Albany, N. Y.; the U. S. Naval Observatory, at Washington, D. C.; the Lick Observatory, at Mt. Hamilton, Cal.; the Yerkes Observatory, at Williams Bay, Wis.; and the observatories of Carleton College, at Northfield, Minn., and of the University of Pennsylvania, at Philadelphia, Pa., are all represented by engravings executed in the finest style of the art. The detail views of the instruments that have made these observatories famous, are also exceptionally good, and a view such as that presented in Plate 31 (which shows the eye end of the big 40-inch Yerkes telescope) gives the layman a most impressive idea of the amount of delicate machinery that the modern high-grade telescope requires.

Explosion of a Model Boiler.

ON October 26th a small model of a steam boiler exploded at Shamokin, Pa., killing Thomas Stevenson and injuring eight of his friends. The young men had built a small engine and boiler, devoting their spare time to the task for two years past. Harry Dauert, one of the injured persons, tells the story thus to a reporter of the Philadelphia *North American*: "I conceived the idea of building a shaft engine and boiler two years ago, when I was working in the Henry Clay shaft. The other boys liked the idea, and we all worked with a will until Friday (the day of the explosion), when it was completed. The engine was a little beauty, and we were full of excitement when the first fire was started in the furnace. Soon the engine began to run as smoothly as anything I ever saw. Tommy Stevenson was the most enthusiastic of all. He said that he would run a washing machine with the engine, and to test the speed he turned the steam valve wide open and put more wood on the fire. Then the boiler exploded. All of us were crowded closely around him at the time, and we were thrown in every direction. When

I recovered my senses I found that all of the boys were alive (although badly injured) with the single exception of Tommy. I am through with building engines."

Concerning Circles.

It is well known that the circumference of a circle can be calculated, approximately, by multiplying the diameter by the decimal number 3.1416. The result so obtained is not *exact*, however, because the ratio of the circumference of a circle to its diameter is not exactly 3.1416. In fact, the true decimal runs on forever, and has no end; 3.1416 is its value to the nearest unit in the fourth decimal place; 3.141593 is its value to the nearest unit in the sixth decimal place; 3.1415926536 is its value to the nearest unit in the tenth decimal place; and so on.

In the issue of The Locomotive for August, 1899, we explained how this decimal can be calculated as accurately as we please. "The circumference of a circle," we said, "can be calculated in terms of the radius [or diameter] to within any proposed limit of accuracy; but it can never be expressed with absolute precision, because the ratio of the circumference to the diameter consists in a decimal that never ends, and never repeats itself. A great many enthusiasts have worked over this decimal, and it has been calculated to seven hundred places, presumably in the hope that somewhere or other it might begin to repeat itself, and hence be capable of expression in finite form. The general problem of expressing the ratio of the circumference of a circle to its diameter with *absolute precision*, and yet without the use of a never-ending decimal, is commonly known as the problem of 'squaring the circle.' It has been recognized, for a long time, that it is probably impossible to 'square the circle,' and yet no absolute *proof* of this impossibility was given until 1882, when such a proof was given by the German mathematician Lindemann."

The method of calculating the decimal in question, which we explained in the article here cited, is perfectly correct, and is perhaps the simplest one, so far as easy comprehension by a non-mathematical reader is concerned. Our object in printing the article referred to, was merely to make the familiar decimal appear reasonable, by showing how it can be calculated by anyone who has plenty of time and patience, and a good knowledge of the fundamental operations of arithmetic. We wished to present a method that could be easily understood, rather than one that would be of practical use to the computer. A man who proposed to devote a year or two to the calculation of this decimal would care little how hard or how easy it might be to grasp the principles of a proposed method of calculation. What he would want, would be a method which would save him as many figures as possible; and if the proposed method required a month of preliminary study, that month would be well spent if it saved him (say) twenty-five per cent. of his subsequent labor. So it happens that the men who have calculated the decimal to many places, have all made use of certain unfamiliar formulas which come up in the study of trigonometry.

The most indefatigable of the calculators who have given their attention to the decimal 3.1416 is undoubtedly Mr. William Shanks, who has computed it to no less than 707 decimal places. We reproduce, herewith, his final result, as printed, in corrected form, on page 45 of the 22d volume of the *Proceedings* of the Royal Society of London.

It is impossible for the human mind to grasp the significance of a number like this; but a single illustration may be given, which will satisfy the reader that we shall never need to know this decimal with more precision than we do at present.

In giving this illustration we shall make use of the fact that the *area* of a circle is found by multiplying the square of the radius of the circle by this same decimal, 3.1415 etc.; and we seek to discover how much we should be in error, if we should calculate the area of the biggest circle we can think of with Mr. Shanks' number, instead of using the true number (which, as has already been said, runs on into the decimals forever).

We know, from accurate experiments, that light travels through space at the prodigious speed of 186,000 miles per second, or almost fast enough to go entirely around this little earth of ours eight times in every second. It has also been roughly estimated that the visible universe of stars and nebulæ is so big that it would take light, even traveling at this enormous speed, no less than 3,000 years to cross from one side of it to the other. Now we are going to imagine a circle big enough to make this whole universe look like a small speck, in comparison with it. Let us, for example, take a circle so big that light would require 1,500,000,000,000 years to cross it from one side to the other, or 750,000,000,000 years to pass from its center to its circumference. Such a

3.141 592 653 589 793 238 462 643 383 279 502 884 197 169 399 375
105 820 974 944 592 307 816 406 286 208 998 628 034 825 342 117
067 982 148 086 513 282 306 647 093 844 609 550 582 231 725 359
408 128 481 117 450 284 102 701 938 521 105 559 644 622 948 954
930 381 964 428 810 975 665 933 446 128 475 648 233 786 783 165
271 201 909 145 648 566 923 460 348 610 454 326 648 213 393 607
260 249 141 273 724 587 006 606 315 588 174 881 520 920 962 829
254 091 715 364 367 892 590 360 011 330 530 548 820 466 521 384
146 951 941 511 609 433 057 270 365 759 591 953 092 186 117 381
932 611 793 105 118 548 074 462 379 962 749 567 351 885 752 724
891 227 938 183 011 949 129 833 673 362 440 656 643 086 021 395
016 092 448 077 230 943 628 553 096 620 275 569 397 986 950 222
474 996 206 074 970 304 123 668 861 995 110 089 202 383 770 213
141 694 119 029 885 825 446 816 397 999 046 597 000 817 002 963
123 773 813 420 841 307 914 511 839 805 709 85, etc.

RATIO OF THE CIRCUMFERENCE OF A CIRCLE TO ITS DIAMETER, AS CALCULATED TO 707 DECIMAL PLACES BY MR. SHANKS.

[This is all one long number. Read across the first line first, then across the second, then across the third, and so on, just as in reading a book. The number is separated into groups of three figures each, merely to assist the eye in following the figures.]

circle would be, roughly speaking, five hundred million times as great in diameter as the entire visible universe,— would exceed it, in fact, in about the same proportion that the earth's equator exceeds a one-inch circle.

If we assume that Mr. Shanks' result is right as far as it goes, and inquire what error we should make, if we computed the area of this vast circle by means of Mr. Shanks' decimal, which runs only to 707 places, instead of the true one, which runs on forever, we shall be led to a rather surprising conclusion. We shall find, in fact, that the difference between the true area of the circle, and the area as calculated by Mr. Shanks' decimal, would be so small that it would have to be multiplied many millions of millions of times before it would be visible in our finest microscopes.

If the reader should ask whether it is really worth anybody's while to calculate the "circle decimal" to so many places, we should answer emphatically in the negative. Mr. Shanks spent an enormous amount of time and labor upon his calculation; but there must have been moments, after it was all over, when he would think with remorse of the many cords of good firewood he could have sawed up, if he had worked with the bucksaw half as assiduously as he did with his pen.

The Recent Cruise of the "Albatross."

Discoveries of great value to navigation and to science are reported by the United States Fish Commission steamship *Albatross*, which has just returned to San Francisco from a fourteen months' cruise in the South seas, and in Japanese and Alaskan waters.

The naval officers controlling the vessels have learned that nearly all of the South Sea islands are mischarted anywhere from two to a dozen miles, making steering by chart extremely dangerous. The exceptions are the Fiji group, owned by Great Britain, and the Tahiti group, owned by France.

In about the middle of Behring Sea they discovered a bank just two hundred fathoms below the surface, where the charts showed two thousand fathoms' depth. This bank is from five to ten miles in extent. The knowledge of its existence will permit navigators to try sounding in that part of the ocean when they wish to determine their bearings in cloudy weather. As the sky is sometimes overcast in those latitudes for days and nights continuously, the usual solar or astral observations are not always possible. Knowing that there is this extensive area only twelve hundred feet below the surface in latitude 54 degrees 30 minutes north and longitude 179 degrees 30 minutes east, confused captains may hereafter learn where they are in Behring Sea, if the lead strikes bottom where the charts show impossible soundings.

A world's record for deep-sea net-dragging was made about fifty miles east of the Tonga group of islands in latitude 20 degrees south. Specimens of marine life were brought up from a depth of four thousand two hundred fathoms, or nearly five miles. The greater previous record was less than three thousand fathoms. It was made by the British Scientific Deep-Sea Exploration steamer *Challenger* between 1873 and 1876. From the five-mile bottom the *Albatross* secured specimens simply of a low form of sponge life adhering to pumice stone, indicating neither a sandy nor a muddy bottom, but one of rough volcanic rock.

Wherever time and opportunity permitted in the southern group of islands the naval officers made careful hydrographic surveys to determine depths. At the same time they compiled sailing directions, which will enable navigators to steer accurately into many of the more important insular harbors. They also took magnetic observations in connection with these surveys.

All this reliable data will be properly presented upon new charts and marine maps to be issued by the government. The maritime nations of the world will profit by the published information.

Another scientific fact determined is that the temperature at the bottom of the ocean is uniformly a fraction above thirty-five degrees, or a little more than three degrees above the freezing point. This rule holds good for all depths from five hundred fathoms to four thousand two hundred fathoms, or from three thousand feet to five miles below the surface of the sea.

Aboard the *Albatross* is a remarkable illustration of deep-sea pressure. There is a hollow glass globe eight inches in diameter with walls three-eighths of an inch thick.

This globe was empty when it was sent down to a depth of twelve thousand feet, or nearly two and a half miles. When it came up it was three-fourths full of water, as it is yet. That water was forced through the thick, smooth, flawless glass. A bottle of wine, lowered deep to cool it, came up with the cork forced inside the bottle and the wine spoiled.

Shrimps in infinite variety were brought up from depths varying from a few yards to fifteen thousand feet. They ranged from little ones a half-inch in length to giant shrimps a foot long. All were edible. They were found wherever the nets were lowered among the South Sea islands, and off the southern coast of Japan. That shrimps live at great depths was not known before. In San Francisco bay, where the Chinese annually catch about $225,000 worth of shrimps for domestic and Oriental markets, the big nets are set at the bottom at depths of only twenty or thirty feet.

Specimens of red coral discovered deep in the Arctic Ocean are among the curios on the *Albatross*. They proved to the scientific world that red coral is not found solely in the temperate Mediterranean Sea. This discovery was made on a previous voyage, but it never gained publicity.

Good weather and clear skies last June, all the way across from Kamchatka on the Asiatic coast to Unalaska on the North American coast, enabled the officers of the *Albatross* to make daily solar observations. This exceptional opportunity for accurate bearings convinced the observers that there are not strong currents out in the Behring Sea as was generally supposed. The currents are strong inshore or near straits.

South of the equator the *Albatross* brought up from the bottom of the ocean fossil bones from whales and fossil teeth of sharks. These specimens are thought to have lain on the floor of the sea for thousands of years.

During the investigations off the south coast of Japan the *Albatross* entertained two Japanese government scientists. They knew much about the marine life, but they had never seen such effective apparatus and appliances as those used by the United States fish experts.

As a general result of the fourteen-months' cruise, the *Albatross* has a cargo of thousands of marine specimens pickled in formaline. These will be sent to Washington. Thence some of them will be distributed to experts all over the world for classification and study, and for scientific collections. There are sea freaks by the hundred, marine animals and fish with eyes out on the ends of long tentacles that permit them to look around corners, deep-sea things that are mostly eyes, silicious sponges that look like hollow footballs made of clear yellow honeycomb, curious star-fish that look like miniature cocoa-nut palm trees, and an endless number of fishes of many varieties.

The *Albatross* is a trim white vessel two hundred and fifteen feet long, and carries a complement of sixty men. She is commanded by Commander Jefferson F. Mosher of the United States Navy. When she left San Francisco fourteen months ago to begin her latest cruise, she took, in addition to her present officers and crew, a little party of government scientists, chief of whom was Professor Alexander Agassiz. These scientists left the vessel at Japan and returned to America months ago, their particular work having been completed.

From San Francisco the *Albatross* went southwestward to the Marquesas Islands in the South seas and then thoroughly explored the neighboring Paumotu group. Then she steamed westward to the Society Islands, then westward again to the Cook Islands, and west once more to the Tonga Islands, where the deep haul was made, then northwestward through the Fiji Islands to the Ellice Islands, then through the Gilbert Islands and the Marshall Islands to the northwestward, then westward through the Caroline

Islands, touching at Guam last February, then to Yokohama. In May the *Albatross* explored the south coast of Japan to the southward and westward. Then she cruised along through the archipelago known as the Kurile Islands, stretching from Japan to the peninsula of Kamchatka. A stop was made at the Russian town of Petropavlovski, near the southeastern end of Kamchatka. Thence the route was eastward across the Behring Sea to Unalaska and the Aleutian Islands. From Unalaska southward the ship was engaged in salmon work through Bristol Bay, along the southern shores of the Alaskan peninsula and throughout the southeast of Alaska.

Many of the islands of the Paumotu, the Ellice, the Marshall, and the Caroline groups were accurately re-charted by the officers of the *Albatross*, and will be given their proper positions on new maps. The investigations seemed to show that hundreds of islands have simply been sketched in place on charts by sea captains and never correctly located. This is why they are miles out of the way. The entire cruise was without storm or serious accident or notable occurrence other than the discovery of unexpected things. — *San Francisco Chronicle*.

Stop Valves and Inspections.

In the October issue of THE LOCOMOTIVE, under the heading "Don't Touch the Valves," we told of an accident near Scranton, Pa., in which a man was very severely scalded by the accidental opening of a main stop valve on the boiler he was inspecting; and we counseled boiler room attendants never to touch any valve whatever, when the inspector is around, until he has come out of the last boiler, and has reported that he is through with the internal examination.

A correspondent, who observed this item, writes as follows: "I once saw just this thing occur in a rolling mill with which I was connected, and have always thought that the only safe way is to put locks on the valves of boilers into which a workman goes for any purpose. I suggest that your inspectors carry bicycle locks with them for this purpose. No one would be inclined to break such a lock, and a precaution of this kind would be a sure check to carelessness of this sort."

The suggestion here made is well worth attention. We can understand that an inspector might prefer to take his chances rather than to bother with locks; or that he might regard the use of a lock as evidence of undue timidity and might decline to use it on that account, even though he might admit the idea to be a good one, when considered as an abstract proposition. Every man will have to decide these points for himself; but we take pleasure in printing our correspondent's suggestion for the benefit of any who may choose to adopt it.

IN *Modern Machinery* for October 1, 1900, we find an article on "Boiler Explosions" by Mr. W. H. Wakeman, which ought to be of some service in educating the readers of that journal out of the idea that boilers never explode except from low water. We do not mean to imply that the readers of *Modern Machinery* are at all more likely to entertain this erroneous belief than any other class of readers, but we have found that many very intelligent men believe that there is no risk whatever if plenty of water is present. These same men would not claim that a rope supporting a weight could not break unless it caught fire; they would admit, of course, that the amount of the load and the age and condition of the rope would also be potent factors in determining its safety. It is hard to understand how they can admit so many causes of failure for a rope (for example) and yet maintain that there is only one thinkable reason why a boiler can give way.