HARTFORD STEAM BOILER ★ INSPECTION AND INSURANCE CO. ★

HARTFORD,

CONN.

The Locomotive.

PUBLISHED BY THE

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

NEW SERIES.
Vol. X.

HARTFORD, CONN.
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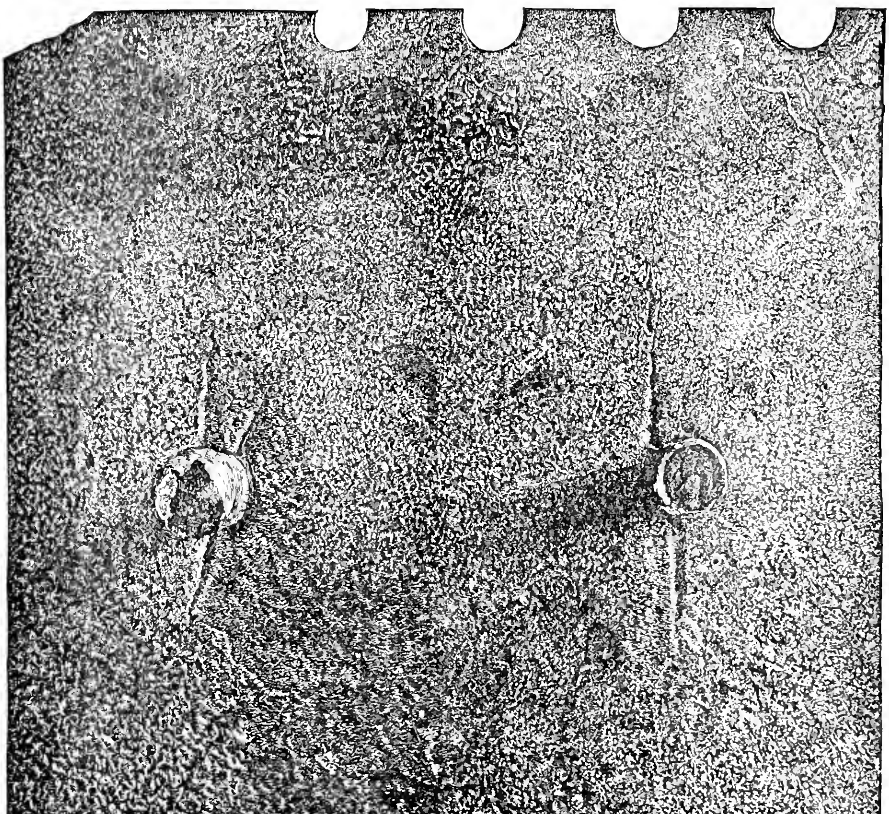
Corrosion Around Stay Bolts.

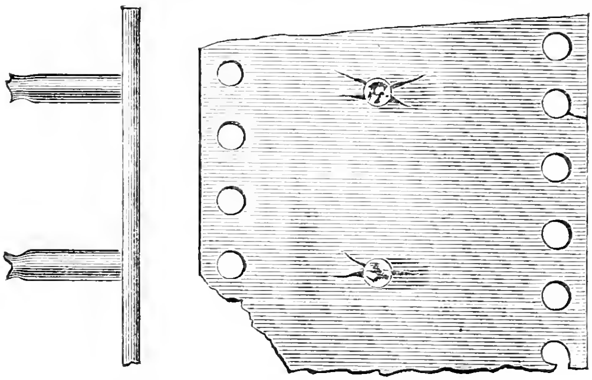
Around the stay bolts of water legs, or furnaces, curious grooves are often found in the plates, radiating from the bolts as centers. This kind of corrosion is well illustrated in Fig. 1, which shows the water side of a piece of metal recently cut from a fire-box subjected to considerable strain. The plate, undoubtedly, bent backward and forward



CORROSION AROUND STAY BOLTS.—FIG. 1.

slightly under the varying pressures, and though the flexure, and consequent alteration of the surface, was probably too small to be seen, it is easy to believe that it was sufficient to open up the fibres to the water in certain directions, rather than in certain others. Judging from the appearance of the plate, it seems likely, also, that in tapping out the holes for the stay bolts, strains were brought to bear on the plate, which disturbed the skin of the iron and afterwards hastened the corrosion. The effects of apparently unimportant strains are often much greater than one who has not studied them would readily believe. We have already shown that surface markings on iron plates may often be reproduced with considerable distinctness, by simple immersion in acid, even after they have been planed off, and the metal polished until its surface appears to be perfectly uniform. (See the LOCOMOTIVE for JULY, 1884.)

In the case illustrated in Fig. 1, the boiler often lay idle for a considerable time, and the water that was used was rather impure, so that the action was naturally more



CORROSION AROUND STAY BOLTS. — FIG. 2.

rapid than it would be under less favorable circumstances ; but the same thing takes place with the purest water, provided there is sufficient strain upon the bolts to disturb the arrangement of the surface particles. In cases of this kind there is no external evidence of the condition of things inside, for the exterior looks perfectly sound.

Fig. 2 represents a portion of the inner plate of a water leg of a locomotive boiler. The furrows in this case were quite deep, and looked as though they had been cut by a tool ; and the stay bolts had been corroded entirely off at the outer ends.

Inspectors' Reports.

NOVEMBER, 1888.

In the month of November, 1888, our inspectors made 4,467 inspection trips, visited 8,606 boilers, inspected 3,216 both internally and externally, and subjected 642 to hydrostatic pressure. The whole number of defects reported reached 6,835, of which 555 were considered dangerous; 38 boilers were regarded unsafe for further use. The defects in detail were as follows:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	378	25
Cases of incrustation and scale,	672	30
Cases of internal grooving,	50	12
Cases of internal corrosion,	210	32
Cases of external corrosion,	463	45
Broken and loose braces and stays,	95	31
Settings defective,	212	23
Furnaces out of shape,	250	8

Nature of Defects.	Whole Number.	Dangerous.
Fractured plates,	167	36
Burned plates,	126	28
Blistered plates,	263	26
Cases of defective riveting,	1,679	44
Defective heads,	60	11
Serious leakage around tube ends,	1,276	119
Serious leakage at seams,	303	16
Defective water-gauges,	220	12
Defective blow-offs,	47	9
Cases of deficiency of water,	18	5
Safety-valves overloaded,	27	7
Safety-valves defective in construction,	61	13
Pressure-gauges defective,	223	21
Boilers without pressure-gauges,	2	2
Unclassified defects,	33	0
Total,	6,835	555

December, 1888.

During this month our inspectors made 4,353 inspection trips, visited 8,628 boilers, inspected 3,239 both internally and externally, and subjected 461 to hydrostatic pressure. The whole number of defects reported reached 7,419, of which 629 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,	479	17
Cases of incrustation and scale,	727	31
Cases of internal grooving,	61	9
Cases of internal corrosion,	283	30
Cases of external corrosion,	479	57
Broken and loose braces and stays,	178	62
Settings defective,	260	18
Furnaces out of shape,	259	9
Fractured plates,	242	52
Burned plates,	134	19
Blistered plates,	349	13
Cases of defective riveting,	1,620	66
Defective heads,	76	13
Serious leakage around tube ends,	1,233	85
Serious leakage at seams,	375	50
Defective water-gauges,	218	22
Defective blow-offs,	63	6
Cases of deficiency of water,	33	7
Safety-valves overloaded,	56	22
Safety-valves defective in construction,	38	16
Pressure-gauges defective,	236	19
Boilers without pressure-gauges,	5	5
Unclassified defects,	15	1
Total,	7,419	629

SUMMARY OF INSPECTORS' REPORTS FOR THE YEAR 1888.

We present herewith a summary of the work done by the inspectors during the past year, and, for comparison, we give the corresponding summary for 1887:

	1887.	1888.
Visits of inspection made,	46,761	51,483
Total number of boilers inspected,	89,994	102,314
" " " " " internally,	36,166	40,240
" " " " tested by hydrostatic pressure,	5,741	6,536
" " " defects reported,	99,642	91,567
" " " dangerous defects reported,	11,522	8,967
" " " boilers condemned,	622	426

The following is the analysis in detail of defects reported during the year 1888:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	6,199	353
Cases of incrustation and scale,	9,262	473
Cases of internal grooving,	502	122
Cases of internal corrosion,	3,649	399
Cases of external corrosion,	6,010	437
Broken and loose braces and stays,	1,484	306
Settings defective,	2,394	178
Furnaces out of shape,	3,045	115
Fractured plates,	2,178	634
Burned plates,	1,702	255
Blistered plates,	3,226	177
Cases of defective riveting,	22,747	1,588
Defective heads,	1,404	192
Serious leakage around tube ends,	15,122	2,065
Serious leakage at seams,	4,552	417
Defective water-gauges,	1,703	238
Defective blow-offs,	682	141
Cases of deficiency of water,	168	54
Safety-valves overloaded,	473	146
Safety-valves defective in construction,	542	176
Pressure-gauges defective,	3,208	361
Boilers without pressure gauges,	92	59
Miscellaneous defects,	1,223	81
Total,	91,567	8,967

GRAND TOTAL OF THE INSPECTORS' WORK SINCE THE COMPANY BEGAN BUSINESS, TO JANUARY 1, 1889.

Visits of inspection made,	450,262
Whole number of boilers inspected,	901,896
Complete internal inspection,	330,347
Boilers tested by hydrostatic pressure,	64,496
Total number of defects discovered,	614,140
" " " dangerous defects,	101,989
" " " boilers condemned,	5,722

Boiler Explosions.

December, 1888.

Donkey Engine (208). The boiler of the donkey engine in use at H. A. Stevens's coal yard, on South Front Street, Fair Haven, blew up on Wednesday, Dec. 5th. The explosion destroyed the engine and boiler, and blew the shanty in which the machinery was located, in every direction. The noise of the explosion was heard a long distance away. The engineer, Thomas Hempstock, was somewhat injured, but not seriously so.

Iron Works (209). A boiler exploded at the Shelby Iron Works, Shelby, Ala., on Dec. 6th, killing three men.

Bituminous Rock Heater (210). On Dec. 7th, Mark Bates was standing before a steam boiler used to melt bituminous rock, at San Diego, Cal., when it exploded, blowing him twenty feet and literally cooking his flesh. He died in five minutes.

Steam Yacht (211). An explosion took place on the fast Herreshoff yacht, *Say When*, off Hope Island, Narragansett Bay, on Dec. 8th, while she was making her trial trip. Charles F. Newman, fireman, was fatally injured, and George C. Horton, engineer, was fearfully scalded about the face and arms. The *Say When*, disabled, was picked up by a tugboat and taken to Bristol. The boiler was of the well-known Herreshoff safety coil type.

Feed Mill (212). The explosion of a boiler in Strohel & Hamon's feed mill at Trowbridge, Ohio, on Dec. 10th, killed Henry Hamon and Albert Kline, and badly injured Wallace Strohel and a boy. The mill was wrecked.

Oatmeal Mills (213). An explosion occurred at the oatmeal mills, corner of Halstead and Fulton Streets, Chicago, at 2 o'clock on the morning of Dec. 11th, and the building was soon wrapped in flames. Several lives were lost.

Saw-Mill (214). On Wednesday afternoon, Dec. 12th, a boiler exploded in Wilcox Mills, near Evergreen, Ala., killing four persons. Five others were wounded, but their names were not learned. The property was valuable, and is now a total wreck. The dead were horribly mutilated, and it is said that parts of their bodies were found four hundred yards away.

Machine Shop (215). On the afternoon of Dec. 12th, a boiler exploded in the shop of William Bonner, at the corner of North Main and Read Streets, Providence, R. I. The top went up into the ceiling, striking directly beneath a boiler in the works of Samuel Crane, breaking the main steam pipe and damaging the engine. No one was killed, and the damage was small.

Cotton Gin (216). A boiler explosion on Dec. 13th, in G. W. Turner's cotton gin, near Montgomery, Ala., killed George Turner and two negroes. Seven other persons were wounded.

Cotton Gin (217). In Selma, N. C., on Dec. 14th, the head of Mr. B. L. Aycock's boiler blew out, breaking the arm of his son, Mr. Charles Aycock, in two places, and inflicting a dangerous wound on his head. The fireman and three others were also injured, some of them seriously.

Steam Heating Apparatus (218). Mr. T. L. Aldrich was heating water for live stock, in Woodville, Mass., on Dec. 16th, and as he reached up to open a valve, the boiler exploded. He was seriously but not fatally burned about the face and arms.

Steam Tug (219). On December 17th, the steam tug *Susie* was bought by the Fox Island clay works, situated near Tacoma, W. T. Two days later, while she was being looked over by her purchasers, her boiler exploded with great violence, shattering her hull to the water's edge, so that she sank in a few minutes. The president of the company was blown over a high pile of lumber, and across an eighty-foot wharf, striking the water again fully 100 feet from the tug. He was badly cut and bruised, and severely scalded about the back and legs. The captain of the steamer was found on the edge of a boom of logs. He was badly disfigured, and will probably die. His brother, who was present, was badly scalded, and was picked up in the water 100 feet away. The engineer, who escaped without injury, made off into the woods after the accident, and could not be found. He was a new hand, in place of the regular engineer, who was away to be married. The new man is blamed for the accident, as the boilers and machinery had been inspected before the purchase. The *Susie* was a twin-screw propeller, 100 feet long.

QUARTZ MILL (220). One of the boilers in a ten-stamp quartz mill in Silver Creek, Nevada, exploded on December 18th, while the men were at dinner. The mill was badly damaged and another boiler that stood by the side of the exploded one was thrown about 300 yards, out into a salt marsh. The boiler that exploded had bagged over the fire. No one was in the mill at the time of the explosion, and no one was injured.

SPOKE FACTORY (221). The large boiler in the spoke factory of Emmett & Sons, at Mount Vernon, Ind., exploded on Dec. 20th. James Lett, of Columbus, was instantly killed, and James Lee, Joshua E. Low, Andy Jones, and Charles Reed were fatally wounded. Several other employees were injured.

STAVE FACTORY (222). On Dec. 21st, the boiler in Bracken's stave factory, Frankfort, Ind., exploded, killing Martin Nolan, the engineer. Walter Fenstemacher and Albert Franty were mortally wounded. Nolan was a married man, and leaves a widow and two children.

HORSE RADISH GRATER (223). A small boiler exploded in East Hartford on December 21st. The man in charge was struck on the forehead by a fragment, and had a narrow escape from death. The water in the boiler had probably frozen during the night and broken the stays.

LUMBER YARD (224). Rufus Swett, 32 years old, was killed by the explosion of a boiler in the lumber yard of Warren J. Case & Co., at Milbrook Thornton, near Plymouth, N. H., on December 22d. He leaves a wife and three children.

HEATING APPARATUS (225). The boiler used for heating the Eagle Bridge Hotel, near Troy, N. Y., exploded on Dec. 22d, severely injuring seven persons who were in the waiting-room of the Delaware & Hudson railroad, which is in the hotel. Station Agent Reynolds was badly scalded, and two ladies were dangerously injured. The loss on the boiler and building is about $1,000.

SAW-MILL (226). An explosion occurred near Gold Hill, twenty-nine miles from Denver, on Dec. 22d, which resulted in the instant death of four men and the scalding of another. The mill hands had gone to work early, and, wishing to do a big day's work, they fired up with low water in the boiler in order to get steam quickly. When the pressure reached 115 pounds the boiler foamed badly and cold water was pumped in. Those killed are: Andy McDonald, whose head was blown off, and A. Barnard, Adam Nodlett, and —— Niles. Another man was badly scalded.

LOCOMOTIVE (227). Engine No. 52, on the Cincinnati, Washington & Baltimore railroad, left Blanchester, Ohio, at 9:15 A. M., on Dec. 24th. When it was about one mile west of the town the boiler exploded with a loud report, tearing out the two front sheets of the shell, and completely wrecking the engine. Engineer Rother's hand was slightly injured, but otherwise nobody was hurt.

Flouring Mill (228). The mud drum under two boilers in the National Flouring Mill, San Francisco, burst on December 26th. The boilers were under 80 pounds of steam, and the engineer, who was firing up at the time, was badly scalded. The setting of the boilers was ruined, but very little damage was done otherwise. The opening is only nine inches by twelve, and was caused by external corrosion.

Sugar Refinery (229). The boiler in W. M. Lonsdale & Co.'s molasses and sugar refinery, New Orleans, exploded on Dec. 27th, doing considerable damage to the building and injuring three of the employees. In its flight the boiler passed through two twelve-inch brick walls, and the shell was found seventy-five feet away from its original position.

Shingle Mill (230). The boiler in Dush's shingle mill, near Millbrook, Mich., exploded at 6 a. m., on Dec. 31st, killing W. W. Dush, the proprietor, and John Carr, the night watchman. A man named Miley was fatally injured, also. The whole establishment is a complete wreck.

Correcting Thermometers.

(Concluded from December Number.)

The first step is to separate from the column of mercury in the tube, a portion which shall occupy about 10° of the scale. This may at first sight appear to be a difficult matter, but it is very easily done. Invert the tube and tap the end on the table, it will separate at some point, and a portion will run down the tube. The point of separation will nearly always be determined by a minute air bubble adhering to the side of the tube. If the mercury runs out of the bulb and fills the tube without breaking, turn the tube up and let the mercury run back into the bulb; an air bubble will always be found here, which with a little patient manipulation may be made to ascend to the neck of the tube, when by again inverting the tube the column will separate at this point. Sometimes a vigorous shaking up of the tube so as to agitate the mercury will produce the same effect. The portion which now separates will generally be longer than is wanted, but it can be "cut off" to any desired length as follows: Suppose the piece which has separated is two inches long, and we want a piece three-fourths of an inch long. Heat the bulb, still keeping the tube inverted, and the column separated, until that portion connected with the bulb has risen (or descended, as the tube is in an inverted position) $1\frac{1}{4}$ inches. The end of the column of mercury will push the air-bubble before it. When it has descended $1\frac{1}{4}$ inches, quickly bring the tube to the upright position, and bring the separated portions of the column together. A slight tap on the table may be necessary to bring them into contact. The mercury in the bulb now contracts, while the air-bubble sticks to the side of the tube, and the mercury flows past it. When it has regained its former temperature, again invert the tube, when the column will separate at the air-bubble, and we shall have a thread of the required length, if the operation has been dexterously performed. If it has not, one or two repetitions will usually suffice to separate a portion of the desired length.

Having a thread of the required length we now proceed to bring it to different portions of the tube by inclining the tube, and measuring its length in the various positions. It is evident that the length of the division of the scale, instead of being of uniform length, must be *inversely* proportional to the area of the bore of the tube, or what is the same thing, directly proportional to length of the thread of mercury in the various corresponding portions of the tube. The method usually followed is to use the scale, which accompanies each instrument, and determine the error for each degree. A table of these errors is kept to refer to. Our method of procedure with common thermometers is to discard entirely the original scale, and make a new one. This is most conveniently done by marking it on the back of the original scale. The first method requires less labor, and is the more accurate one. The second makes the after use of the thermometer much more convenient, and is sufficiently accurate for all practical purposes, where scientific exactness is not necessary. It has the great advantage of not requiring any special or refined apparatus or calculations, and may therefore be easily performed by any one. It gives very good results, and where geater accuracy is essential, it is always better to send the thermometer to some physical laboratory and have it compared with some standard thermometer by trained observers.

If we are graduating to the Fahrenheit scale, separate as above described, a portion of the mercury which shall occupy *about* 10 degrees of the scale. Divide the interval between the freezing and boiling points into eighteen equal parts, mark these divisions with a pencil, each division is then equal to approximately 10 degrees. Bring the separated column of mercury into each one of the divisions and measure its length. Then make the permanent spaces for each 10 degrees proportional to the length of the column measured when it occupied that particular division. Divide each 10° space into ten equal spaces for the degrees, and the operation is complete.

Suppose, for example, the distance from freezing to boiling points is $6\frac{3}{4}$ inches. $6\frac{3}{4}''$ divided by 18 equals $\frac{3}{8}''$, the space occupied by 10° on the scale. Mark on the scale with a pencil these 18 divisions, making each $\frac{3}{8}$ of an inch long. Separate a portion of the mercury column *about* $\frac{3}{8}$ of an inch long; *exactness* is unnecessary. Then bring it to coincide with each division successively, and measure its length in each. Suppose we find these lengths as follows :—

1st	division,	from	32°	to	40°	the	mercury	measures	.39″
2d	"	"	42	"	52	"	"	"	.395
3d	"	"	52	"	62	"	"	"	.40
4th	"	"	62	"	72	"	"	"	.40
5th	"	"	72	"	82	"	"	"	.40
6th	"	"	82	"	92	"	"	"	.39
7th	"	"	92	"	102	"	"	"	.40
8th	"	"	102	"	112	"	"	"	.405
9th	"	"	112	"	122	"	"	"	.41
10th	"	"	122	"	132	"	"	"	.41
11th	"	"	132	"	142	"	"	"	.41
12th	"	"	142	"	152	"	"	"	.415
13th	"	"	152	"	162	"	"	"	.415
14th	"	"	162	"	172	"	"	"	.41
15th	"	"	172	"	182	"	"	"	.41
16th	"	"	182	"	192	"	"	"	.415
17th	"	"	192	"	202	"	"	"	.42
18th	"	"	202	"	212	"	"	"	.42
									7.315″

Take the sum of the lengths of the mercury column as found by measurement, which in this case is 7.315 inches, and find the correct length of each 10 degree division by proportion as follows :—

7.315 : 6.75 :: .39″ : .359 = the 10° from 32 to 42.
7.315 : 6.75 :: .395 : .365 = " 10° " 42 to 52.
7.315 : 6.75 :: .4 : .369 = " 10° " 52 to 62.

And similarly we find the length of the remaining divisions.

From	62°	to	72	=	.369″
"	72	to	82	=	.369
"	82	to	92	=	.359
"	92	to	102	=	.369
"	102	to	112	=	.374
"	112	to	122	=	.378
"	122	to	132	=	.378
"	132	to	142	=	.378
"	142	to	152	=	.383
"	152	to	162	=	.383
"	162	to	172	=	.378
"	172	to	182	=	.378
"	182	to	192	=	.383
"	192	to	202	=	.388
"	202	to	212	=	.388
Total,					=6.748″ within $\frac{1}{500}$″ of $6\frac{3}{4}$

The sum would come out exactly $6\frac{3}{4}$″ if the operation is carried far enough, but $\frac{1}{500}$″ is within the limit of error in reading the thermometer, or marking the scale by ordinary means.

These divisions are now marked permanently on the scale, divided in degree marks, and the thermometer is corrected accurately enough for all practical purposes.

H. F. S.

The Microscopist's Serenade.

O come, my love, and seek with me
  A realm by grosser eye unseen,
Where fairy forms will welcome thee,
  And dainty creatures hail thee queen.
In silent pools the tube I'll ply,
  Where green conferva-threads lie curled,
And proudly bring to thy bright eye
  The trophies of the protist world.

We'll rouse the stentor from his lair,
  And gaze into the cyclops' eye;
In chara and nitella hair
  The protoplasmic stream descry,
Forever weaving to and fro
  With faint molecular melody;
And curious rotifers I'll show,
  And graceful vorticellidæ.

Where melicertæ ply their craft
  We'll watch the playful water-bear,
And no envenomed hydra's shaft
  Shall mar our peaceful pleasure there;
But while we whisper love's sweet tale
  We'll trace, with sympathetic art,
Within the embryonic snail
  The growing rudimental heart.

Where rolls the volvox sphere of green,
  And plastids move in Brownian dance,—
If, wandering 'mid that gentle scene,
  Two fond amœbæ shall perchance
Be changed to one beneath our sight
  By process of biocrasis,
We'll recognize, with rare delight,
  A type of our prospective bliss.

O dearer thou by far to me
  In thy sweet maidenly estate
Than any seventy-fifth could be,
  Of aperture however great!
Come, go with me, and we will stray
  Through realm by grosser eye unseen,
Where protophytes shall homage pay,
  And protozoa hail thee queen.

Jacob F. Henrici.

The Locomotive.

HARTFORD, JANUARY, 1889.

J. M. ALLEN, *Editor.*

H. F. SMITH, A. D. RISTEEN, } *Associate Editors.*

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.

THE "Microscopist's Serenade," given on another page, is from our editorial scrap book. We regret that we cannot give proper credit for it, as we do not know where it first appeared.

Obituary.

GEORGE W. ROGERS.

We are pained to announce the death of George W. Rogers, Chief Inspector of our Southern Department, which occurred on the 10th of December, at Charleston, S. C. He was ill with pneumonia but a few days, and his death so sudden was a surprise to all his friends. In early life Mr. Rogers learned his trade at the works of Woodruff & Beach in this city, naturally choosing mechanical and steam engineering. His grandfather, Capt. Moses Rogers, commanded the *Savannah* on her first trip across the Atlantic Ocean (this was the first ship that crossed the Atlantic Ocean propelled by steam), and his father was the engineer of the ill-fated steamer *Arctic*, of the Collins Line, which was lost at sea many years ago. After finishing his trade young Rogers was appointed engineer in the United States service, and was on the *Niagara* when the negro captives were returned to Africa after having been landed in this country as slaves. He was in the naval service during the war, and was commended for efficiency and intrepidity. He entered the service of the Hartford Steam Boiler Inspection and Insurance Company about eight years ago, and had always proved an able and efficient member of the inspection corps. When the Southern Department of the company's business was established, he was appointed chief inspector of it, and this office he filled up to the time of his death. Mr. Rogers was a genial, companionable man. He made many friends and was widely known the country over. In his death this office loses an honest and capable officer, and his associates a firm and faithful friend.

WE have before us a map of the planet Mars, constructed from observations made by the Italian astronomer Schiaparelli. Maps of this interesting little world have been made before, but this one excels in the amount of detail shown; and such careful work has been done by Schiaparelli and others that we actually know more about the geography of the polar regions of Mars than we do about that of our own polar regions, especially in our southern hemisphere.

The things that are known about our neighbor, thus far, are extremely interesting and suggestive. There is water over there, certainly; for the spectroscope tells us that. There is some kind of an atmosphere, also, for we can distinguish masses of cloud and even trace the course of storms. It seems to be comfortably warm there, too; for there is nowhere near the amount of snow about the poles that there is about our own poles.

We can see continents and islands, and undoubtedly there are mountains and valleys on them, and so we have every reason to believe that there are rivers and lakes. And, strangest of all, the continents are crossed in many directions by dark streaks about forty miles or so wide, running from sea to sea. No one knows what these streaks are. They do not look like natural formations, yet who can say what Nature may be doing on this other world, so many millions of miles away? If they are not natural formations, then Mars is undoubtedly inhabited by a remarkable race of beings, whose skill in engineering is vastly greater than our own. Years must elapse before the mystery can be solved, but if it can be shown to be probable that our neighbor is inhabited by intelligent creatures, who are watching us, perhaps, as we are watching them, there can be no doubt that we shall find some way of communicating with them.

Light Without Heat.

great many experimenters are now trying to find out some way of producing light without producing heat at the same time. If this can be done at all it will probably lessen the cost of lighting our streets and buildings very considerably. Some years ago James Clerk Maxwell advanced the theory that light is a sort of electrical disturbance of the ether that is supposed to fill space. This theory, though not yet rigorously proven, is supported by a great deal of evidence — in fact, by all the evidence we have. We know, for instance, that light and electric induction are propagated by the same medium, and with the same velocity. We know, further, that each consists of wave-like motions, or strains, in that medium; and that the waves of both are transverse and unlike those of sound. There are other reasons, too, for believing that Maxwell's theory is correct, and that the difference between light and electric induction is the period of their respective waves. If this is a fact, it is evident that if we could charge and discharge a Leyden jar rapidly enough it would break out and shine with a brilliancy that would depend only on the intensity of the electricity supplied to it. Now it is believed to be possible to charge and discharge such a jar a thousand million times a second, which would be the same as sending a thousand million waves a second out into space; yet this rapidity, though it is utterly inconceivable to the human mind, is stillness itself compared with what is required to produce light, and it must be increased at least *four hundred thousand fold* before it can produce the faintest glimmer.

Grim as the outlook is, we can take courage from the fire-flies, for they seem to have overcome the difficulties somehow. Maxwell's theory, if correct, is a stupendous generalization; and though it has been of no use to us yet, some way of applying it in the arts must soon be discovered. The possibility that it suggests, of transmitting light by electricity as we now transmit sound, is curious and interesting; and it would be a novel experience to stroll the streets of Hartford on a summer evening, bathed in light shining somewhere in China.

Electric Power.

A great many people seem to think that the days of steam are numbered, and that electricity is to supplant it as soon as inventors have sufficiently reduced the cost of the apparatus and secured the proper efficiency. This belief is partially correct, when taken in a certain sense ; but when taken literally it is in error. Electricity, as a prime mover, is still in extreme infancy; for there are problems involved in its use that are much more difficult than the mere reduction of the cost of installation, and the securing of efficient motors: in fact, we shall probably find these the easiest to solve of all. Before steam can be dethroned, a great principle must be discovered: a method of generating electricity directly, by the combustion of coal, and not indirectly as at present. This principle has been approached from various directions, and we have thermopiles, primary carbon batteries, calelectric generators, and pyromagnetic motors; but thus far we have had only a glimpse of the incalculable possibilities, while the main problem is still before us.

In another way, however, electricity promises to be of great service to us. It is a recognized fact that power can be developed at large central stations, and transmitted to small users, with greater efficiency than these users could produce it themselves by small local engines; and it is this fact, principally, that creates the great field now open to electricity. There are numerous industries, too, where the electric motor is valuable on account of its simplicity and cleanliness, and where it could be used with advantage, even if the cost of running it should be somewhat greater than the cost of steam.

As an agent for transferring energy, there is much for the subtle fluid to do; but as a prime mover it is, as yet, exceedingly expensive and unprofitable.

Heating and Ventilation.

A great many mistakes are made in these things, and we are often consulted with regard to the heating of dwellings and other buildings by steam. The changes that may be desirable can usually be made without much difficulty when the heating is direct; but in indirect heating we often find that the expense of altering the system so as to bring it into proper arrangement and proportion, greatly exceeds the first cost of it; for the mutilation of nicely-finished rooms in cutting out the walls so as to secure sufficient area in air ducts, is serious business. The ducts can be properly constructed when building without one cent of extra expense, and architects and builders should see that this is done; or, if the individual who proposes to build would first consult some specialist on heating and ventilation, disappointment and failure might be easily avoided.

One example will show how far out of proportion some of the arrangements of flues are that are to be met with. In examining a dwelling heated wholly by the indirect system, we found the surface of the radiator stacks ranging from 80 to 160 square feet, and the hot-air ducts all one size — four inches by ten, or forty inches in area — and cased up in the brick walls. The cold-air boxes were in better proportion, but would not have been sufficient for the stacks had proper hot-air flues been put in. Another defect that is often found is that there is no closure between the stacks and boxes, cold air passing up all around the heated coils, and not through them as it should.

We give below a table of openings for registers and cold-air ducts, which has been found to give very satisfactory results. The cold-air boxes should have 1½ square inches area for each square foot of radiator surface, and never less than ¾ the sectional area of the hot-air ducts. The hot-air ducts should have 2 square inches of sectional area to each square foot of radiator surface on the first floor, and from 1½ to 2 inches on the second floor.

Heating surface in stacks.	Cold air supply first floor.	Size register.	Cold air supply, second floor.
30 square feet.	45 square inches = 5″ by 9″	9″ by 12″	4″ by 10″
40 " "	60 " " = 6″ by 10″	10″ by 14″	4″ by 14″
50 " "	75 " " = 8″ by 10″	10″ by 14″	5″ by 15″
60 " "	90 " " = 9″ by 10″	12″ by 15″	6″ by 15″
70 " "	108 " " = 9″ by 12″	12″ by 19″	6″ by 18″
80 " "	120 " " = 10″ by 12″	12″ by 22″	8″ by 15″
90 " "	135 " " = 11″ by 12″	14″ by 24″	9″ by 15″
100 " "	150 " " = 12″ by 12″	16″ by 20″	12″ by 12″

The sizes in the table approximate to the rules given, and it will be found that they will allow an easy flow of air and a full distribution throughout the room to be heated.

The Manufacture of Paper.

We make the following extracts from a pamphlet called *A Sheet of Paper*, issued by the L. L. Brown Paper Company, of Adams, Mass. The entire pamphlet is well worth reading, and those interested in paper will find it worth their while to secure a copy: —

The rudimentary art of paper making was acquired by the Arabians, from the nomadic tribes of Buckharia; and Damascus appears to have been one of the first cities where paper was made, for it was known at that time as "Carta Damascene." There was a manufactory established at Samarcand as early as the year 648, for making paper, and about the same time there was one in Mecca; and when the Moors invaded Spain, they carried with them the knowledge of the art. From Spain linen paper passed into France, in the year 1290. It was carried into Germany in 1312, reached England in 1320, and in the year 1690 John Rittenhuysen, a native of Holland, built the first paper mill in America at Roxboro, Pa. The first machine was invented by a Frenchman, Louis Robert. In 1806 another Frenchman — Fourdrinier by name — perfected a self-acting machine which, with improvements, is the one used to-day, and known as the Fourdrinier machine.

The difference between hand and machine-made papers, lies in the manipulation of the sheets. In making a sheet of paper by hand, the pulp, made from rags by the usual process of washing and beating, is emptied into an open vat, along with a considerable quantity of water. Into this vat, the workman dips a mold or framed piece of wire cloth, which he holds in both hands at an inclination of about 65°, and taking up a sufficient quantity of pulp, he raises it horizontally, the frame or deckle holding it upon the wire cloth. A double oscillating motion is imparted to the frame, distributing the pulp with beautiful uniformity over the entire surface of the mold, and intertwining the fibres. Gradually the water drains through, and the pulp solidifies and assumes a peculiar, shiny look, which indicates to the experienced eye the completion of the first process. The frame or deckle is then removed, and the mold is laid upon a woolen felt or blanket, to which the wet sheet or pulp adheres as the mold is lifted away. Another felt is spread over this, upon which the next sheet of pulp is laid, and this is continued, alternating the layers of felt and paper, until a sufficient number are accumulated to form a "post"; after which the whole is carried to a press, and subjected to varying degrees of pressure, suitable to the purpose and finish of the sheets to be made. After this come the sizing, drying, and other finishing processes.

In taking a retrospective view of the early days, we are struck with wonder at the changes that have taken place in the old-time method of production. Prior to 1816 the manufacture of paper in the United States was carried on entirely by hand. By this slow, laborious process, it took five persons a day to make three reams. The same quantity is now produced in fifteen minutes. Upon the introduction of machinery for forming rag pulp into sheets of paper, making by hand was practically abandoned. The deckle-edged paper disappeared from the markets, and skilled artisans who could give the "old-time shake" to the mold, had passed away. A modern paper-making machine will turn out a sheet of ordinary newspaper, from sixty to ninety inches wide, at the rate of 150 to 200 feet a minute — that is, more than twenty miles of it in a working day of ten hours. There are thirty mills in the Ohio Valley to-day, producing daily 180 tons of paper, of various grades; but about 90 per cent. of the writing paper made in the United States comes from Massachusetts.

A word as to how the water mark is produced. The mold or wire frame, on which the pulp is formed, is raised where it is desired to stamp the water mark, making the layer of pulp thinner there than in other portions of the mold, so that the design remains impressed in each sheet.

Wrought Iron Welded Pipes for Gas, Steam, or Water.

TABLE OF STANDARD DIMENSIONS.

(*Morris, Tasker & Co., Limited.*)

1¼″ and below, butt welded, 1½″ and above, lap welded. Proved to 300 lbs. per sq. inch by hydraulic pressure.

Nominal Size.	Actual Inside Diameter.	Actual Outside Diameter.	Thickness.	Internal Circumference.	External Circumference.	Internal Area.	External Area.	Length of pipe per square foot of Inside Surface.	Length of pipe per sqr. foot of Outside Surface.	Length of pipe per sqr. foot of Mean Surface.	Length of pipe containing 1 cu. foot.	Weight per foot of length.	Length of Perfect Screw.	Theads per inch in Length of Screw.	Taper of Screw per inch of Length.
Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	Sqr. Inch.	Sqr. Inch.	Feet.	Feet.	Feet.	Feet.	Pounds.	Inches.		Inches.
⅛	.27	.405	.068	.848	1.272	.0572	.129	14.15	9.44	11.795	2,500.	.243	.19	27	1/32
¼	.364	.54	.088	1.144	1.696	.1041	.229	10.50	7.075	8.787	1,385.	.422	.29	18	1/32
⅜	.494	.675	.091	1.552	2.121	.1916	.358	7.67	5.657	6.663	751.5	.561	.30	18	1/32
½	.623	.84	.109	1.957	2.652	.3048	.554	6.13	4.502	5.316	472.4	.845	.39	14	1/32
¾	.824	1.05	.113	2.589	3.299	.5333	.866	4.635	3.637	4.136	270.	1.126	.40	14	1/32
1	1.048	1.315	.131	3.292	4.134	.8627	1.357	3.679	2.903	3.291	166.9	1.670	.51	11½	1/32
1¼	1.38	1.66	.140	4.335	5.215	1.496	2.164	2.768	2.301	2.531	96.25	2.258	.54	11½	1/32
1½	1.611	1.9	.145	5.061	5.969	2.038	2.835	2.371	2.01	2.190	70.65	2.691	.55	11½	1/32
2	2.067	2.375	.154	6.494	7.461	3.355	4.430	1.848	1.611	1.729	42.36	3.667	.58	11½	1/32
2½	2.468	2.875	.204	7.754	9.032	4.783	6.494	1.547	1.328	1.437	30.11	5.773	.89	8	1/32
3	3.067	3.5	.217	9.636	10.996	7.388	9.621	1.245	1.091	1.668	19.49	7.547	.95	8	1/32
3½	3.548	4.0	.226	11.146	12.566	9.887	12.566	1.077	.955	1.016	14.56	9.055	1.00	8	1/32
4	4.026	4.5	.237	12.648	14.137	12.730	15.904	.919	.849	.899	11.31	10.728	1.05	8	1/32
4½	4.508	5.	.247	14.153	15.708	15.939	19.635	.848	.765	.806	9.03	12.492	1.10	8	1/32
5	5.045	5.563	.259	15.849	17.475	19.990	24.299	.757	.629	.693	7.20	14.564	1.16	8	1/32
6	6.065	6.625	.28	19.054	20.813	28.889	34.471	.63	.577	.603	4.98	18.767	1.26	8	1/32
7	7.023	7.625	.301	22.063	23.954	38.737	45.663	.544	.505	.524	3.72	23.410	1.36	8	1/32
8	7.982	8.625	.322	25.076	27.096	50.039	58.426	.478	.444	.461	2.88	28.348	1.46	8	1/64
9	9.001	9.688	.344	28.277	30.433	63.633	73.715	.425	.394	.409	2.26	34.077	1.57	8	1/64
10	10.019	10.75	.366	31.475	33.772	78.838	90.762	.381	.355	.368	1.80	40.641	1.68	8	1/64
11	11.224	12.	.388	35.261	37.699	98.942	113.097	.340	.318	.329	1.455	47.727			
12	12.180	13.	.41	38.264	40.840	116.535	132.732	.313	.293	.303	1.235	54.655			
13	13.136	14.	.432	41.268	43.982	134.582	153.938	.290	.273	.281	1.069	61.940			
14	14.092	15.	.451	44.271	47.124	155.968	176.715	.271	.254	.262	.923	70.008			
15	15.048	16.	.476	47.274	50.265	177.867	201.062	.254	.238	.246	.809	78.269			
16	16.004	17.	.498	50.278	53.407	201.162	226.980	.238	.225	.231	.715	87.120			
17	16.960	18.	.520	53.281	56.548	225.907	254.469	.225	.212	.218	.638	96.379			
18	17.916	19.	.542	56.284	59.690	252.096	283.529	.213	.201	.207	.571	106.067			
19	18.872	20.	.564	59.288	62.832	279.720	314.160	.202	.191	.196	.515	116.214			
20	19.828	21.	.586	62.291	65.973	308.771	346.361	.192	.183	.187	.466	126.760			

For sizes above 10 in. diam. Cast Iron Flanges riveted on are recommended instead of Screw Joints.

Lap Welded American Charcoal Iron Boiler Tubes.

Standard Dimensions.

(Table of Morris, Tasker & Co., Limited.)

External Diam.	Internal Diam.	Standard Thickness.	Internal Circumference.	External Circumference.	Internal Area.		External Area.		Length of tube per sq. foot of Inside Surface.	Length of tube pr. sq. foot of Outside Surface.	Length of tube per sq. foot of Mean Surface.	Weight pr. Lineal foot.
Inches.	Inches.	Inches.	Inches.	Inches.	Square Ins.	Sqr. Feet.	Square Ins.	Sqr. Feet.	Feet.	Feet.	Feet.	Pounds.
1	.856	.072	2.689	3.142	.575	.004	.785	.0055	4.460	3.819	4.139	.708
1¼	1.106	.072	3.474	3.927	.960	.0067	1.227	.0085	3.455	3.056	3.255	.9
1½	1.334	.083	4.191	4.712	1.396	.0097	1.767	.0123	2.863	2.547	2.705	1.25
1¾	1.560	.095	4.901	5.498	1.911	.0133	2.405	.0167	2.448	2.183	2.315	1.665
2	1.804	.098	5.667	6.283	2.556	.0177	3.142	.0218	2.118	1.909	2.013	1.981
2¼	2.054	.098	6.484	7.069	3.314	.0230	3.976	.0276	1.850	1.698	1.774	2.238
2½	2.283	.109	7.172	7.854	4.094	.0284	4.909	.0341	1.673	1.528	1.600	2.755
2¾	2.533	.109	7.957	8.639	5.039	.035	5.940	.0412	1.508	1.390	1.449	3.045
3	2.783	.109	8.743	9.425	6.083	.0422	7.069	.0491	1.373	1.273	1.323	3.333
3¼	3.012	.119	9.462	10.210	7.125	.0495	8.296	.0576	1.268	1.175	1.221	3.958
3½	3.262	.119	10.248	10.995	8.357	.058	9.621	.0668	1.171	1.091	1.131	4.272
3¾	3.512	.119	11.033	11.781	9.687	.0673	11.045	.0767	1.088	1.018	1.053	4.590
4	3.741	.130	11.753	12.566	10.992	.0763	12.566	.0872	1.023	.955	.989	5.32
4½	4.241	.130	13.323	14.137	14.126	.0981	15.904	.1104	.901	.849	.875	6.01
5	4.720	.140	14.818	15.708	17.497	.1215	19.635	.1364	.809	.764	.786	7.226
6	5.699	.151	17.904	18.849	25.509	.1771	28.274	.1963	.670	.637	.653	9.346
7	6.657	.172	20.914	21.991	34.805	.2417	38.484	.2673	.574	.545	.560	12.435
8	7.636	.182	23.989	25.132	45.795	.318	50.265	.3490	.500	.478	.489	15.109
9	8.615	.193	27.055	28.274	58.291	.4048	63.617	.4418	.444	.424	.434	18.002
10	9.573	.214	30.074	31.416	71.975	.4998	78.540	.5454	.399	.382	.391	22.19
11	10.560	.22	33.175	34.557	87.479	.6075	95.033	.6601	.361	.347	.354	25.489
12	11.542	.229	36.26	37.699	103.749	.7205	113.097	.7854	.330	.318	.324	28.516
13	12.524	.238	39.345	40.840	123.187	.8554	132.732	.9213	.305	.293	.299	32.208
14	13.504	.248	42.414	43.982	143.189	.9943	153.938	1.069	.282	.272	.277	36.271
15	14.482	.259	45.496	47.124	164.718	1.1438	176.715	1.2272	.263	.254	.258	40.612
16	15.458	.271	48.562	50.265	187.667	1.3032	201.062	1.188	.247	.238	.242	45.199
17	16.432	.284	51.662	53.407	212.227	1.4738	226.980	1.5762	.232	.224	.228	49.902
18	17.416	.292	54.714	56.548	238.224	1.6543	254.469	1.7671	.219	.212	.215	54.816
19	18.400	.3	57.805	59.690	265.903	1.8465	283.529	1.969	.207	.200	.203	59.479
20	19.360	.32	60.821	62.832	294.373	2.0443	314.159	2.1817	.197	.190	.193	66.765
21	20.320	.34	63.837	65.973	324.311	2.2522	346.361	2.4053	.188	.181	.184	73.404

In estimating the effective steam-heating or boiler surface of Tubes, the surface in contact with air or gases of combustion (whether internal or external to the tubes) is to be taken.

For heating liquids by steam, superheating steam, or transferring heat from one liquid or gas to another, the mean surface of the Tubes is to be taken.

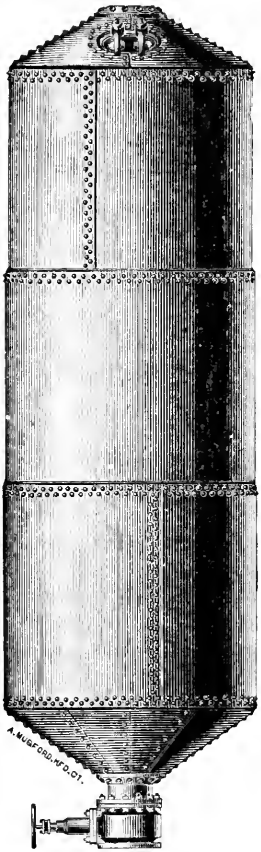
The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. X. HARTFORD, CONN., FEBRUARY, 1889. No. 2.

The Construction and Management of Rendering Tanks.

By the explosion of two rendering tanks, as hereinafter described, a three-story brick tank house was demolished, surrounding property injured, and a considerable part of the equipment wrecked, so that the resulting damage probably exceeded $25,000. We are gratified to announce there was no loss of life by this explosion, as it occurred in the early evening, after the large force that is employed there had gone home and left the night-tank man in charge, who, fortunately, was in a distant part of the room at the time of the occurrence. Even as it was he would not have escaped had he not been near a heavy wall, against which the falling debris lodged and shielded him. In addition to the two tanks that exploded, a third was blown some distance, and several adjacent ones were moved from their foundations, breaking the pipe connections, fittings, and attachments, and adding to the general destruction and confusion.



RENDERING TANK.
FIG. 1.—NEW STYLE.

Fig. 2 shows the old style of tank commonly found in our best packing establishments, with the safety-bolt from head to head as recommended by this company. These tanks are usually five to six feet in diameter, and fourteen to sixteen feet high, made of good material and equipped with a safety-valve and suitable pipe connections for filling and emptying the tank. We may here note, and it probably will not be disputed, that tank construction has not been improved during the past ten years to the extent that steam-boiler construction has. Yet the demand for packing products has been greatly increased, and there has been a corresponding need of increased tank service. This has been met partly by putting in additional tanks, and partly by driving the old ones a little harder.

As near as can be computed from the limited data available, eighty-five explosions of these tanks have occurred within a few years, resulting in a loss of 149 lives, in injuries to 170, and in an approximate property damage of over a million of dollars.

In view of the foregoing, and considering the number of human lives at stake and the magnitude of the business interests involved, it may be profitable to review the subject of construction and management of tanks, with some practical suggestions, the application of which has been found of value in lessening the danger, and possibly has prevented the occurrence of many such disasters.

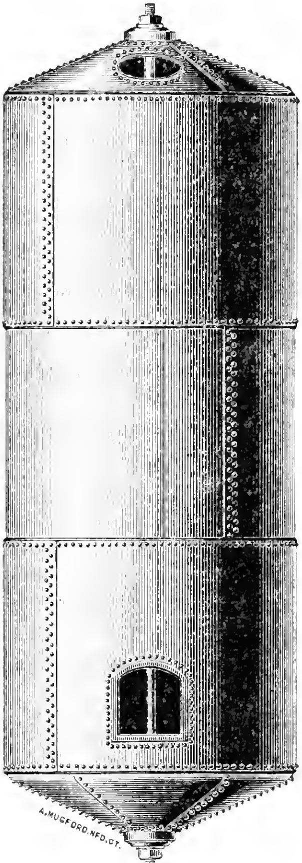
In the old style of tanks, the bottom often rested in a timber framework or cradle. This was objectionable because, while it prevented access to the bottom plates, it facilitated corrosion by keeping the wetted surfaces in contact. The better plan is to suspend the tank from lugs riveted to the sides of the shell, and resting on suitable beams. (These are not illustrated because their positions will vary within certain limits.) The external surface of such a tank is at all times in sight, external corrosion is reduced to the minimum, and the metal can be scraped off and painted as often as is necessary. There should be as few seams as possible in a tank; and if the shell could be made in one sheet and the joint welded, it would be a great advantage, for the fatty acids will in time find their way between the plates through small leaks at the lap-seam, and corrode and groove the plates at the joints with astonishing rapidity. Probably the expense of such work will be so reduced in the near future as to make such welding practicable. We must for the present, however, content ourselves with making shells in two or more rings, and in doing this we shall increase the durability, if we arrange the laps of the circular ring so that they will look down rather than up, thus preventing a lodgment of corrosive material on the edge of each ring. A suitable combing of wood or angle iron, the latter preferably, should be on the charging floor surrounding every tank. This will prevent the continued drippings and washing of the floor from running down the sides of the tank,— an abominable nuisance in many tank-houses.

Where the older kind of tanks are used, with an arched frame or mouthpiece, as shown in Fig. 2, frequent examinations should be made, for it is a very common thing to find such frames fractured; and if rupture occurs with a charge in, the results are most disastrous. To provide against such a contingency, when tanks are made in the old way, there should be a strong bolt from head to head of the tank which, in the event of accident, will hold it together until it can be put out of service. Fig. 2 illustrates the form of bolt we have recommended. The same precaution has been recommended by this company, with satisfactory results, in plain cylinder boilers, that formerly went off in two parts whenever the shell ruptured, wrecking everything within range; but which are now generally held together by the bolts until they can be shut off and put out of service.

Cast-iron mouthpieces and frames are unreliable at best, and in a joint that is opened and closed once in twenty-four hours, by men not the most experienced, forged ones would be far safer and more durable.

Modern tanks, illustrated in Fig. 1, discharge through a gate valve in the bottom, which gives an unobstructed opening. Braces cannot so easily be put in these tanks without obstructing the movement of the charge. Therefore, additional strength should be provided in the shell. All shell seams, both girth and vertical, should be double staggered riveted. This is done not only to give an increased strength at the riveted seam (an important consideration owing to the stress upon the heads and the tendency to separation of the shell girthwise, which tendency, owing to the absence of the holding power of the long bolt heretofore referred to, is measured by the resistance of the shell plates at their weakest section), but also to give as large a bond as is possible, and one free from leaks. The gore-sheets forming the top and bottom heads are single riveted, with rivets of the necessary diameter, and ample length to head up properly, conformably to the plan of this company in such cases — all rivets to be driven from the inside, and all seams to be caulked both inside and out. Upon the shell and heads there should be reinforcing pieces, of proper thickness and suitable size, with holes of the requisite diameter for the various pipe fittings all threaded and ready for use. The difference in the general shape of the tanks shown in the two cuts is accidental, and is not intended to indicate a corresponding difference in design between the old and new styles.

Tank-heads are now made more conical than formerly, and the gore-sheets are better arranged, so that there is less fretting at the seams. The cone should be about twenty inches high, surmounted by a substantial cast-iron center-plate on the top head and a flange on the bottom, both drilled and tapped for pipe fittings. To the flange-plate on the bottom, a gate-valve is attached. As the heads, under ordinary circumstances, corrode faster than any other part of the tank, they should be made correspondingly thick. The durability of the heads will be increased by careful design and workmanlike fitting up of the gore-sheets, by the use of cast-iron plates, and by attention to other essential details. We fear that in the past, anything half way decent in the way of material or work was thought good enough for tank use ; and while we do not believe that the best material would prove to be the most durable (because not so likely to resist corrosive action), the material used should be sufficiently ductile to flange without fracture, and a little additional expense in the purchase of the material may be considered a good investment, as it will prolong the life of the tank and make it safer to use.



RENDERING TANK.
FIG. 2.—OLD STYLE.

At many of our largest packing houses it has been found more satisfactory and no more expensive to set off a portion of the boilers and run them at a lower pressure for the tanks (say fifty pounds), than to draw the supply from the other boilers that are run at a much higher pressure, and depend upon reducing pressure-valves ; for these valves, however well they perform elsewhere, are troublesome here. Even with the foregoing precautions, the steam pressure is sometimes raised above the desired pressure. This is apt to in the drowsy hours toward morning. To prevent this as far as possible it is necessary that at some convenient place, in plain sight of the tank man, there should be a large faced steam gauge, with pipe connections, so arranged that it can be readily removed as often as is necessary to clean and adjust it.

The safety-valve should be a free-working one, and it should be examined frequently, and arranged, if possible, so as to blow off *in the room* when the safe pressure at which it is set is exceeded.

A careful, experienced man in the tank-room is to be desired. The attendant there has it in his power to make or lose considerable for his employer, not only in maintaining or neglecting to maintain a low and even temperature on the product in the tanks, but also by the care that he exercises in gradually warming the tanks from the lower temperature at which they are charged, to that at which they are to be run.

The stresses at the lap-joints about door-frames, mouthpieces, etc., from unequal expansion alone, are sufficient in many cases to cause fractures, though commonly they are brought to notice by leaks that require frequent caulking. The wrench used for screwing up the manhole covers, or other joints, should not be longer than eighteen inches. When the joint cannot be made tight with that leverage, it should be taken off and re-made. To attempt to force it to its place with a longer leverage will often cause a fracture of the mouthpiece or frame ; and when steam is on, as is commonly the case, such an accident has many times cost the operator his life.

Our assured, or those contemplating insurance, may obtain, without charge, full information concerning the experience of this company in these matters, and also plans and specifications for tanks, stills, digesters, rotaries, and other special boilers, by communicating with the home office at Hartford, or with any agency.

F. B. A.

Inspectors' Reports.

JANUARY, 1889.

During this month our inspectors made 5,009 inspection trips, visited 9,324 boilers, inspected 3,300 both internally and externally, and subjected 533 to hydrostatic pressure. The whole number of defects reported reached 7,131, of which 717 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,	400	31
Cases of incrustation and scale,	694	26
Cases of internal grooving,	47	7
Cases of internal corrosion,	182	24
Cases of external corrosion,	315	61
Broken and loose braces and stays,	142	39
Settings defective,	179	13
Furnaces out of shape,	111	10
Fractured plates,	201	81
Burned plates,	126	19
Blistered plates,	213	6
Cases of defective riveting,	1,890	78
Defective heads,	81	24
Serious leakage around tube ends,	1,605	174
Serious leakage at seams,	319	23
Defective water-gauges,	108	19
Defective blow-offs,	57	14
Cases of deficiency of water,	24	8
Safety-valves overloaded,	39	11
Safety-valves defective in construction,	56	22
Pressure-gauges defective,	254	20
Boilers without pressure-gauges,	7	7
Unclassified defects,	81	0
Total,	7,131	717

Strange accidents happen in connection with boilers, as well as with other things. One of them happened not long ago. The engineer had been inside the boiler cleaning it out, and as the shell and setting were still warm he perspired profusely. He had with him a cloth on which he wiped his face at frequent intervals. When he left the boiler he forgot this cloth, and, closing the man-hole, left it inside. In the course of time the cloth lodged on the seat of the blow-off valve, keeping it slightly open and slowly allowing the water to escape. Well, the boiler got dry and was badly burned ; all on account of forgetting the rag.

Boiler Explosions.

JANUARY, 1889.

HOOP FACTORY (1). At Clinton, N. C., on Jan. 3d, a boiler exploded in the hoop factory of Colonel John Ashford, instantly killing two sons of Colonel Ashford, and also a negro, and fatally injuring Colonel Ashford himself. A man named W. H. Britt was also seriously and perhaps fatally wounded.

LOCOMOTIVE (2). When the passenger train from Cincinnati on the Cincinnati, Hope & Greensburg Railroad, was about two miles out of Columbus, Ind., on January 5th, several of the tubes in the locomotive gave way. Lou Foster, the fireman, and Arch Black, a brakeman, were blown from their positions by the force of the escaping steam and water. The train was moving rapidly, and their fall was terrible. Foster had both of his arms broken in two places, and was badly scalded on the body and face, besides receiving internal injuries which will cause his death. Black received a broken arm and was badly burned.

GRIST-MILL (3). About 1 o'clock on January 5th, William Jerome, Thomas Carter, J. E. French, Wade Shufflebarger, John Wimmer, Levi Shields, and Eli Shields were sitting in William Carter's steam grist-mill, at Newhope, W. Va., when the boiler burst. The mill was wrecked, and French, Carter, Levi Shields, and John Wimmer were killed. Eli Shields was horribly scalded, and died next day. Shufflebarger was badly burned about the face and body. Jerome was injured on the head and had his collar-bone broken. William Carter was seriously injured internally. The explosion was of terrific force, breaking the beams into splinters, and pieces of the boiler weighing 200 pounds were blown over 300 yards.

SAW-MILL (4). The boiler in Bell's mill, at Pellston, Mich., blew up on Jan. 11th, killing the fireman, the head sawyer, and one other man.

FACTORY (5). The boiler in the Appleton Manufacturing Company's works, Appleton, Wis., exploded at 3 o'clock in the morning of January 14th, killing watchman Reichter. Flues and pieces of boiler shell were thrown several hundred feet, and the boiler-house was torn to pieces, not one brick being left upon another. The wood-working department, situated thirty feet from the boiler-house, was bombarded with bricks and twisted, racked, and splintered. Windows and doors were blown out, and the inside filled with debris. The report and concussion shook houses for half a mile around. The loss is estimated at $5,000.00.

STEAM HEATER (6). A steam-heating boiler exploded at Carter's greenhouse, Newburg, N. Y., on Jan. 14th. The sheets of the boiler were ripped off, and large pieces were hurled in all directions. The boiler was a second-hand one, and had been put in only a few weeks.

STEEL WORKS (7). A terrific boiler explosion occurred at Park Bros.' Black Diamond steel works, in Pittsburgh, on Jan. 15th. The head of one of the boilers in the pumping department gave way, and the explosion followed, seriously injuring one man, and tearing out a large portion of one of the sheet-iron walls of the mill. A Scotchman named Seehan had charge of the boiler, and was standing near it at the time of the explosion. The force of the shock stunned him, and the boiling water flew all over him, horribly scalding his face, hands, and head. The mill physician was summoned and dressed his wounds, after which he was removed to his home. His injuries are not considered to be fatal. Seehan's escape from death is considered almost a miracle by his fellow workmen, as he was within a very few feet of the boiler when the explosion occurred, and yet he was not touched by the flying fragments. Had the explosion happened two or three hours later, several persons would probably have been killed. The day men had not come to work yet. Seehan was a night man, and had charge of the pumps.

NEWSPAPER OFFICE (8). On Jan. 16th the boiler in the building occupied by the *Standard* and *Democrat*, in De Pere, Wis., exploded, injuring several men and causing $6,000 loss.

FARM BOILER (9). A boiler exploded on the farm of Maj. W. J. Sutherland, at Milton, N. C., on Jan. 19th, killing Paul Terry, and badly injuring several others.

SAW-MILL (10). The boiler of a portable steam saw-mill, situated in the west part of Danville, Vt., exploded on Jan. 22d, instantly killing Ernest Comstock and seriously injuring Albert Morgan and Carl White. Comstock's death is peculiarly sad, as he leaves a young wife who is nearly helpless with paralysis, and a young child.

SAW-MILL (11). On Jan. 22d, the boiler in Robert Carter's saw-mill, Dawn, Ont., exploded, demolishing the mill.

SAW-MILL (12). On Jan. 23d, a boiler exploded at Cabot, Vt., killing the owner and injuring several others.

SAW-MILL (13). By the explosion of a saw-mill boiler near Chillicothe, O., on Jan. 24th, two men were killed and two others received probably fatal injuries. The saw-mill was located in a region known as Tar Hollow in the hills northeast of the city about twelve miles. It was operated by George and James Dearth, John W. Arlidge, and Ebenezer Starling. The explosion occurred just after the men had returned to work from dinner, killing both the Dearths and mangling Arlidge and Starling in a horrible manner. The head of George Dearth was torn from the body and thrown through the air fully one hundred yards. The body was also thrown a considerable distance in an opposite direction, landing upon the bank of a creek. The body of James Dearth was also hurled about one hundred yards and landed on a hill across the hollow. Arlidge and Starling are not expected to live.

SAW-MILL (14). A terrible boiler explosion occurred on Jan. 27th at Perkins's mill, five miles east of Poplar Bluff, Mo. Just before the explosion Judge Shamount of Poplar Bluff and a farmer named Robins were passing and dropped in to see Mr. Perkins. The explosion wrecked the mill and 100 feet of shed attached to it. Judge Shamount, John Moore, and John Chronister were instantly killed. W. H. Perkins, Mr. Robins, and a young man named Malcolm were so badly burned and injured that they are not expected to live. Two brothers named Spencer, employed in the mill, were badly scalded. Portions of the boiler were found 300 yards away.

THRESHER (15). The boiler of a rye-thresher, owned and operated by Dennis Hammond, exploded on Jan. —th, while threshing at Mr. John D. Gaither's, near Unionville, Mo., sending the debris in all directions. Mr. John Gaither, his brother, W. A. Trump, and Keston Coats were all struck with the flying matter, the latter being felled to the ground. They had been threshing about an hour and a half, when something became disarranged and the strap flew off the straw carrier. The machinery was stopped for repairs, and was just starting up when the explosion occurred. Mr. Gaither was stationed at the jack with a crowbar in his hand, to keep the strap on the pulley while the machinery got under way. Mr. Hammond had just left the front of his machine to look after the straw carrier, thereby escaping death or fatal injury, as the entire machine is a total wreck. Mr. Gaither, the moment the explosion occurred, ran to his horses, but in his flight a ten pound piece of cylinder struck him upon the head, but not low enough to do serious damage.

Electric Light Plant (16). About 11 o'clock on Jan. 27th, one of the boilers belonging to the old Pontiac coal shaft, Pontiac, Ill., exploded, instantly killing Charles Young, the fireman. A. B. Sells, brother of the engineer, was seriously injured and is not expected to live. His injuries are principally internal. Samuel Calkins, a young man whose parents reside a couple of blocks from the shaft, had just stepped into the engine-room, and he received slight injuries about the face from the escaping steam. The engine-room caught fire immediately, and was mostly burned down before the fire company reached it. The shaft, owned by Haynes & Co., of Chenoa, has not been in operation for the past two years, but the boilers were leased to the Pontiac Electric Light Company, who used them to run their engine. The exploded boiler was comparatively a new one.

Ocean Steamer (17). An accident occurred on the White Star Line steamer *Republic* on Jan. 27th, shortly after noon, by which ten men narrowly escaped being scalded to death in the stoke hold by the bursting of a boiler-flue. Three of them, Thomas McFarland, fourth engineer; James Dwer, sixth engineer; and John Leonard, a coal passer, died afterward, from their injuries. Two of the men — Charles Yates, second engineer, and Henry Ibbs, fifth engineer — returned to the vessel after their wounds were dressed. From an investigation it appears that six firemen and coal-passers, and five assistant engineers, were in the hold drawing the fires, cleaning up, and making everything snug so that they could leave their posts. There was a steam pressure of fifty-six pounds to the square inch on the boiler that failed. There was a sharp report, and at the same instant the men received a stream of boiling water and steam in their faces. The room that the men were in was about forty feet long and twelve feet wide, and as it was in the hold of the vessel, there was no way for the steam to get out except through the openings where the ladders stood. There were two ladders, and some of the men climbed out on one of them, but the others were cut off by the jet and could get out only by passing through the stream of steam and water. Those who got out quickly opened the safety-valve and relieved the pressure. Meantime those shut up in the hold, which was by this time filled by steam, suffered horribly, and they were all of them nearly suffocated. Three were entirely prostrated, and had to be hoisted out of the hold by means of a derrick; the others could barely crawl up the ladder into the engine-room.

Silk-Mill (18). A terrific explosion occurred at Harvey's silk-mill, at Scranton, Pa., on Jan. 28th. One of the four large boilers in use exploded, tearing the engine and boiler rooms to pieces, and throwing the debris in every direction. One side of the mill was completely wrecked, and the three floors were filled with bricks and pieces of timber. Nicholas Schistel, engineer, and Horace Anderson, fireman, were badly scalded. August Albert, another fireman, and Alfred Harvey, owner of the mill, who were in the engine-room, were slightly cut by flying debris. Schistel's home, a small two-story frame house close by, was literally torn in pieces; but his wife, though covered with wreckage, escaped serious injury.

Summary of Boiler Explosions for the Year 1888.

Our usual summary and classified list of explosions during the year is given below. The total number of explosions, so far as we have been able to learn, was 246. In a number of cases more than one boiler exploded at the same time, and while it has been our custom in previous years to count instances of this kind as single explosions, we have this year counted each boiler separately, believing that by so doing we can convey a fairer conception of the amount of damage done during the year. It is partly for this reason that the number of explosions (246) reported in 1888 exceeds those (198) reported in 1887 so considerably.

The number of persons killed outright, or who died within a very short time, was 331 during 1888, against 264 in 1887, and 254 in 1886; and the number injured (fully 100 of whom were reported to be fatally so) was 505, against 388 in 1887, and 314 in 1886. This makes a total of 836 persons killed and maimed during the year — not counting the many minor accidents that were not considered sufficiently "newsy" to interest the general public.

CLASSIFIED LIST OF BOILER EXPLOSIONS IN THE YEAR 1888.

CLASS OF BOILER.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Totals.
1 Saw-mills and other Wood-working Establishments,	9	11	6	4	9	7	1	7	8	1	3	3	69
2 Locomotives,	2	4	5	2	2	..	2	1	1	3	..	1	23
3 Steamships, Tugs, and other Steam Vessels,	2	2	1	3	2	2	1	3	1	1	..	2	20
4 Portable Boilers, Hoisters, and Agricultural Engines,	2	1	1	..	1	4	2	5	5	2	3	4	30
5 Mines, Oil Wells, Collieries,	1	.	3	1	..	1	1	..	3	1	1	..	12
6 Paper Mills, Bleacheries, Digesters, etc.,	.	..	..	1	..	..	..	1	..	..	1	..	3
7 Rolling Mills and Iron Works,	3	..	2	1	..	1	1	..	2	1	..	2	13
8 Distilleries, Breweries, Dye-Works, Sugar Houses, and Rendering Works,	1	..	1	..	..	1	7	..	..	1	..	1	12
9 Flour Mills and Grain Elevators,	2	..	1	..	..	..	..	..	2	..	2	3	10
10 Textile Manufactories,	..	1	..	2	..	1	1	1	.	..	..	.	6
11 Miscellaneous,	7	3	2	4	2	2	8	2	3	3	5	7	48
Total per month,	29	22	22	18	16	19	24	20	25	13	15	23	246
Persons killed, (total, 331,) " " "	22	59	23	20	20	20	17	54	37	13	22	24	
Persons injured, (total, 505,) " " "	56	68	37	40	35	38	40	41	56	15	29	50	

Photographing Wonders in the Heavens.

The effort now making to enable the Naval Observatory at Washington to take part in the great enterprise of photographing the heavens, in which the astronomers of half a dozen nations are engaged, calls attention once more to the surprising developments of astronomical photography. Nobody would have believed, ten years ago, that any such achievements and discoveries as we have recently witnessed were possible. It is as if a new sense had been given to man. We are surrounded by thousands of celestial phenomena which powerful telescopes were unable to disclose to the eye, but which the same telescopes, when properly prepared, reveal to the more sensitive, or more efficient, retina of the photographic camera. Even well-known objects, like the Orion nebula, take on new forms, and are beheld surrounded by unsuspected subsidiary phenomena when they are photographed. The etheric undulations, which escape the ordinary sense of sight, have a story of their own to tell respecting the constitution of the universe; and by impressing their images upon chemical films, they give us glimpses into the arcana of the heavens that are startling in their significance. We now possess well-printed photographs of vast and monstrous creations, gulfs of chaos, like some of those strange nebulous masses in Orion or the Pleiades, whose existence had hardly been suspected four or five years ago.

Streams of suns, strung along like pebbles in the bed of a creek, are seen involved in streaks and masses of nebulous matter of perfectly enormous extent. In one place in the group of the Pleiades, which at this season adorns the evening sky, there is seen, in the photographs taken at the Paris observatory, a nebula in the form of a long, straight, narrow streak, upon which six or seven stars are set, like diamonds on a silver bar. Assuming that the parallax of this object is half a second of an arc, which is the largest posble value that could be given to it, it has been shown that the length of that strange nebulous pathway, leading from sun to sun, cannot be less than five hundred thousand millions of miles ; and the distance between the two nearest of the stars thus connected is more than four hundred times as great as that which separates our sun from the earth ! The reader should keep in mind that these are minimum values, and that in all probability the dimensions involved are really much larger. By the same calculation the width of the nebulous streak can be shown to be not less than seven hundred and eighty million miles, or more than eight times the distance from the earth to the sun. It seems highly probable that this great streak is in reality only the rim of a broad circular disk of nebulous stuff, presented edgewise toward the earth, and which, as indicated by the stars already involved in it, is undergoing changes that will finally result in its complete transformation into stars.

One of the most interesting of the celestial photographs recently taken has just been published in England. It is a photograph of the great nebula in Andromeda, made by Mr. Roberts, of Liverpool, and it shows that stupendous cosmical mass in an entirely new light. Heretofore it has been represented as a shapeless expanse of nebula, sprinkled over with stars. But the photograph brings into view fainter portions which give a most suggestive shape to the nebula. It is now seen to be composed of a huge central mass encircled by ring within ring, and presented in an inclined position to our line of sight so that its outline is strongly elliptical. This is regarded as confirmatory of La Place's nebular theory of the origin of solar systems. Two or three globular masses are seen, whose situation and aspect suggest that they are in the act of formation from the nebulous rings, just as the planets are supposed to have been shaped from similar rings in the first stages of our solar system.

The appearance of motion, or rather of the evident effects of motion, as shown in this photograph, is very striking. Covering all the sky where the nebula is, dotting the nebula itself over as thick as falling snowflakes, appear innumerable stars. Through these stars shine the great ovals of the nebula surrounding the enormous, white, and comparatively shapeless central body. In the stream-like arrangement of the stars, in the broad sweep of the nebular rings, even in the chaotic central aggregation itself, the eye is seized by the whirling appearance that characterizes the whole phenomenon. It is like facing a storm of snow, and perceiving through the fast-flying throngs of nearer flakes a huge eddy of the storm bearing down upon the beholder, furiously swept and gyrated by a cyclonic blast into an immense, white, confused, all-swallowing cloud ! In fact, the simile of a storm is particularly apt, if one has in mind Mr. Lockyer's recent theories, according to which nebulæ must be regarded as clouds of whirling and clashing meteors. Considering that the dimensions of the nebulous phenomenon in the Pleiades, described above, sink into insignificance in comparison with those of this nebula in Andromeda, it is enough to make the imagination dizzy to gaze upon Mr. Roberts's photograph.—*New York Sun.*

The Locomotive.

HARTFORD, FEBRUARY, 1889.

J. M. ALLEN, *Editor.*

H. F. SMITH, A. D. RISTEEN, } *Associate Editors.*

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.

MR. GEO. H. BARRUS has kindly sent us a neatly-bound copy of his recent paper on *Boiler Tests*, read before the New England Cotton Manufacturers' Association at its October meeting. This paper contains 199 pages, gives results of fully 150 evaporative tests conducted personally by the author, or under his direction, and is a very interesting and valuable collection of data.

WE have received a copy of the second edition of *The Electric Motor and its Applications*, written by Messrs. Wetzler and Martin, and published by the *Electrical World*. The first edition came out in 1887, and was very full and complete ; but the progress of electrical science has been very rapid since that time, so that much matter has been added to bring the book down to date, and in its present form it gives a very satisfactory account of the various motors and railway systems now in use, and makes numerous interesting suggestions concerning the directions in which future progress will probably be made.

THE editor of the *Railway Master Mechanic*, in a recent issue of his journal, is inclined to criticise our remark in the LOCOMOTIVE of July, 1888, page 111, that it is an eminently safe rule to "*burn* your fuel as close to the heating surface of a boiler as you conveniently can." He evidently failed to see that the word *burn* was italicized. We also referred more particularly to the *furnaces* of horizontal tubular boilers than we did to the fire-boxes of locomotive boilers. If, however, he wishes to confine the question to locomotive boilers, he is at perfect liberty to do so ; but it would be a good plan for him to examine into the performance of the Strong locomotive boiler, also those used on the Pennsylvania Railroad where the bottom of the fire-box comes above the frames. There is also an excellent article on the subject of locomotive fire-boxes in a recent number of the *The Railroad and Engineering Journal.*

A FEW years ago there was a considerable discussion in the papers about the ability of base-ball players to pitch a ball in a curved line. This is now well known and understood ; but we wish to call attention to the following extract from a letter written by Sir Isaac Newton to Oldenburg, for it appears from this that Sir Isaac had noticed a similar phenomenon in connection with tennis balls, as early as 1666, and that he had given the correct explanation of it :

"Then I began to suspect, whether the rays, after their trajection through the prism, did not move in curve lines, and according to their more or less curvity, tend to divers parts of the wall. And it increased my suspicion, when I remembered that I had often seen a tennis-ball, struck with an oblique racket, describe such a curve line. For, a circular as well as a progressive motion being communicated to it by that stroke, its parts, on that side where the motions conspire, must press and beat the contiguous air more violently than on the other, and there excite a reluctancy and reaction of the air proportionably greater."

The Lion and the Lamb.

In a recent number of the LOCOMOTIVE we published an article on electric welding. A number of papers asked permission to reproduce the article, and among them, we regret to say, was one that printed it *verbatim, literatim, et punctuatim*, and then credited us simply with the *cuts*.

A Lamb was one day walking in a Desert, when he met a famishing Lion. "I have no doubt you would like to Eat me," said the Lamb, keeping at a respectful distance. "My Friend," said the hypocritical Lion, approaching him with doleful Look and stealthy Step, "Lamb has not agreed with me for many Days." "That is doubtless true," cried the Lamb; "but you have purposely neglected to say that Nothing has agreed with you; you have told Part of the truth, but not All of it; you have tried to get all the Benefits of a Lie, without Telling one. Such Dishonesty should not go unpunished;" and he Fell upon the Lion and punished him Severely.

This Fable teaches that papers should do the square Thing, or they won't get any more of our Cuts.

Collapse of a Corrugated Furnace.

THE LOCOMOTIVE recently printed a paper by Mr. W. Parker, Chief Engineer Surveyor to Lloyd's Register, on copper tubes deposited by electricity. This same gentleman has lately made a report concerning an interesting accident on a new British steamer, from which we take the following: "The vessel was engaged in trade between Garston and Dublin, and had been at sea only 240 hours, altogether. Her engines and boiler were properly designed, the latter being 11 ft. 6 in. in diameter and 10 ft. long, with two ribbed furnaces, 41 in. in diameter and $\frac{17}{32}$ in. thick, stayed to work under a pressure of 160 lbs. per square inch. On examination it was found that the port furnace had collapsed in two places to the extent of 14 inches, and the starboard furnace to 3 inches. The whole of the surfaces below the water line, including tubes, chambers, furnaces, and shell, were covered with small cubical crystals, samples of which have been analyzed and found to consist of nearly pure common salt, there being only traces of other matter.

"This is the first case of a furnace of this form collapsing, and considering the peculiar appearance of the inside of the boiler it was thought proper that it should be investigated. The boiler was originally filled with fresh water, and the practice of the man in charge, according to his statement, was to pump the boiler up to what he called "three-quarter glass" when at Garston and Dublin, and when at sea to blow out five inches of water each trip. When at sea the density of the water was measured by a salinometer, and was never found to exceed (in the language used by sea-going engineers) "three-and-a-quarter thirty-twos," one "thirty-two" being equal to five ounces of solid matter to each gallon, which is the mean density of sea water. Any extra supply of water required was taken from the sea. This salinometer has been tested and found to be inaccurate, inasmuch as it shows three ounces per gallon short of the true density at a temperature of 200 degrees Fah., and when the density approaches sixteen ounces per gallon, the density at which the engineer acknowledges the boiler was worked, the reading of the salinometer becomes quite unreliable owing to defective weighting, so that it was never known at what density the boiler was being worked. At times the water must have almost reached the point of saturation.

"This is a case which shows the safety of furnaces of this form to resist collapse even when neglected until they become highly heated. If they had been plain furnaces the collapse would probably have been accompanied with rupture, and a serious accident might have occurred. In their cold state it would have taken a pressure of from 800 to 850 lbs. to have collapsed them, but when hot they collapsed locally at 160 lbs., the strengthening ribs keeping the remaining portions of the furnaces in their original position and preventing rupture taking place.

"Theoretically speaking, by the process of converting water in steam, condensing it into water, and again converting it into steam, no loss whatever should take place; but in practice there is a considerable loss from leaky pumps, stuffing boxes, safety-valves, condenser tubes, etc., and in an engine kept in good working order, I find that for every thousand horse-power exerted, one ton of water per day has to be added to the boiler in the form of extra supply. If this water has to be taken from the sea, no less than two cwt. of solid matter must be deposited every day, and it can easily be seen how detrimental such treatment must be to boilers engaged on long voyages. It is considered that all boilers working at high pressures should have some means of making up this loss in the form of fresh water, either by carrying it in the vessel, or evaporating and condensing."

We understand, from another source, that the deposit of salt in this boiler was from 1½ to 2 inches thick, and "nearly level with the top of the corrugations."

The Dance of the Lady Crab.

About the 12th of September, 1888, there was brought into the laboratory of the United States Fish Commission a male specimen of the lady crab (*Platyonychus ocellatus*), which was placed in an aquarium with a female crab of the same species. During the evening of the 13th, while sketching some hermit crabs which had previously been placed in the same tank, I was attracted by the movements of the male Platyonychus. Without apparent cause, he was seen to rise upon the third and fourth pairs of legs; his large chelæ were thrown above his head with the claws open and their points touching in the middle line; his fifth pair of feet were held horizontally behind, and his body perpendicular to the floor of the aquarium, or at right angles to the normal position. The posture was ludicrous, and, when in this position he began slowly to gyrate, his movements and attitude were the cause of much merriment upon the part of the spectators. At times he balanced on two legs of one side, again on two legs of opposite sides. Now he advances slowly and majestically, and now he wheels in circles in the sand on the floor of the aquarium, and now for a few moments he stands as if transfixed in this unnatural position. An electric light hung above and to one side of the water, which suggested the possibility that it might be the exciting cause. It was turned out, and still the dance went on, and the joy was unconfined. At last, from sheer exhaustion, he sinks down to the sand in his usual attitude.

But now the female, who has all this time remained tucked away in the sand, comes forth and begins to move about the aquarium; soon she comes near to the male crab, when instantly he rises to his feet and begins to dance. Again and again the performance is repeated, and each time the approach of the female is the signal for the male to rear high upon his hind-feet, and to reel about the aquarium as if intoxicated.

At times, when the female approached as he danced, he was seen to make attempts to enclose her in his great chelate arms, not with any violence, for the claws never snapped nor closed violently; but she was coy, however, and refused to be won by his advances, for the dance may have been nothing new to the lady crab, nor half as interesting as it was to the two spectators outside the water. Later, he too buried himself in the sand, and the performance came to an end.

The next day, and the day following it, the two crabs were watched, but without anything unusual taking place. . . . . . Performances such as these are by no means uncommon among the vertebrates, especially with male birds in their endeavors to attract the female; but I believe there are few, if any, performances of this kind on record below the vertebrates.—T. H. MORGAN, in the *Popular Science Monthly*.

The Stability of Chimneys.*

After the determination of the proper size and height of a chimney flue to produce the requisite draft for any given boiler-plant, the next step is to fix upon such dimensions for the stack as shall insure its safety against overturning by the highest winds to which it is likely to be subjected.

The factor which operates to overturn a chimney is the force of the wind acting against the body of the stack; the resistance to overturning is due to the weight of the masonry taken in connection with the diameter of the chimney at the base.

The relation between the velocity of the wind and its pressure against flat or curved surfaces opposed to its force is not very well understood. Proper experiments to determine it exactly have never been made, although it would appear that there is no great difficulty involved in making such experiments at the present time. The pressure is generally supposed to increase as the square of the velocity when the opposing surface is at right angles to the direction of the wind, and in such cases Smeaton's rule is to—

Divide the square of the velocity in miles per hour by 200; *the quotient is the pressure in pounds per square foot.*

By this rule which is used by the U. S. Signal Service, and engineers generally, but which Trautwine, an excellent authority, considers "probably quite defective," the table on page 30 has been calculated, which will be found interesting.

Whether the rule is correct or not, it is certain that wind pressures of between forty and fifty pounds per square foot have been observed in this country, so it will be well to make allowance for the latter pressure in designing a new chimney. It was the practice of Professor Rankine to provide against a pressure of fifty-five pounds per square foot for such structures in England.

In designing new chimneys we must depend upon the weight of the brick-work alone to prevent the shaft from overturning, for fresh mortar has no amount of tensile strength for several months after it is laid. The theoretically correct outline for a chimney-shaft is a hollow batter, nearly straight at the top, and increasing in concavity as the ground is approached, but this form is difficult to build, and in chimneys of ordinary heights the amount of concavity is so slight as to be hardly worth considering, and certainly not worth the extra cost required to build it. For chimneys of four feet in diameter and one hundred feet high, and upwards, the best form is circular with a straight batter on the outside. A circular chimney of this size, in addition to being cheaper than any other form is lighter, stronger, and looks much better and more shapely.

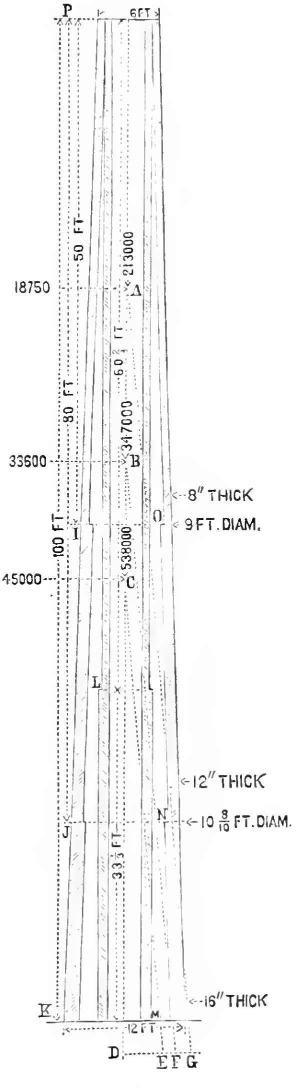


FIG. 1.

* Reprinted by request from the LOCOMOTIVE for JUNE, 1886.

TABLE OF WIND VELOCITIES AND PRESSURES.

Velocity in miles per hour.	Velocity in feet per second.	Pressure in pounds per square foot.	REMARKS.— Character of wind, etc.
1	1.467	.005	Hardly perceptible.
2	2.933	.02	Pleasant.
3	4.400	.045	
4	5.867	.08	
5	7.33	.125	
10	14.67	.5	
12½	18.33	.781	Fresh breeze.
15	22.	1.125	
20	29.33	2.	
25	36.67	3.125	Brisk wind.
30	44.	4.5	Strong wind.
40	58.67	8.	High wind.
50	73.33	12.5	Storm.
60	88.	18.	Violent storm.
80	117.3	32.	Hurricane.
100	146.7	50.	Violent hurricane, uprooting large trees.

Chimneys of any considerable height are not built up of uniform thickness from top to bottom, nor with a uniformly varying thickness of wall, but the wall heaviest of course at the base, is reduced by a series of steps, as shown in the illustration. It is evident that any given section of the wall is weakest at its lower end, or where the thickness changes; hence, if the stack as shown possesses a sufficient margin of strength at the joints, IO, JN, and at the base, it will be amply strong at all other portions of its height, for the joints mentioned are its weakest points.

To determine the stability of the chimney, it is necessary to consider first, the upper section, from I to P, second, the two upper sections from J to P, and last, the entire chimney from K to P, calculating the weight and pressure of the wind against each separately, as though they were independent stacks and standing by themselves.

In calculating the weight of the brick-work which is available to resist the action of the wind, we can figure in that in the inside stack, for although the two stacks are not bonded together, and the wind-pressure acts only on the outer one, yet the wings built into the outer one, and running in and almost touching the inner one, as shown in Fig. 2, practically make one stack of the two, as far as resistance to a lateral pressure is concerned. The pressure of the wind being practically horizontal and acting uniformly on each square foot of the shaft, we may consider it for the purposes of our calculation as concentrated at the center of the figure of each section. Thus the surface of the upper section from I to P, in the sketch shown would be 375 square feet, and the total pressure against this section, if we allow for a wind-pressure of fifty pounds per square foot, would be $375 \times 50 = 18,750$ pounds, which we may consider to be concentrated at A, the center of the surface of this section.

In a similar manner we find that the pressure against that portion of the stack above J N, to be 33,600 pounds acting at B, while for the whole stack it is equal to 45,000 pounds acting at C.

The centers of magnitude, A, B, and C, of the sections shown, or of any similar pyramidal or conical figure, may be found by the following rule:

Divide the difference of the outside diameter at the base and top by three times their sum; subtract the quotient from 1; *multiply the remainder by half the height; the product will be the height of the required point above the base.*

Thus to find the height of the center of pressure A, in the example we are considering: the diameter of the outer shaft at I, O, is 9 feet, the diameter at the top is 6 feet. The height of this section is 50 feet from I to P, then the height of A, above the base IO, is equal to $\left(1 - \frac{9 - 6}{3\,(9 + 6)}\right) \times 25 = 23\frac{1}{3}$ feet.

In a like manner we find B to be 36.19 feet above J; and C to be $44\frac{4}{9}$ feet above the surface of the ground.

Having found the heights of these centers above their respective bases, we lay them off on the center line of the chimney, as shown in A, B, and C.

Next, we compute the weight of brick-work in both shafts above the respective joints I, J, and K, the weight of each cubic foot being about 112 pounds. In the example, which represents a square chimney 100 feet high with a 40-inch flue, the weight above I would be about 213,000 pounds; the weight above J about 347,000, and the weight of the whole chimney about 538,000 pounds.

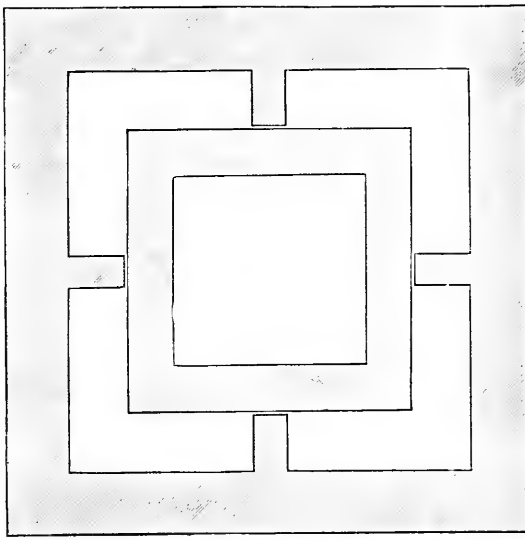


FIG. 2.

Now, with any convenient scale, lay off on the center line of the chimney, from A downward, AD equal to 213,000, and from D, in a horizontal direction, DG with the same scale 18,750, and draw the line AG. This is the resultant of the two forces which may be considered as acting at A, the one, 213,000 pounds vertically downward, and due to the weight of the structure above the joint I, giving it *stability*, and the other, 18,150 horizontally, and due to the force of the wind, and tending to *overturn* it. If their resultant falls within the base of the joint at I, the chimney would stand in a gale blowing with sufficient intensity to cause a pressure of fifty pounds per square foot. As will be seen, it falls *well within* the base, crossing it at O, hence we conclude that the upper section has a good margin of safety.

Proceeding similarly with the other joints where the thickness of the wall changes, using the figures for weight and pressure due to these joints, we find that in each case the resultant lines BF, and CE, fall well within the stack; hence we may conclude that the chimney, as a whole, has an ample margin of safety.

Had the resultant line in either case fallen outside the outer shaft at the respective joints IO, JN, or KM, the chimney would be unsafe, and would fall in any wind blowing with a force of fifty pounds per square foot.

If the chimney shaft has any other form of cross section, the effect of the pressure of the wind against it will be modified. If it is hexagonal in form the effect of the pressure will be about three-fourths, if octagonal about five-eighths, and if it is circular only about nine-sixteenths what it would be on a square stack of the same cross section. Thus in the example given, if the shaft were circular in plan, the force of the wind tending to overturn it would be but a trifle over one-half of the figures given, while the reduced weight, due to the fact that a lesser number of bricks would be required for the circular construction, would be about three-fourths of that given for the square cross section. Thus we see that the round stack would be, for equal dimensions, considerably stronger than the square one.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. X. HARTFORD, CONN., MARCH, 1889. No. 3.

A Terrible Catastrophe.

At 4.50 A. M., February 18, 1889, a tubular boiler of about sixty nominal horse power exploded in the cellar of the Park Central Hotel, corner High and Allyn streets, Hartford, Conn., the building, a fine looking five-story brick structure, was completely

FIG. 1.—THE PARK CENTRAL HOTEL AFTER THE EXPLOSION.

demolished, and the inmates were buried in the ruins. The work of rescue began at once, and ten persons were taken out more or less severely injured and sent to the hospital; while twenty-three bodies, many of which were so mutilated as to be scarcely recognizable, were sent home and buried by sympathizing friends. In several cases whole families perished. The loss is estimated at $75,000, none of which can be recovered, as the property was covered by fire insurance only, which does not indemnify against loss or damage by explosion. Such was the violence of the catastrophe that the roar and shock of it were heard and felt for miles around the city, and surrounding property suffered a damage of thousands of dollars.

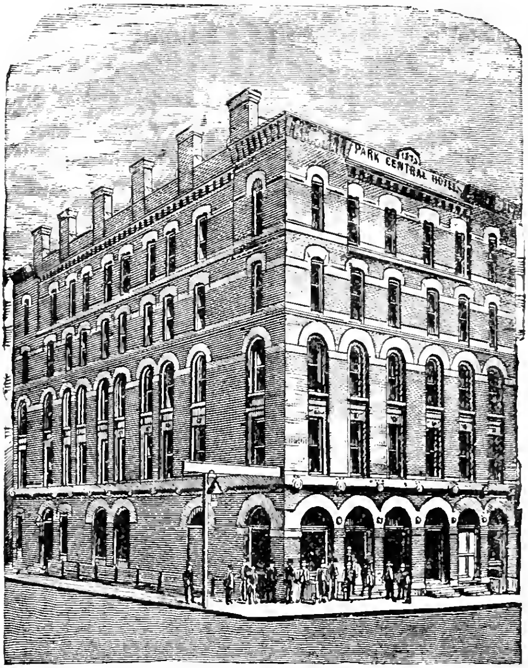


FIG. 2. — THE HOTEL BEFORE THE EXPLOSION.

Our illustrations will give the reader a good idea of the appearance and magnitude of the hotel. Fig. 2 shows it as it was before the explosion, and Fig. 1 shows what was left standing of the rear portion of the building. This had afterwards to be pulled down, thus making the destruction complete.

The cause of this terrible disaster was an iron boiler of the horizontal tubular type, about four years old, and of the following dimensions: diameter 54 inches; length 16 ft. 3 in.; shell plates of Bay State refined iron, 5-16 inches thick, double riveted; heads (iron) 3-8 inches thick; tubes 3 in. in diameter, 15 ft. long and 58 in number. Two engineers were employed, one of whom has held a marine license; one of them stood watch by day, the other by night. The boiler was inspected annually by the State Inspector of Steam Boilers, First Congressional District, and was last tested by hydrostatic pressure in August, 1888, and a certificate given conformably to law, for a steam pressure of 75 lbs. per square inch. It is not true, as was stated in various papers, that this boiler had been inspected by the Hartford Steam Boiler Inspection and Insurance Company. This company had never inspected the boiler in question, nor had it any knowledge of it.

The work of recovering the fragments of the boiler was undertaken promptly after the explosion, and as fast as they were brought out of the ruins they were carefully measured, and the work of re-assembling them was begun. The result is shown in Figs. 3 and 4. It will be readily seen that, although a few small pieces were lost, the five principal pieces into which the boiler separated (see lines of fracture, Figs. 3 and 4) were recovered, and their position, condition, etc., carefully noted; and these tell the story of the explosion.

It was thought at one time, before the wreck was cleared up, that owing to defects and general structural weakness known to have existed in the building, it was possible that the building had fallen first and in its fall wrecked the boiler; but as soon as the pieces of the boiler were exhumed from the ruins that belief was dispelled, and it was apparent that a boiler explosion was the cause of the calamity, and not the effect.

There was some diversity of opinion as to the cause of the explosion, but it was thought from the first, by the representatives of this company, that there was no evidence of low water, nor any appearance of overheating upon the shell plates or heads. This opinion was fully sustained by the subsequent discovery of the back head of the boiler with the fusible safety-plug still unmelted.

The shock of the explosion (which was felt for miles around the city), and the general destruction of the hotel and injury to adjoining property, must, of necessity, have

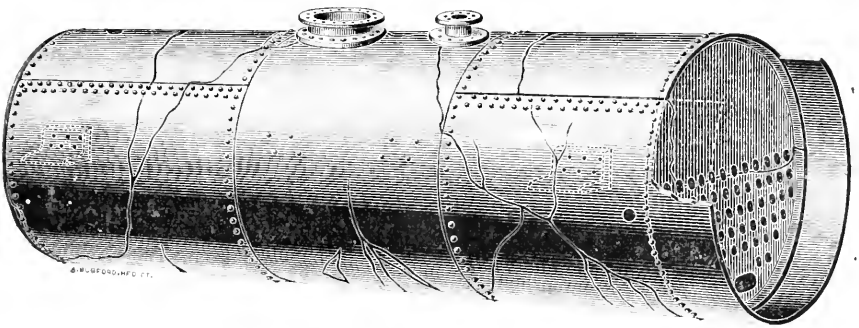


Fig. 3. — Elevation of the Restored Boiler.

arisen from the release of a very considerable force; and this force we believe to have been the stored energy in the water contained in the boiler at the time of the explosion, the approximate amount of which we will endeavor to compute from the available data. In view of all the facts that have been brought out by investigation since the explosion, we are of the opinion that it cannot be accounted for upon any other hypothesis than that of a pressure greatly in excess of the seventy-five pounds allowed by the State In-

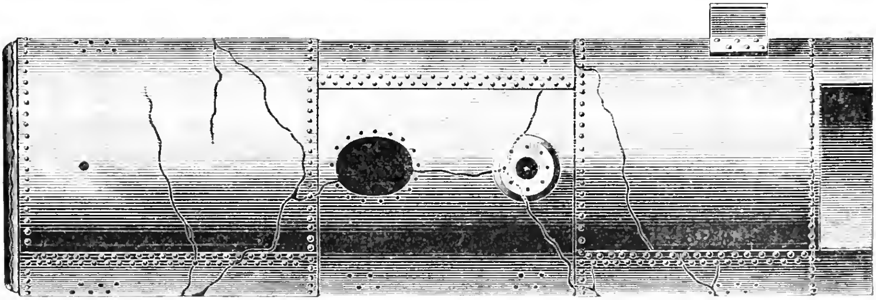


Fig. 4. — Plan View of the Restored Boiler.

spector's certificate, — how much greater, is a matter of conjecture. The steam gauge, one of the Bourdon patent, was found in the ruins in a dismembered condition (unfortunately it had been so badly shattered as to be of little service in unraveling the mystery), but it was noted that the steam tube or Bourdon spring had been straightened out so as to receive a permanent set; and there were no indications that this had resulted from any other cause than a high pressure. As Bay State refined stamps were found upon the plate of the boiler, it will, perhaps, be fair to assume it to have been of the tensile strength usually accorded to that quality of iron plate; that is, 45,000 lbs. per square inch of sectional area. This, in a boiler of 5-16 inch thickness, double riveted, and 54 inches diameter, would give a safe load of 104 lbs. (see United States Steamboat Inspectors' Manual, p. 76), and a bursting pressure of some 375 lbs. The steam nozzle and man-hole of this boiler were placed upon the same sheet, the openings being 8½ inches, and 12½ by 16½ inches respectively. It will be apparent from a study of the illustrations that this portion of the shell would not be as strong as other parts of the shell of like area. Under an excessive pressure the longitudinal section of the middle part in the line of the man-hole opening would be the weakest, and there would be a distortion, as it flattened down in assuming an oval shape under a gradually increased pressure, from a concentration of the strain at that part. That this was the case seems demonstrated by the drawing down of the plate on that line; for this was the only place, so far noticed, where there was any perceptible reduction of thickness in the plate along a line of rupture. This strain would have to be withstood by the man-hole frame; and when that fractured, the opening being so close to the edge of the sheet, rupture and explosion were inevitable. (See Fig. 5.)

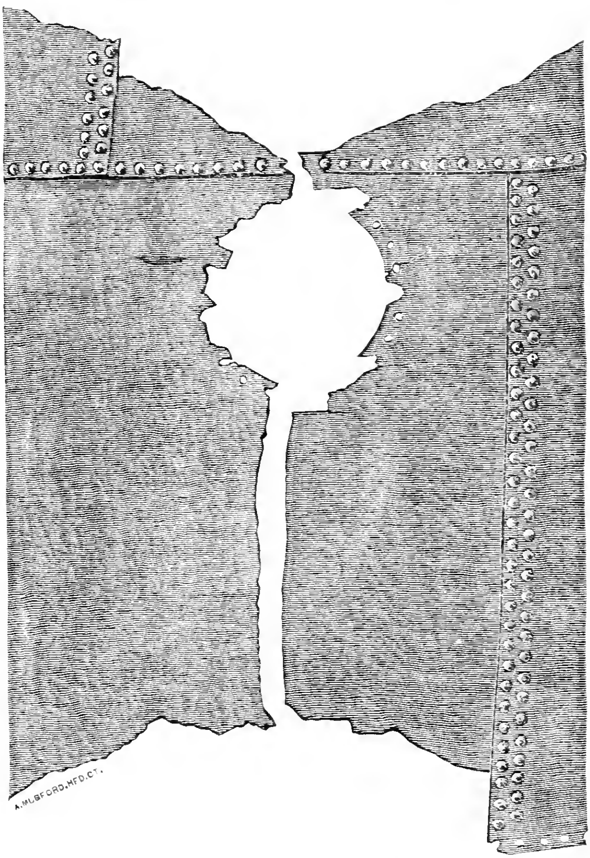


FIG. 5.—THE INITIAL RUPTURE THROUGH THE MAN-HOLE.

The man-hole frame is thought to have been shattered, but no pieces have as yet been found.

If, as we believe, this middle sheet was weaker than the others, a much lower pressure than 375 lbs. (the theoretical bursting pressure) would cause rupture. Suppose, then, for the purpose of our computation, that the pressure at the time of rupture was 200 lbs. per square inch, the corresponding temperature being 388° Fahr. It is true that we cannot tell the height of water in the boiler at the time of the explosion with precision, but the fact that the fusible plug was found intact and that it readily fused when subsequently heated, establishes beyond dispute that there must have been at least enough water to cover it; and our calculation will assume this to have been the case. On making this assumption we find that the boiler contained 5,552 lbs. of water and 48 lbs. of steam. When the explosion occurred a portion of this mass of water was vaporized, the temperature of the remaining water being thereby reduced to 212 degrees. The assumed original temperature being 388 degrees, the fall in temperature was 388°—

212°, or 176°; and this multiplied by 5,552 lbs. gives 977,150 British thermal units, which is the amount of heat given off and immediately converted into mechanical energy. The difference between the total heat of a pound of steam at the assumed pressure and at atmospheric pressure is 1200°.2–1146°.6, or 53°.6; and this, multiplied by 48 lbs., the weight of steam in the boiler, gives 53°.6 × 48 = 2572. British thermal units. Now if we add this to 977,150 (the heat given off by the water) we have 979,722 heat units, which is the amount of heat given off in the form of mechanical energy. Since one heat unit is equivalent to 772 foot pounds of energy, the heat given off by the boiler was equivalent to 772 × 979,722 = 756,345,000 foot pounds.

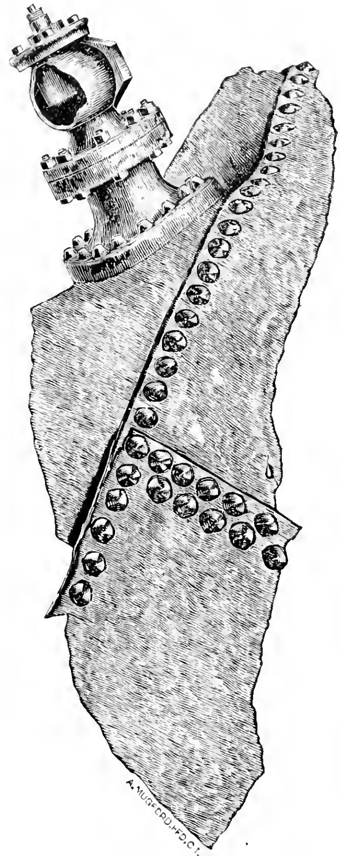


Fig. 6. — The Safety Valve.

This large number of foot pounds means this: The mechanical energy developed by the liberation of the water and steam in the boiler, at the temperature due to 200 pounds pressure, was sufficient to raise 756,345,000 pounds one foot; or, if we assume that the boiler and fixtures weighed 6 tons, it would have been sufficient, if applied vertically to the boiler alone, to raise it in the air to a height of many thousand feet.

We may more fully understand the magnitude of the force confined within the boiler by comparing it with the destructive effect of the wind at the time of a violent hurricane that destroys buildings and uproots large trees. The wind, we are told, has a maximum velocity at such times of one hundred miles per hour, and exerts a pressure of 50 lbs. per square foot; while in the boiler under consideration the pressure is believed to have been 200 × 144 = 28,800 lbs. per square foot.

Many of the most destructive explosions of which we have any knowledge, have been caused by an inoperative safety valve, an accumulated pressure, and a full supply of water in the boiler; indeed the greater the quantity of water at such times, the more disastrous the effect.

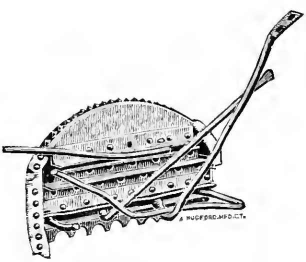


Fig. 7. — Upper Half of Front Head.

There are many stories in circulation as to the want of care and proper management of this boiler. The coroner is now engaged in an investigation, and it is hoped that he may clear up the mystery of the safety-valve, and among other things, tell us whether it was purposely set fast, or became so in some other way. It was of the common lever variety, with a conical valve 3 inches in diameter, and it was amply large, when in working order and intelligently used, to discharge all the steam the boiler was capable of making. Fig. 6 shows the valve as it appeared after the explosion. The observed tendency of a conical valve to stick in its seat, and the ease with which it may be tampered with, have led to the introduction of various improved safety-valves. Figs. 7, 8, and 9, represent portions of the heads. There are other details of the boiler that might be discussed with advantage, and will be, in a later issue of the LOCOMOTIVE; but it would not be courteous for us to discuss them now, while the official investigation is in progress.

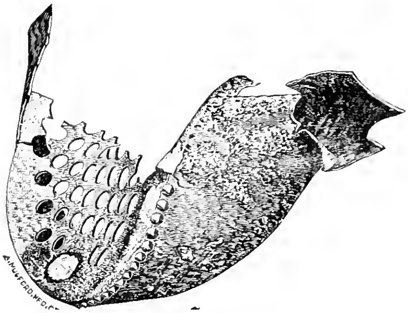


FIG. 8.—LOWER HALF OF FRONT HEAD.

The facts that we have outlined seem to justify the following hypothesis: That the fire was not properly banked by the engineer who went off duty at midnight; or that if it was, one of the two tramps who were allowed to sleep in the fire-room, and lost their lives there, had opened the damper and closed the fire-door after the engineer was gone, probably not realizing the danger of the act: that the safety-valve was inoperative and that steam accumulated until the strain on the shell reached the limit of strength of the weakest point, which weakest point is shown by the explosion to have been the man-hole frame and middle course sheet: that the explosion wrecked the partition wall in the cellar, against which the boiler was placed, and that it then raised the building, displacing connecting walls, joints, and supports, drawing them inwardly with the exception of the front wall on High street, which, not being connected, was blown outwardly and fell into the street.

Explosions of boilers similarly placed have not always wrecked the building as completely as this one did, but of course there is the possibility that the other explosions were not so violent. When boilers are placed beneath buildings (and it is impossible to avoid placing them so, in some cases), the result is apt to be very serious in the event of an explosion, for such walls as are not blown down at the time are often so badly shattered that they have to be pulled down and rebuilt. In this case if more of the main walls had remained standing it is probable that beams and other parts would have lodged against them in such a manner as to save many of the lives that were lost.

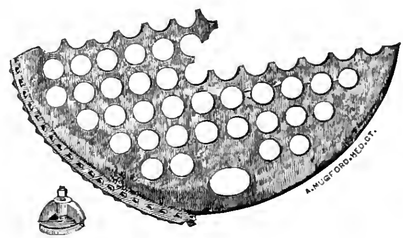


FIG. 9.— LOWER HALF OF BACK HEAD.

We shall be glad to record for the benefit of our readers the result of the coroner's inquest, and also to describe some examinations and tests of our own concerning the iron boiler plates, giving the conclusions we have drawn from them and discussing some other matters not referred to in the present article.

Boiler Explosions.

FEBRUARY, 1889.

TOW-BOAT (19). The tow-boat *Two Brothers*, lying at the Allegheny wharf at the foot of Eleventh Street, Pittsburgh, Pa., burst her boiler on Feb. 2d, completely demolishing the vessel and badly wrecking the tow-boat *Return*, which was lying by the side of the *Two Brothers*. When the boiler burst the debris and scalding water was scattered in all directions. Two persons were killed outright and eight others were injured. The names of the killed are: George Wilson, engineer of the *Return*, and Robert Cochran, fireman of the *Two Brothers*. Pieces of fire-brick struck a grain elevator, 200 yards distant, and the safety-valve was picked up on the corner of Eleventh Street and Penn Avenue.

Insane Hospital (20). Two boilers in the engine-room of the State hospital for the insane exploded at Lincoln, Neb., on Feb. 5th, completely wrecking the engine-house, killing two patients and one engineer, and injuring two patients and the other engineer. The main building was uninjured with the exception of glass broken by the concussion. The explosion completely destroyed the five boilers and the dynamo for furnishing electric light, leaving the building without heat or means of preparing food. The loss will probably be $20,000.

Portable Boiler (21). A boiler explosion at Darlington, Mo., on Feb. 7th, killed Ben McCurry, injured Henderson Weeks so that he died soon afterwards, and seriously wounded Elmer Shelley. The men were engaged with a portable engine in sawing lumber, the engineer being inexperienced and the boiler old and unreliable. Weeks leaves a large family of children. McCurry was a single man.

Creosoting Works (22). On Feb. 11th a brick creosoting boiler exploded at Chattanooga, Tenn., saturating H. J. Falls with hot tar and burning him to a crisp. His son was also frightfully injured, so that there is no possibility of his recovery. According to the night engineer the gauge showed 38 lbs. ten minutes before the explosion, the manufacturers having guaranteed that the boiler would safely stand 50 lbs. It failed by blowing out the front head. As this was removable, it is probable that it was not properly braced.

Saw-Mill (23). A disastrous explosion occurred at Maroney's saw-mill in Aspen, Col., on Feb. 11th. One of the strange things about it was that though there were sixteen men in and around the mill at the time, only one was injured. Suddenly, without any warning, there was a crash like the explosion of a stick of giant powder, the men inside were all thrown down and none of them could see what had happened. Some were covered with falling boards, and each thought that the rest must be dead; but when they all crawled out it was found that they were uninjured with the single exception mentioned. They were all coal black, supposedly from flying soot. On looking around the men saw that there was nothing of the mill left. The boiler was all gone, except a piece of one grate-bar. The 10x10 timbers to which the boiler was bolted was gone. Two cords of wood that stood in front of the boiler were gone. The carriage was broken in two. The main shaft was gone and the building was literally carried away, the saw itself being the only thing that was not destroyed. The men who were outside declare that the boiler went up through the roof and exploded in mid-air like a fire-cracker. It was several hours before any part of it could be found, when the smokestack was discovered behind a lumber pile. It was then observed that a track had been mowed through the timber up the hill. This was followed and one-half of the boiler was found a quarter of a mile away. It had cut a swath in its flight, cutting off a great many large trees about 50 feet from the ground. No other part of the wreck has been discovered, not even the timbers upon which the boiler stood.

Locomotive (24). The boiler of a locomotive attached to a freight train on the North Pennsylvania branch of the Philadelphia & Reading road exploded near Centre Valley, Pa., Feb. 15th, killing Fireman Crockett and fatally injuring Frank McGowan, the engineer, both of Philadelphia. Brakeman Fred Schroek, who was in the cab at the time, was thrown 100 feet, but escaped with comparatively slight injuries. The locomotive was a camel-back, No. 935.

SAW-MILL (25). Six men were killed on Feb. 16th, by a boiler explosion in John F. Jenks' saw-mill at Murphy, Pleasant County, W. Va. Mrs. Jenks, who was passing by, was also killed.

HOTEL (26). The boiler in the Park Central Hotel, Hartford, Conn., exploded on Feb. 18th, burying the inmates of the building in the ruins. Details of this explosion will be found in our leading article for this month.

MINE (27). A boiler of the Blue Jay mine at Butte, Mont., burst on Feb. 21st, and narrowly missed killing five men. The boiler was blown 190 feet through the office, which was entirely destroyed. Five men, who were working at the mouth of the mine, were all injured. Jim McCrimmir was the most seriously hurt. He was struck on the head by an anvil, which was blown sixty feet by the explosion. Pieces of the boiler were blown 1000 feet.

MACHINE SHOP (28). A boiler in the Lake Erie & Western shops exploded on Feb. 21st, killing Peter Shick and demolishing a part of the building.

SAW-MILL (29). At Clarksonville, Mich., on Feb. 21st, the boiler of M. Shanks & Son's saw and planing mill exploded, completely wrecking the mill, instantly killing Charles Rogers, the engineer, and slightly injuring several other employees. Seven employees were at work on the floor above and adjoining the boiler-room, all of whom were prostrated by the concussion, the roof falling almost at the same instant. Pieces of the boiler were hurled forty rods, one large piece passing over the head of a man who was unloading logs in the yard at the time. The loss on the mill is about $2,000.

COTTON MILL (30). A boiler explosion occurred on Feb. 26th, at Wampanoag Mill, No. 1, Fall River, Mass., in which John Hyslop, a fireman, was scalded. The mill has six boilers of the Harrison pattern, and of late they have been in the habit of exploding.

MACHINE SHOP (31). A boiler exploded on Feb. 26th, in the machine room of the Bigelow Blue Stone Company's works, Malden, N. Y., and two men were injured badly, one of them perhaps fatally. Considerable damage was done to the boiler-room, and the chimney was so cracked that it will have to be taken down. The boiler was small and failed by blowing out a head.

18,000 or 20,000 H. P.

The great experiment of the past year has been the Inman and International Company's steamer *City of New York*. She was intended to make the run to New York in six days. The *Etruria* has crossed the Atlantic in six days and one hour, but this was an exceptional run, and the average performance of the *Etruria* is more like six and a half days. Consequently the *City of New York* must be somewhat faster than the Cunard boats. Up to the present she has failed to attain the expected speed, but she is an extremely fast ship, and it is worth notice that in stormy weather she has twice beaten the *Etruria* by some hours as a consequence of her great size. The *City of New York* has been taken off the line for the purpose of undergoing some modifications, which, it is expected, will bring up her speed to the required point.

Calculation shows that certainly not less than 18,000 indicated horse-power will be needed to drive the ship at 20 knots an hour. It is possible that more will be needed, because of the way in which the hull has been put together with vertical butt straps outside. Taking, however, as a basis, 18,000 horse-power, we find that nine boilers have been provided to supply it. These boilers are double-ended, with six furnaces in each; the boilers are about 19 ft. long, and the grates 6 ft. 6 in.; the boilers stand fore and aft, in groups of three; there are in all 54 furnaces. The *Etruria*, to indicate 14,000 horse-power, has 72 furnaces; but she has only compound engines, while the *City of New York* has triple expansion engines. The area of her grates is approximately 1,250 square feet to produce 18,000 horse power. Then each square foot of grate must represent nearly 15 horse-power.

It is a very easy matter to talk of 18,000 or 20,000 horse-power; but few people we think realize what it means. The following figures may help them to form a conception of what the much-despised practical engineer has to do and does. It is more than probable that the White Star boats being built by Messrs. Harland & Woolf will develop 20,000 horse power. At least, so rumor says; for rightly or wrongly, it is asserted that they will have each 12 boilers and 72 furnaces, worked with forced draught on Howden's system. Assuming that the engines will require 18 pounds of steam per horse per hour, then 160 tons of feed water must be pumped into the boilers every hour, and 160 tons of steam will pass through the engines in the same time. In twenty-four hours the feed water will amount to 3,840 tons, occupying 138,240 cubic feet. A tank measuring 52 ft. on the side would hold one day's consumption, or it would fill a length of 493 ft. of a canal 40 ft. wide and 7 ft. deep. Taking the condensing water at thirty times the feed water, it will amount to 4,800 tons per hour — 115,200 tons in twenty-four hours; or, for a six days' run across the Atlantic, to not less than 691,200 tons, or 24,883,000 cubic feet. This would fill a cubical tank 295 ft. on the side — a tank into which the biggest church in London, steeple and all, could be put and covered up. The coal consumed will be 400 tons per day, which would fill forty wagons. This will require for its combustion 8,600 tons of air, occupying a space of 222,336,000 cubic feet. It is impossible for the mind to take in the significance of these latter figures. It may help if we say that if this air was supplied to the ship through a pipe 20 ft. in diameter, the air would traverse that pipe at the rate of about 5.6 miles per hour. It will be seen that the circulating pumps and fan engines of such a ship have no sinecure. — *The Engineer.*

We are all familiar with the legend, "Drop a nickel in the slot." As a contemporary expresses it, "One can be weighed, have his strength tested, secure some chewing gum or a package of cigarettes, have his handkerchief perfumed, buy postage stamps and stationery, or even insure his life, in this most convenient way." The latest device that we know of in this line is the "pre-payment gas meter," invented in England by a Mr. Brownhill. A penny deposited in the proper place will cause the meter to work for six or eight hours; and if several pence are deposited, the time will be increased proportionately. By this means, the inventor hopes to save the gas companies considerable trouble, and also to enable small tenants to buy their gas at retail.

Owing to the fact that water is slightly compressible, the lower strata of the ocean are pressed into a smaller space than they would occupy at the surface. This means that the ocean is somewhat shallower than it would be if water were perfectly incompressible. According to Prof. Tait, "in a depth of six miles the decrease in depth from this cause would be 620 feet; and if the water of the ocean were to suddenly cease being compressible the result would be that four per cent. of the habitable land on the globe would be submerged, because the mean level of the sea would be raised by 116 feet."

The Locomotive.

HARTFORD, MARCH, 1889.

J. M. ALLEN, *Editor.*

H. F. SMITH, A. D. RISTEEN, } *Associate Editors.*

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.

IN the January number of the LOCOMOTIVE, we referred to an explosion in an oatmeal mill in Chicago. Our information was from the daily press, as usual, and we have since learned that the explosion was caused by *dust*, and that the boilers were afterwards found intact. We make the correction with pleasure.

THE cut on the first page of this issue of the LOCOMOTIVE is from a sketch made by "our special artist" early on Monday morning. It represents the condition of the hotel immediately after the explosion much more perfectly than the photographs do, for the day was so rainy and the air so full of smoke and steam that no photograph could be taken until late in the forenoon, and the better ones were not taken until the next day, after the debris had been well pulled over. The hotel extended out into the near foreground of the picture, before the explosion, and was flush with the front of the house shown on the right. The photographs of the parts of the boiler were taken under the direction of Mr. F. B. Allen, second Vice-President of the company, who made a very thorough investigation into the cause of the explosion, the results of which are set forth in our leading article.

WE have received from Prof. J. F. Klein, of Lehigh University, a set of tables for laying out accurate profiles of cycloidal, epicycloidal, hypocycloidal, and involute gear-teeth. The method he proposes involves only multiplication, the use of the T-square and triangle, and ability to lay off distances accurately. Numerous points on the profile of each tooth are laid out by the draughtsman, with the aid of the tables, and the outline of the tooth is then sketched through them. The labor of this process would be prohibitory, of course, unless the nicest results are required. We consider the tables good things, however, and have no doubt but that they will find a wide field of usefulness.

THE fifth annual report of the State Inspector of Workshops and Factories in Ohio is full of instructive matter, and shows that Inspector Dorn has been mindful of his duties. Among other things he makes some good suggestions regarding the care of boilers and fittings, which we quote and commend: "Another dangerous practice is the caulking of joints in steam pipes while pressure is on. If pipes or fittings are corroded, as they very frequently are, there is danger that the chisel or caulking tool may be driven through the pipe. In such a case the workman is likely to be seriously scalded. The practice of screwing up man-hole, hand-hole, and similar plates, while boilers are under pressure, to stop leakage, is of a similar nature and should be as strongly discountenanced. A great many accidents have been caused in this manner. The following occurred some years ago: A battery of three horizontal tubular boilers was fired up, and on raising steam the joint of one of the man-hole plates was found to leak quite badly.

Instead of letting down the steam and repacking the joint, a wrench was applied and the attempt was made to stop the leak by screwing up on the bolt. This proving insufficient, a long piece of pipe was slipped over the handle of the wrench and more force applied. The immediate result was the fracture of the man-hole frame, the explosion of the boiler, the destruction of about $10,000 worth of property, and the loss of three lives."

Electricity and Light.

In the Locomotive for January we referred to the relation that is believed to exist between light and electricity. Since that time we have had the pleasure of reading accounts of the experiments of Dr. Hertz and others in this direction. Dr. Hertz finds that Maxwell's theories are correct in every respect, so far as he has been able to examine them experimentally. He finds, for instance, that waves of electrical disturbance travel with the same velocity as light, and that some substances, such as glass, are transparent to them, while others, such as the metals, are opaque. They are reflected from polished metal surfaces in the same manner as light, and may be brought to a focus, or sent in a parallel beam, by parabolic mirrors. He found, also, that the electric waves are capable of giving interference phenomena in every way analogous to those of light. By passing them through a prism of pitch he was even able to calculate that the refractive index of this substance for the particular waves he used is 1.68. But, most remarkable of all, Dr. Hertz found that the rays of electric disturbance can be polarized in the same manner as light.

The discoveries that we have outlined here are of such a magnitude, and give us such an insight into the machinery of nature, that in future years they will, without doubt, be ranked in importance with the discovery of universal gravitation. We may now rest assured that light is nothing more nor less than a vibratory electrical disturbance in the ether. This being established both by theory and by experiment, it cannot be long before some application is made of it to the practical affairs of every-day life. It seems probable that this will be in the way of electric illumination; for so much energy is now wasted by our electric lights, in the shape of heat, that there is great room for improvement.

The Alaskan *Free Press* tells of the "City of the Icebergs":

"The great field of ice in Glacier Bay reveals to the looker-on many of the wonders of Nature, but perhaps none are more wonderful than the reflection of a great and strange city upon its glassy surface. When atmosphere and fogs are at certain phases, and just as the sun has set out of sight behind Mount Fairweather, this mirage, as it is, shows remarkably clear and seems to be suspended in the air, just over a huge basin, formed by Nature, in this icy waste. The streets of this strange city are very wide, perhaps fifty yards or more, and away back in the dim distance, as far as the eye can reach, they appear as a thread, still lined upon either side with tiny dark objects, or buildings, indicating that the city is of great length; but its width cannot be determined, for back a street or two from this main one, the buildings grow dim and hazy, apparently being enveloped in the fog. Upon certain days, when the atmosphere is just right, the houses along the main street show up very plain, the most prominent one observed being seven stories high, with arched doors and windows, and whether from lights within or paintings on the glass, they all show red, the top of the building running up in spires and cupolas. In the streets many people are seen moving about, dressed in loose-flowing garments, with something after the fashion of Turkish caps upon their heads. Domestic animals are also seen; mules, of apparently twice the ordinary size, are drawing loads, and large dogs, with lion-like heads and manes, are following the human beings. From the architecture of the buildings and the dress of the inhabitants, the picture resembles a Japanese city; only the width of the streets, and the size of the domestic animals and the queer appearance of the dogs are certainly unlike those of this earth. But whether it is a city in Japan or on some planet or world unknown, scientific men are better able to judge than we." — *Vox Populi*, Lowell, Mass.

Chesley Heal, the Centenarian.

Chesley Heal was born at Westport, Me., on November 16, 1778, and died at Searsmont, Me., October 6, 1888, nearly completing the almost unprecedented term of 110 years. He was a soldier in the war of 1812, and served in the division stationed along the coast of Maine, at Lincolnville, Northport, and Belfast. He was at Belfast when the British forces, under Major-General Gasselin, crossed the Penobscot Bay from Castline and captured the town. The English force consisted of 700 picked men, of almost equal height, who had served under Wellington. The small American regiment was unable to cope with this force, and no opposition was offered to the landing of the troops. Owing to this fact, the British commander gave orders that the people should not be molested, and that all provisions should be paid for, which was accordingly done.

In 1823, Heal purchased a farm of several hundred acres, at Searsmont, near Belfast. He determined upon clearing and developing this land, and turned all his energies to to that end. He took great interest in raising cattle, and his farm was usually in a good state of cultivation. He was very frugal, very industrious, almost parsimonious in his style of living, and as he was considered a successful farmer, it was anticipated that during so long a life his accumulations would be considerable, but at his decease very little was discovered, and what has become of his wealth nobody knows. Some suspect that he buried his money, and as he never confided it to any one, his secret died with him.

He took quite an interest in politics, and was a staunch Democrat, having voted at every election from 1800 to 1880. His first vote was cast for Thomas Jefferson. Possibly his absolutely quiet life had something to do with his longevity. He rarely left his own neighborhood, and never, it is said, traveled on a steamer or on a railroad train. He never saw anything of the turmoil and bustle of the world, and his nerves were never disturbed. He was quite unlettered, being unable to read or write. He kept his accounts by peculiar marks on his barn door, which he alone understood. His memory was highly cultivated, owing to the constant calls made upon it on account of his being unable to read and write, and this aided him in keeping his accounts.

Physically he was well proportioned and strongly built. He was five feet eight inches in height, and weighed normally about 175 pounds. He had a full, well-developed chest. He was a great talker, and had a loud voice. His health was so perfect that during his whole life he was only once visited by a physician, until his last illness. His eyesight and hearing continued unimpaired until the end. His hair did not turn gray until he had experienced the frosts of a hundred winters. He was a remarkably good sleeper, retiring usually at sunset and arising at dawn. He was a good eater, living on fresh meat during the autumn and early winter when the farmers were slaughtering, but during the summer his diet was principally salt pork cut into slices and fried. The bread on his table was made from wheat, rye, corn, barley, and buckwheat from his own farm. He used tobacco nearly his whole life. He preferred to chew rather than smoke the weed. When young he was addicted to the use of spirituous liquors. He never had any mental labor of any kind, nor any care or worry. A curious feature of his life is that at the age of 105 he concluded to remain in-doors, and although being quite strong and active in his movements, he did not leave the house during the last five years of his life. He did not use a cane, and at times was as active as a boy. He said he could move about the country as well as ever, and would give no reason for his voluntary seclusion. He retained his faculties to the end, and died quietly, and was buried in a field on his own farm.

It is interesting for a moment to look at the remarkable changes that have taken place during the lifetime of a single human being. Heal was born in the midst of the revolutionary war, and was nearly three years old when the surrender of Cornwallis marked the close of the struggle. He was in his nineteenth year when Washington retired from the Presidency, and during his life all the Presidents were nominated to their high offices. He was nearly fifteen when Louis XVI was beheaded and the Reign of Terror began. He had entered on his twentieth year when Napoleon was made first consul, and was twenty-six years old when he was elected emperor. It was in his thirty-seventh year that the great commander was defeated at Waterloo. He lived during the period of the three French revolutions. During his life France had been three times a kingdom, three times an empire, and three times a republic. He was a boy in his teens when Robert Burns was composing his lyrics, when Burke was thundering in the House of Commons, and when Sir Joshua Reynolds was giving the world his great works of art. He was twenty-eight when Fulton launched the first regular steamboat, and sixty-six when Morse first brought the telegraph into practical use by sending messages between Washington and Baltimore. It is almost impossible to conceive that a single life can span such epochs in history.— *Scientific American.*

Bellite, the New Explosive.

We learn from *Engineering* that an extensive series of experiments made in England with this explosive in the early part of February, showed that it is, without doubt, the safest substance yet discovered for blasting and similar uses. "The experiments were arranged in groups, each of which was intended to illustrate either a distinguishing characteristic of bellite or its adaptability to some specified end. The first experiment was intended to exemplify its use in submarine mining; 1½ lbs. of the material was inclosed in a tin canister, and on being fired by a detonator, the explosion sent the spray fully 150 ft. high. The next group of experiments were made with the object of showing the perfect safety of the material and that it could only be fired by a detonator. A bellite cartridge was broken in two, and one-half thrown on a fire, where it slowly burnt away with a reddish flame. The other half, weighing about 2 oz., was then exploded on a wrought-iron plate 12 in. by 12 in. by ⅜ in. thick, the charge being tamped with clay. The shock bulged the plate to a depth of about 2 in., but did not pierce it. To our mind an even more convincing proof of its safety was afforded by the chairman of the company, who, holding part of a naked bellite cartridge in one hand, calmly applied a lighted fuse to the fragment with the other. The bellite charred and smouldered, but went out immediately on removing the match. An iron weight, weighing 120 lbs., was then dropped from a height of 18 ft. on to a number of naked bellite cartridges supported on an iron plate. The test was repeated twice, as on the first occasion the weight fell somewhat to one side; but on the second trial, with more careful centering, the mass of bellite was crushed to a powder." A severer test than this had been applied some time previously, a weight of half a ton being allowed to fall upon the cartridge from a height of 20 feet, without causing it to explode. "A small canister, capable of holding 5 oz., was then filled with the fragments resulting from the last experiment, and laid on the web of an old steel-faced rail, the charge being slightly tamped with clay. On firing, the rail was snapped in two, a piece about 1 ft. long being flung 6 yards, and smaller fragments much farther, while a pit 15 in. deep was sunk in the ground immediately underneath the position of the charge.

"The next experiment was a repetition of one first made at one of the collieries of South Wales. In it 1 lb. of ordinary blasting powder and 1 lb. of naked bellite cartridges were placed together in an open pit 1 ft. 10 in. deep, and the powder ignited. Some pieces of the bellite were thrown out of the hole, and all were slightly charred; but none of it exploded.

"To further illustrate the safety of the material, a fragment of bellite was fired from a large calibre gun (No. 8) with two drachms of powder, against an iron plate, without any explosion of the bellite occurring either in the bore of the gun or on striking the target. This experiment would seem to prove that bellite is well adapted for use in shells. It had been the intention of the experimenters to fire a bullet from the same gun at a target formed of bellite cartridges backed by an iron plate, but owing to the jamming of a cartridge in the gun, this experiment had to be abandoned.

"To compare the effects of bellite with those of dynamite, 2 oz. of each explosive were fired on wrought-iron plates measuring 12 in. by 12 in. by $\frac{3}{8}$ in. thick, each plate, with the object of rendering the conditions as uniform as possible, being supported above the ground by a narrow cast-iron ring, about $\frac{5}{16}$ in. thick, 3 in. high, and 11 in. internal diameter, the charge in each case being tamped with clay. Both plates were pierced through, but the rents in the one on which the dynamite had been fired were considerably larger, while, on the other hand, the bulge in this plate was only $2\frac{1}{2}$ in. deep, as compared with 3 in. in the case of the other, thus showing the action of the dynamite to be more local.

"The next series of experiments were made with a view to showing the adaptability of bellite to military purposes. To this end the ballistic properties of bellite and rifle powder were first compared, a 6-in. ball weighing 32 lb. being fired from a mortar, first with $\frac{1}{2}$ oz. of powder, and secondly, with $\frac{1}{4}$ oz. of bellite. With the powder the ball was thrown a distance of 40 yards 1 ft., and with the bellite to a distance of upwards of 100 yards, the penetration into the ground being also much greater in this case. A mine containing 8 lbs. of bellite was fired underneath a length of railway laid down for the purpose. The explosion smashed both rails clean through, and several of the sleepers were splintered, a large piece of one being flung fully 40 yards, while the crater formed was upwards of 12 ft. in diameter."

If inventions of this nature are to go on multiplying, there will come a time when war will become a too disastrous operation for anybody to undertake, and the remark facetiously attributed to Bismarck will be full of painful meaning: "Peace? You *bet* we will have peace!"

Curiosities of Exploration in Africa.

The ten or twelve explorers who have done most to prove that the Congo basin, until recently almost unknown, is the second greatest river system in the world, have of course discovered many things of surpassing interest to the student of geography and its kindred sciences. It is intended here to speak, not of the great discoveries of sensational importance, but of interesting facts which have attracted less attention.

About 450 miles above the mouth of the river the Congo widens into an almost sea-like expanse, and for more than a hundred miles up stream it is from five to twenty miles in width. It is a curious fact that though many of the Congo tribes travel far from home, the natives along one bank of the widened stream had hardly a particle of information about the dwellers on the other shore when the whites first met them. The great river was a barrier that news rarely crossed, separating the tribes almost as completely as though an ocean stretched between them. Here hundreds of lovely islands so impede the view that travelers skirting one bank cannot see the other for more than one hundred miles. Of course the river is very shallow except in the channels, which are not yet well known, and steamers often run aground. It has occurred that steamers have passed in broad daylight without knowing of each other's proximity.

Many natives are eager to learn the results of exploring expeditions. When the more intelligent chiefs understand that the whites are spying out the land, they are anxious to learn whether the new facts can be utilized to their own advantage. Thus when Grenfell returned to the Congo from his 260-mile trip up the Lulongo, the big Chief Ibengo and his head men were as inquisitive as an American interviewer. They wished to know how far the Lulongo could be ascended in canoes, whether the natives were numerous and friendly, whether they had ivory and slaves to sell, and so on. Here, as in other parts of the Congo Basin, the discoveries of the whites have largely stimulated the inland trade of the natives. They now send canoe trading parties far up tributaries where they did not venture before the whites pioneered the way. Native geographical information has been rarely serviceable to the whites. Coquilhat says that before a native answers a geographical question he makes up his mind what answer is desired or expected and replies accordingly. Von François found on some of the southern tributaries that information given in one village was contradicted in the next.

While women perform most of the drudgery of the field and house, there are certain compensations for the stern fact that they belong to the fair sex. Women are not regarded as fit subjects for the boiling pot, and throughout the Congo basin, where cannibalism is doubtless practiced to a greater extent than in any other part of the world, women as a rule are not among the victims. Then while the lazy men are exchanging gossip in the village street the women are pounding grain into flour or delving in the fields. The result is that in some tribes the women fully equal the men in muscular development. In the great Baluba tribe the harmful practice of hemp smoking, confined to the men, has made them conspicuously inferior to the women in physique. So it happens that in many a Congo household it is not the man who "bosses the ranch." Many of the women are credited with great ability as scolds, and having the muscle needed to back up their voluble complaints, they lord it over the household as completely as though they were strong-minded Caucasians.

Some very forcible methods are employed for keeping up the price of commodities on the Congo. A while ago a woman's body was found hanging from a tree on the river bank near Irebu. It was learned that the crime of which she was accused was that of selling provisions too cheaply to white men.

If we happened to be on a Congo steamboat, which, rounding a sharp bend, came suddenly into view of scores of people who had never heard of a steamboat or a white man, we would probably regard the actions of that astounded crowd as among the strangest spectacles we ever saw. Explorers say that every mode of expressing astonishment is shown on such occasions, and that actors would find among these awe-stricken blacks a rare chance to study facial expression. Many stand and stare, with eyes bursting from their sockets, and with wide open mouths, which they presently cover with their hands, a common mode of expressing unbounded astonishment. Others stand a long time motionless, as though riveted to the spot. Still others are seized with the wildest panic, and bound away into the forest as though bewitched. One day Grenfell on his little steamer suddenly came upon about fifty women, who were fishing along the shore of an island. With a wild shriek all plunged into the water and swam with frantic strokes to the mainland, where they disappeared in the underbrush. On another occasion a woman who suddenly saw the strange apparition fell to the ground in a fit. Dr. Wolf and Lieut. Von François have written most graphic accounts of the remarkable effects upon the natives of their first sight of a puffing steamboat.—*New York Sun.*

The Locomotive.

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Setting Boilers Over a Single Furnace.

We have had a number of calls for designs for settings arranged so that one furnace will suffice for several boilers. The cuts illustrate one of these settings as designed for a saw-mill, Fig. 1 giving an end elevation and Fig. 2 a side elevation. In this case only two boilers are shown, but the method can be readily extended so as to include three or four; and though this is as far as we have yet carried the principle, we can see no reason why even six boilers might not be mounted in the same manner, if there would be any advantage in doing so.

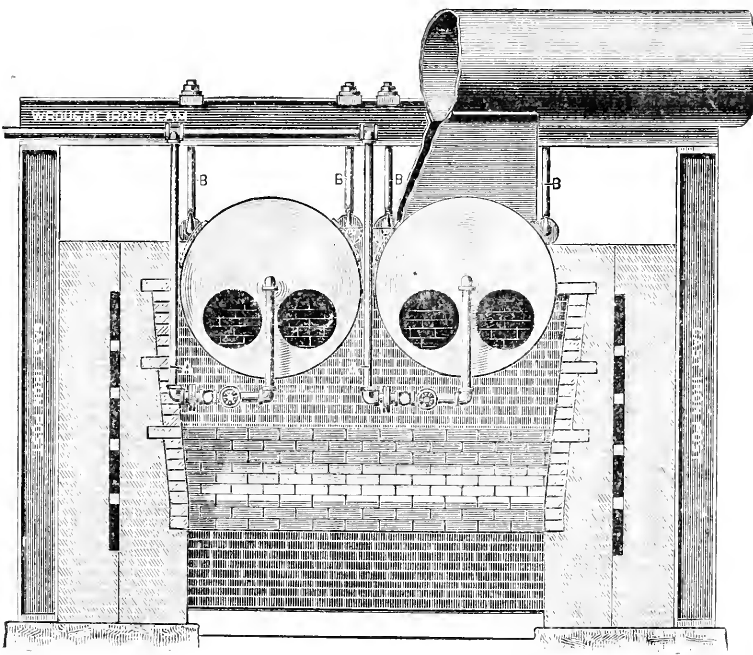

FIG. 1.—SETTING BOILERS OVER A SINGLE FURNACE.

Since there is to be but one furnace, it is evident that the boilers cannot be supported in the usual manner, but must be suspended from overhead by means of beams or trusses. In the pair here shown each boiler was 42 inches in diameter and 21 feet long, and the two together might weigh some 28,000 pounds when filled with water. To support this weight six wrought-iron beams, *D D*, are provided, each being 10½ inches high and of sufficient length to reach over the brick walls on each side and rest on cast-iron posts, as shown. These beams are arranged in pairs and bearing-plates or saddlepieces rest on them, from each of which a two-inch hanger is suspended, the lower end of which is formed into a hook which enters the forged ear *C*, riveted to the shell.

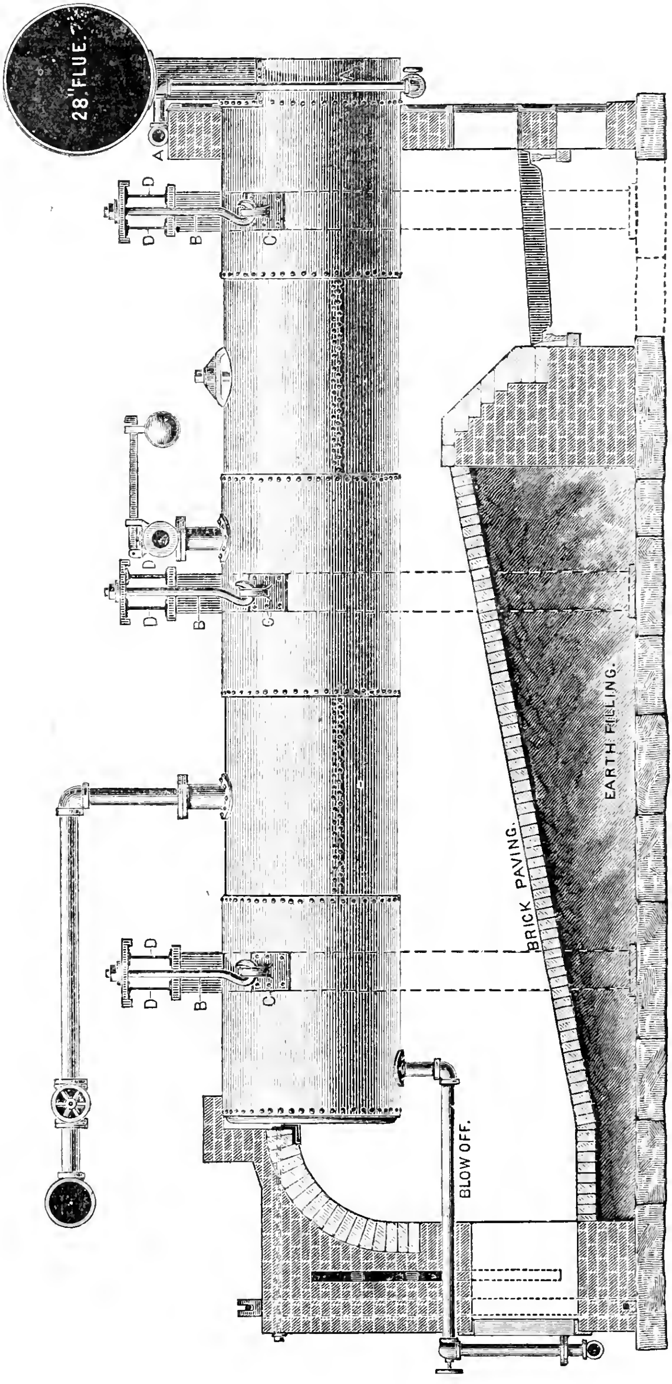

Fig. 2. —Setting Boilers Over a Single Furnace.

AA, feed pipe; *BB*, hangers; *CC*, forged ears; *DD*, wrought iron beams.

The boilers are set much closer to one another than usual, the space between them in this instance being only three inches. This space is closed by means of a filling of cut brick, which rests against both boilers in the manner indicated in Fig. 1, and prevents the products of combustion from escaping between them. A single wide grate extends entirely across the furnace, making it possible to burn slabs and other long pieces that would otherwise have to be sawed. The closeness of the boilers makes it difficult to put in the feed-pipe *A*, in the way that is usually recommended, and it is accordingly arranged, in this case, as shown in the cuts. It then enters near the centers of the heads, running inside nearly through to the back head before it discharges.

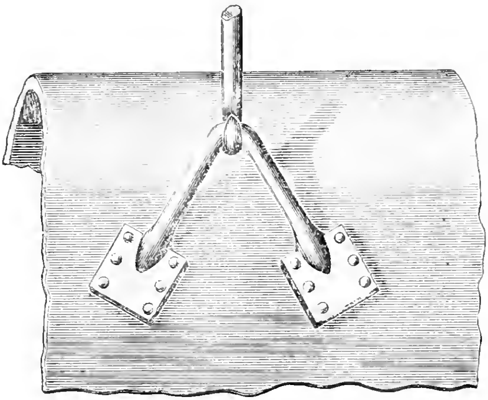

FIG. 3.

We have shown the setting as we should always recommend it to be put in; but objections to this method are sometimes raised, on account of the expense of making the forged ears *C*; so that, while we prefer the forged ears, we have designed a substitute for them, shown in Fig. 3. The ears are not expensive when made by a workman accustomed to such shapes, but the places where this setting is in demand are usually remote from shops where such work is done, and it is generally the case in such places that the only one at all skilled in metal work is the village blacksmith. The support shown in Fig. 3, however, can be easily made by such a workman, and will be found very satisfactory.

Inspectors' Reports.

FEBRUARY, 1889.

During this month our inspectors made 4,281 inspection trips, visited 7,797 boilers, inspected 2,323 both internally and externally, and subjected 424 to hydrostatic pressure. The whole number of defects reported reached 6,471, of which 550 were considered dangerous; 26 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	363	22
Cases of incrustation and scale,	631	17
Cases of internal grooving,	38	4
Cases of internal corrosion,	155	9
Cases of external corrosion,	494	37
Broken and loose braces and stays,	130	14
Settings defective,	142	11
Furnaces out of shape,	226	10
Fractured plates,	191	86
Burned plates,	108	28
Blistered plates,	224	20
Cases of defective riveting,	1,193	16

Defective heads,	148	16
Serious leakage around tube ends,	1,437	136
Serious leakage at seams,	412	36
Defective water-gauges,	169	19
Defective blow-offs,	54	10
Cases of deficiency of water,	3	2
Safety-valves overloaded,	54	9
Safety-valves defective in construction,	59	27
Pressure-gauges defective,	183	18
Boilers without pressure-gauges,	3	3
Unclassified defects,	54	0
Total,	6,471	550

Some remarks have been made, here and there, about inspection failing to prevent explosion in the case of the Park Central Hotel boiler, illustrated in our March issue.

The inspection was thorough. The very violence of the explosion shows that the boiler was in good condition. It is of course impossible for any inspector to watch over a boiler in his charge day and night; that is the engineer's business. It is what he is hired for. The inspector has done his duty when he has looked the boiler over and seen that everything is in good condition; and they who talk about the inefficacy of inspection are really finding fault with the inspector because he is not also engineer.

An Interesting Autobiography.

Hon. William A. Richardson, of Washington, D. C., Chief-Justice of the Court of Claims, who used to reside in Lowell, contributed the following article to the last issue of the *N. E. Historical and Genealogical Register*. As it is not only highly entertaining in itself, but also relates to prominent personages who once lived in Lowell, we cheerfully adopt Judge Richardson's suggestion that it be reproduced in our columns. He writes:—

Some years ago, when residing in Cambridge, I became acquainted with the late Alvan Clark, the distinguished astronomical instrument maker, and after coming to Washington I had some correspondence with him. Among his letters is one containing his autobiography, written at my request ten years ago last October. If you think it would be of interest to the readers of the *Register* you may publish it there.

Cambridgeport, October, 1878.

My Dear Sir,—The account of my career you have desired, I can write in pencil more conveniently than with ink. I have written but little in my life, and less of late than ever; so it is hard and slow work for me.

My father's name was Abram, and he was born in Harwich, Mass.; and my mother was Mary Bassett, born in Dennis, Mass. They removed to Ashfield, Franklin Co., Mass., in 1794, where I was born, March 8, 1804. I was the fifth son of ten children, seven sons and three daughters: five of us are living at this date.

Our farm of one hundred acres was one of the roughest and most rocky in that rough and rocky town, and over the greater part of it, when I was a lad, the stumps of the primitive forest trees, mostly hemlock, and some very large, were standing. Two splendid trout brooks joined near the lower or eastern border of the farm, upon the larger of which is a grand waterfall near the middle of the farm, but being three and one-half miles from the center of Ashford, and about the same distance from Conway and Goshen centers, it has attracted little attention. The year I was born my father built a saw-mill just below the confluence of these streams, and close upon the line between Conway and Ashford. It was a fourth of a mile from the house, in plain sight, and of course a prominent object in my childish thoughts. It was washed away after standing seven years, but rebuilt when I was eight. I concluded that I should be a millwright, being wonderstruck by the achievements of Captain Gaines, the chief in this work of rebuilding.

The first school-house in the district was located on our farm, and built when I was seven years old. At times forty scholars attended there, where now they can scarcely muster ten, and I sometimes might be inclined to fear that in forsaking a home abounding in inviting influences, my example had been pernicious, were it not that I see with regret the same depopulation going on almost all over the rural portions of New England.

An old grist-mill located by the waterfall, built before I was born, was purchased by my father when I was about twelve. The school, the farm, and these mills busied me until about seventeen, when I began to think that perhaps I might be better fitted for some other calling, and I went into a wagon-maker's shop and worked about a year with an older brother, but returned to the paternal mansion and put myself at work in good earnest to learn alone engraving and drawing, though I had first visited Hartford and seen something of such works, which were cheerfully explained to me, green as I was, by strangers well-skilled, of whom there were a number at that time in the place. I visited Boston in the autumn of 1824, carrying with me specimens to show my proficiency, which, though not great, were sufficient to secure me a living employment for the time.

Supplying myself with some of the most needed art materials, I returned to Ashfield the next May, and spent the summer as studiously as possible, with no settled plans further than the acquisition of skill. In neighboring towns I offered my services in making small portraits, some in India ink and some in water colors, and with a pretty satisfactory measure of success.

Here I must give you one little incident which tends to show what small matters can change the course of a human life. Wanting some fine sable-hair brushes, I sent for them by a man in the habit of visiting Boston. Upon looking over a piece of newspaper in which they were wrapped when received, my eye fell upon an advertisement of recent date, headed "Engravers Wanted." I was not long in making up my mind to apply for the situation. On reaching Boston I found the engravers were wanted at the engraving shop of the Merrimac Works, in East Chelmsford, for calico printing. The agent informed me that they had just contracted with Messrs. Mason & Baldwin, of Philadelphia, to do their engraving, and that one of the firm would soon be in East Chelmsford and very likely would employ me as an assistant.

Mason at once on his arrival offered me eight dollars per week for one year, and nine dollars per week for the three succeeding years, with opportunity for learning the trade in which they were engaged. I was to work nine hours in winter and ten in summer, per day, which terms I accepted. Such pay would now be considered small for a beginner in housekeeping, but I was able to supplement it a little by painting and cutting stamps out of the shop.

I have always felt that I incurred a very serious risk in marrying as I did. My wife, Maria, was the daughter of Asher Pease, and was born in Enfield, Conn., November 30, 1808. The family removed to Conway and settled on a farm within half a mile of my own father's residence in 1811, where she resided with her parents until our marriage, except for a short time she boarded in the family of Dr. Edward Hitchcock, while he was settled preacher in Conway, previous to his taking the presidency of Amherst College — this for the purpose of attending a select school After remaining about six months in East Chelmsford, I invited my father to accompany this young woman to the place, which he did, and we were married, as the record shows, on the 25th of March, 1826.* My employer, Mr. Mason, was very kind, and procured credit for me, that we could arrange for housekeeping in an unpretentious way, where I felt we were established for three years and six months at least.

But a disagreement sprang up between Mason & Baldwin and their employees, resulting in Mr. Mason returning to Philadelphia ; but previous to leaving, he offered to cancel our engagement, or take me with him to Philadelphia to serve it out, or he would open a branch shop in Providence, R. I., and give me charge of it, with pay of ten dollars per week and one-fourth of the profits. I accepted the last proposition, as there was no chance that I could remain in the Lowell shop with comfort, for they had imported English engravers who had no notion of allowing the secrets of their art to slip into the hands of Americans. Our tarry in Providence was of only about one year's duration, when this branch of Mason & Baldwin's works was removed to New York, where I continued on the same terms with them, until the spring of 1832, at which date I received an offer from Andrew Robeson for my services at his print works in Fall River, such that I was induced to relinquish my connection with Mason & Baldwin. We had but just settled in Fall River when the cholera broke out in New York. Before passing I would say the partner of Mason was M. W. Baldwin, afterwards the famous builder of locomotives. While residing in New York I had excellent opportunities for studying painting, and practiced all I could, and never gave it up even after removing to Fall River.

In 1835, Lucius Manlius Sargent was invited by temperance people to give a lecture in each of the churches in the place, and as he was to be several days there, I sought a seasonable opportunity for inviting him to give me sittings for an ivory miniature. During these sittings I questioned him as to my chance of success as a miniature painter in Boston. He asked what practice, or experience, or opportunities for instruction I had thus far enjoyed in the art ? After receiving my replies, and perceiving that my heart was in it, without committing himself by advice, he wished to know the highest price I had ever received for a picture, and when I stated twenty dollars he said he wished to take this home with him and also to pay me forty dollars for it. This was an expression of liberality to which I had been quite unused, and caused me to throw up engraving and quit Fall River for Boston. The sympathy and friendship thus opened I was permitted to enjoy through the remainder of Mr. Sargent's life, which was of great advantage to me. I bought the house in Prospect Street, Cambridgeport, in 1836, where I resided until 1860 ; supporting my family by painting portraits and miniatures in Boston.

In 1844 my son, George Bassett Clark, born in Lowell, February 14, 1827, had been for a time in the academy at Andover as a student, with a view of qualifying for a civil engineer. In the course of his scientific reading this youth happened to fall in with some account of casting and grinding reflectors for telescopes, and before mentioning it to me had procured his metal and made a casting for a small mirror. I watched his progress in grinding and polishing with much interest, and perceiving a growing interest on his part, I was at some pains to acquaint myself with what had been done, and how done, in this curious art, that my son could have the benefit of my maturer judgment, in giving effect to his experiments. We spent much time on reflectors, and found for ourselves that the difficulties which have led to such an extensive abandonment of this form of telescope were really irremediable. The sacrifice here was pretty serious for us, with

* This was the first marriage in the *town of Lowell*. That part of Chelmsford called East Chelmsford was incorporated as Lowell, March 1, 1826. The first town meeting was held at Colburn's Tavern, March 25, 1826, and Mr. Clark was married that very day, by the late Rev. Theodore Edson.—W. A. R.

then very limited means. I finally proposed to the youth to try a refractor, but he did not believe we would succeed with it, for the books described it as a very difficult thing.

About this time the great telescope at Harvard College observatory was put to use, and greatly did I wish to see it and look through it ; but Professor Bond informed me that I must come with an order from President Everett before this could be allowed. This order was speedily obtained. I was far enough advanced in knowledge of such matters to perceive and locate the errors of figure in their fifteen-inch glass at first sight, yet those errors were very small, just enough to leave me in full possession of all the hope and courage needed to give me a start, especially when informed that this object-glass alone cost twelve thousand dollars.

I began by reworking some old and poor object-glasses of small instruments, there being no material in our market of suitable quality, and after gaining confidence and tact, sufficient, as I thought, to warrant the outlay, I imported one pair of disks of five and one-quarter inches, and found others in New York of larger size, even up to eight inches, of very good quality.

We made some instruments to order and sold some, working on our own account ; but the encouragement was small, until I reported my doings to Rev. W. R. Dawes, the famous double-star observer in England, in 1851. I gave him the places of two new double stars I had discovered the next year with a glass four and three-quarter inches diameter. One of the stars was a specially difficult one in *Sextantis.*

In 1853 I had finished a glass of $7\frac{1}{2}$ inches aperture, with which the companion of 95 Ceti was discovered. Upon reporting this to Mr. Dawes, he expressed a wish to possess the glass, but to test its qualities further sent me a list of Struve's difficult double stars, wishing me to examine them, which I did, and furnished him such a description of them as satisfied him that they were well seen. I sold him this glass, and afterwards four others, one of which, an 8-inch, in the hands of Huggins, has become well known. Knott, an English astronomer, has one of them, $7\frac{1}{4}$ inches, which he greatly prizes.

Previous to 1859 my correspondence with Dawes had become more extensive than with any other fellow mortal in all my life. I visited him that season, carrying with me one equatorial mounting and two object glasses, one of 8, the other $8\frac{1}{4}$ inches. All were admitted without duty at Liverpool, though I paid 30 per cent. on the rough glass in Boston; nor was that all; the glass was warranted first quality, and when I informed the deputy collector that a large portion of the amount in invoice was in consideration of the warranty, and asked him if any allowance would be made in case it turned out worthless; he said, "No, not a cent; if you buy the devil you may sell him again." The crown *did* turn out defective, and I had to import another and pay 30 per cent. again. But we were then under a democratic administration.

I spent between five and six weeks with Mr. Dawes, visited London with him, and we attended together the visitation at Greenwich Observatory and a meeting of the Royal Astronomical Society, seeing and conversing with many notable personages, among them Sir John Herschel and Lord Rosse. Before taking leave of Dawes I told him he had paid me more money than I had ever received from one individual in all my dealings with my fellow-men, and it was most gratifying to me that he cordially allowed I deserved it.

The reports concerning the performance of these glasses, published by Mr. Dawes from time to time in the monthly notices of the Royal Astronomical Society, was of great service to me in procuring orders, without which, situated as I was, the proficiency which comes from long practice could never have been reached. In 1860, Dr. F. A. P. Barnard, now President of Columbia College, New York, then chief of the University of Mississippi, ordered from us a telescope to be larger than any refractor ever before put to use. I say we, for my two sons, G. B. and Alvan G. Clark, were well-skilled men, on whom my efforts in training had not been thrown away, and who were now ready to embark in an undertaking the importance of which they were qualified to appreciate.

It now became necessary for us to secure more commodious quarters than had served our purposes thus far, and, after visiting various sites, we finally settled where we now are, purchasing nearly an acre and one-half of land, and erecting our buildings in the summer of 1860. The glass for the Mississippi telescope in the rough was received from the makers, Messrs. Chaunce Bros. & Co., of Birmingham, England, about the beginning of 1862, and within one year from that time Alvan G. Clark discovered with it the companion of Sirius, which after a few days in a fine night Prof. George P. Bond was able to see and measure with the 15-inch telescope at Cambridge Observatory. Our glass was 18½ inches, and for the production of such a lens, coupled with this discovery, the Imperial Academy of Paris awarded my son the Lalande prize for 1862.

The war coming on and cutting off all communication with Mississippi, this telescope was sold to parties in Chicago, and is now in charge of S. W. Burnham, who has gained great celebrity by double star discoveries, though much of his work has been done with a glass of only 6 inches aperture.

We have made many instruments of smaller size, but one of 12¼ inches for the Pritchett School Institute of Glasgow, Missouri; one of 12¼ inches for Dr. Henry Draper of New York, one of 11⅞ inches for the Austrian Observatory at Vienna, and one of 11 inches for the observatory at Lisbon, Portugal. Also one of 12 inches for the Wesleyan University at Middletown, Conn., and have now in hand one of 15½ inches for the University of Wisconsin, at Madison.

But the most important work we have ever attempted was making two telescopes of 26 inches clear aperture, one for our government, and one for L. J. McCormick of Chicago. The orders for them were received in the summer of 1871. The government telescope was delivered in the autumn of 1872, and it was with this instrument that Prof. Asaph Hall discovered the two satellites of Mars at the time of its last opposition. The government paid us for this work $46,000. The McCormick telescope is not yet entirely finished, but will be very quickly when provisions are made for it in the way of a suitable site and buildings and the support of a competent astronomer.

Now I must give a narrative in response to another query.

Dr. Jacob Bigelow returned from a visit to Europe soon after the great telescope at Cambridge was placed in the observatory. Knowing that he had been in Munich where it was made, I asked him one day in the street if he saw the establishment where it was made? He answered in the negative. When I informed him that I was interested in such matters, and was then at work upon object glasses, he remarked, that if I wished to learn to make telescopes I must go where they make them, and passed along. Some years later the Rumford committee sought information as to what original means or methods I employed. My reply was that I knew so little of the doings of others that I could not say, but if they would meet at our shop I would explain to them as well as I could the steps by which I had been in the habit of bringing object glasses into figure.

The result was the Rumford prize was awarded me for a method of local correction. Upon the occasion of its presentation the Academy meeting was attended by Dr. Bigelow. The president, Prof. Asa Gray, stated the grounds on which the award was made, and I replied as well as I could. Charles G. Loring and Dr. Bigelow were seated near, and I heard one say to the other, "That was well done." After the adjournment I reminded Dr. B. of his saying that if I wished to learn to make telescopes I must go where they make them, and added that I had been. ,, Have you!—where?" "Cambridgeport," was my reply.

I met Dr. Hare at the August meeting of Scientists at Albany in 1856. Finding him soon after in Boston, I invited him to sit for a portrait, which I finally sold to Dr. Henry for $100. *

So you will perceive that the three periods of my life, of which you write, have been considerably blended. Lives thus changeful are frequently troubled in their finances, but I have been fortunate enough to meet my money promises all along, and have a fair reserve for a rainy day.

I have received the degree of A.M. from Amherst, Chicago, Princeton, and Harvard. I have read much popular astronomy, but in its mathematics I am lamentably deficient. You will see by the printed papers I shall send with this that I have made some use of telescopes. I have lived to see the companion of μ *Herculis* therein mentioned go through considerably more than half a revolution.

This is the most of an autobiography I have ever prepared, and my condition is such that I shall probably never make another attempt, so I would like you to preserve this after selecting your points, for some of the Ashfield people may be pleased to see it. Let me know at once if it is safely received, and when you publish send me a copy of your production.

I will add further what may be of interest. I have always voted with the Republicans, when voting at all, since they came into power, but have never attended caucuses or held an office. I have never been a church-member, nor had either of my parents, but my faith in the universality of God's providence is entire and unswerving. My grandfathers died, one at 87, and the other 88. I knew them well, and they were good men. Both had been engaged in killing whales. I have never heard of one of my progenitors — Thomas Clark † of the "Mayflower" was one — as being a bankrupt, or grossly intemperate. I was never but once sued, and in that case employed Joel Giles as counsel, who made a compromise without going to trial. I never sued but one man, and that was Collector Austin, and I gained my case. I never studied music or attended an opera in my life, and know nothing of chess or card-playing. I never learned to dance, but was a good swimmer, though lacking generally in the points which go to make an expert gymnast. I have long been a member of the American Academy of Arts and Sciences, and my elder son, G. B., enjoys the same honor, more recently conferred.

I hope the above will serve your purpose. Yours with great esteem,

ALVAN CLARK.

Hon. Wm. A. Richardson, Court of Claims.

— *Lowell Vox Populi.*

MR. J. R. HAYDEN, engineer for the Putnam Machine Company, was shoveling coal for the boiler furnace into a wheelbarrow, recently, when his attention was attracted by what seemed to be a round stick of wood about eighteen inches long, and an inch in diameter. He took it up and examined it, and threw a little piece into the fire, which burned with a blue flame. He then took a part of what he had found into the shop, where it was examined and found to be a dynamite cartridge, such as is used in blasting coal. There was no cap on the cartridge, or a sadder tale might have been written. Dynamite explodes by concussion, and under ordinary conditions will burn without explosion, provided that no shock is given, though its use as fuel is not recommended by chemists or physicians. A part of the cartridge was carried to the company's office. It is easy to imagine what the result would have been had there been a cap or "exploder" on the cartridge. Possibly this discovery may give a clue to mysterious boiler explosions. The cartridge was probably carelessly dropped in the coal at the mine. — *Fitchburg Sentinel.*

* This was Prof. Joseph Henry, Secretary or Director of the Smithsonian Institution at Washington, where the portrait is still preserved. — W. A. R.

† From whom Clark's Island, near Plymouth, takes its name.

The Locomotive.

HARTFORD, APRIL, 1889.

J. M. ALLEN, *Editor.*

H. F. SMITH, A. D. RISTEEN, *Associate Editors.*

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SOME weeks ago a cablegram announced that a certain Dr. Krüss of Munich had succeeded in splitting up the metals, nickel and cobalt, into other substances. This was believed to be one of the sensational rumors that come along three or four times a year, wearing such a look of plausibility that we often don't know whether to credit them or not. The truth is that we have come to have such respect for a science that can extract saccharine — a substance 280 times as sweet as cane sugar — from coal tar, that we don't like to say that anything we hear isn't so, if some chemist says it is. This time the report appears to be true. The atomic weights of cobalt and nickel have long been considered to be equal — each 58.6 — and Professors Krüss and Schmidt have been carrying on very delicate measurements with each of the two, presumably for discovering whether the equality is real, or only apparent. After careful investigation ten different methods of splitting up either cobalt or nickel were found, and considerable quantities of a substance common to the two were isolated. A black metal was the result, to which, so far as we know, no name has yet been given.

A Serious Charge.

We take the following from our esteemed New York contemporary, the *American Machinist*: "It is rather a dull day when no new scheme is developed for making money without any very hard work, except that which is done by others not in the scheme, whose labor is of course very necessary to the success of the enterprise. The organized engineers of this city have made a formal protest to the authorities against the operations of a company whose plan seems to be to contract with the owners for the management of steam plants at rates for which competent engineers cannot be employed, and then, in order to make profits upon the service, employ incompetent men utterly unable to obtain licenses, and compel them to act not only as engineers, but as firemen, steam-fitters, and general roustabouts. One of the methods made use of by this enterprising company is said to be to report a boiler as 'out of use,' and thus avoid the necessity of applying for a license. An instance is given of a boiler reported 'out of use,' which exploded, killing the engineer. It is claimed that the steam-heating apparatus of the school buildings is in the hands of utterly incompetent men. The engineers ask that this state of things be remedied, and it is certainly in the interest of the public and of owners of steam plants, as well as of the engineers, that it should be remedied, and that speedily." This is a grave charge to bring against any company, but if it is true — if the engineers have good evidence that this state of things exists — the sooner the transgressors are brought to justice the better. Life and property are endangered enough already, by thoughtlessness and negligence, and the coöperation of any such company is not necessary.

High Pressures.

In the LOCOMOTIVE for October we published an article under this heading, which seems to have been misunderstood in various quarters. The accuracy of our figures has also been questioned. Now, if, as in the case cited, the diameter of the boiler is seventy-two inches, and the length sixteen feet, or one hundred and ninety-two inches, there can be no doubt that the area of the shell is 43,000 square inches in round numbers. Then, if there is a pressure of one hundred pounds on each square inch, the total pressure on the shell must be 4,300,000 pounds, or 2,150 tons. All this seems very simple; and the question as to whether the pressure so calculated tends to burst the boiler or not seems to be equally simple.

There is a suspicion in our minds that one correspondent, at least, who objects to our calculations in the columns of a contemporary, does not see the difference between the pressure of steam against the inside of a boiler, and the strain on the shell produced by this pressure. These two things are widely different; they act at right angles to one another, to begin with, and they are calculated in very different ways. One of them is calculated in the first paragraph of the article mentioned, and the other, by an utterly different process, in the second paragraph.

Read the article again, friend, before moralizing on the relations between theory and practice, and the sweetness of morsels. We have been calculating the strains on boilers for nearly twenty-two years, now, and we think we know how to do it.

Captain John Ericsson.

In the death of John Ericsson, on March 8th, the world loses one of its hardest workers, and one who has done much to bring engineering to the point at which it stands to-day. In his early youth he showed great aptness in scientific and mechanical studies, and his work continued uninterruptedly almost to the day of his death. Up to the last two weeks he had worked in his laboratory personally, and in his last hours, when he could hardly speak above a whisper, he drew his chief engineer's face close to his own, gave him final instructions for continuing the work, and exacted a promise that it should go on.

He was one of the earliest builders of steam fire engines, one of which, built by him, was in use in London in 1829. In that same year he built a locomotive, the *Novelty*, to compete with Stevenson's *Rocket*, on the Liverpool & Manchester Railway. The *Novelty* is said to have attained a speed of thirty miles an hour; but the *Rocket*, weighing nearly twice as much, had considerably more tractive force, and was the accepted competitor.

A few years later Ericsson became a strong advocate of the screw-propeller, urging its special usefulness on ships of war; and in 1837 he built a small tug with twin propellers, which navigated the Thames with success. The British Admiralty authorities inspected his vessel, but declined to adopt her as a model on account of the supposed difficulty of steering a ship whose motive power is applied at the stern. He then removed to this country, and designed the *Princeton* for our navy; and we have the distinction, therefore, of having built the first screw-propeller for use in war.

During the thirteen years that he lived in England, he brought out no less than forty inventions. Among other things he introduced the link motion now used on almost every locomotive built. The caloric engine is another one of his better-known inventions, many hundreds of these engines being now in use in New York city alone. He is known best of all, perhaps, as the designer and builder of the *Monitor*, whose famous engagement with the *Merrimac* in Hampton Roads led all the maritime nations of the earth to remodel their navies. In 1878 he had the torpedo boat *Destroyer* built at the Delamater Iron Works. During an attack this vessel is to be submerged, the torpedoes being discharged under water by means of specially designed apparatus. His latest years were devoted to a study of sunlight, and a means of obtaining power therefrom. A sun-motor, built after his plans in 1883, developed a steady and reliable power when exposed to ordinary sunlight.

"No visitor was allowed to enter his workshop. Even his most intimate friends have never gained entrance there. Nor has any servant been in the room where the captain spent more than twelve hours daily for thirty years. Here in his workshop, as it were, Ericsson lived, and here he died, a recognized leader among those who have added to human welfare, and honoring by his name the rolls of more than a score of associations of learned men."

He never returned to Sweden, his native country, but he has received from her many honors and decorations. In 1867, a great granite monument, quarried by unpaid labor, was set up with festivities before his birthplace, and inscribed, "John Ericsson was born here on July 31, 1803;" and under this stone he will probably be buried.

The fourth annual report of the Bureau of Labor Statistics of the State of Connecnecticut is an interesting publication of about 300 pages, containing much valuable information. We wish to call attention specially to the following extracts from the introduction: "One of the most gratifying features of the investigation has been the discovery of large establishments, owned and operated by corporations, where labor troubles have never been known. The secret of the pleasant relations which have always existed between employers and employed is in the fact that the employers have not only entertained feelings of kindness toward their employees, but have recognized in them fellow beings who had their rights, which they have always been scrupulously careful to respect. There is very little change of help, and the employers have reaped the benefits resulting from permanent help thoroughly trained to their work. In one of these establishments a man died a few years since who had been in its continuous employ for sixty-seven years. During the last years of his life he was able to do but little work, and for the last three years he could do nothing, but his wages were continued to the end. This company has a regular pension list of deserving employees who have become superannuated, or have become incapacitated for work by reason of sickness or accident while in the service of the company. A similar policy is pursued towards employees by a number of other establishments, with like happy results. It by no means follows that such a course should, or could, be adopted by employers generally. With many, perhaps with most, it would not be right. It is easy to see, however, why laboring men and women like to remain in the employ of such corporations.

"Many philanthropic employers who desire to benefit their employees fail to appreciate the sensitiveness of the laboring people to anything which savors of charity or patronage. The laboring man is always on his guard against such a spirit, and frequently resents acts that were meant in the utmost kindness. A policy of liberality on the part of the employer, judiciously exercised, is a good thing, but a careful study of the interests of his employees, and the kind of treatment that will make them respect themselves and honor him, is the greatest good he can bestow. The cultivation by the employer of that spirit which leads them to treat their employees with uniform courtesy and respect will awaken manly instincts in the employee, and bind him to his employer's interests. A disposition to regard his employer's interests as his own is worth a small fortune to the laboring man." And we might add that this same disposition is worth a large fortune to the employer.

History of the Mechanical Equivalent of Heat.

The history of the establishment of the science of thermodynamics is very interesting, especially of that fundamental principle which is known as the "first law." This principle, stated in simple language, is that a pound of water, in cooling one degree Fah., gives off an amount of heat which is capable of raising 778 pounds through a height of one foot.

Credit for the determination of this important constant is usually accorded without question to Mr. James Prescott Joule, of Manchester, England. As early as 1843 this gentleman had made a number of experiments for determining the constant in question, obtaining results varying from 587 to 1,026. He made experiments, also, on the heat evolved by the friction of water in small pipes, from which he deduced an equivalent of 770 foot-pounds. In the following year Mr. Joule entirely changed the plan of his work, employing new and better methods and obtaining numerous results. From five different experiments he obtained as many results; but they agreed very well and gave a mean value of 802 foot pounds. In 1845 he experimented on water agitated by a paddle-wheel, and by comparing the work expended in turning the paddle with the rise in temperature of the water, he found 890 as the value of the equivalent. Two years later he made similar experiments with both water and oil, with additional refinements that his experience had suggested; and from these he obtained 781.5 and 782.1 respectively, the mean of which is 781.8. He had been at work on the problem for a number of years, when in 1849 he undertook a final determination of the equivalent, and with all the care and watchfulness that his experience and keen insight had shown to be necessary, he carried out a series of 40 experiments on the friction of water, 50 on the friction of mercury, and 20 on the friction of cast-iron plates; from which he deduced the value, 772 foot-pounds, that has been accepted without question for nearly 35 years.

Great as is the credit that Joule has fairly won, we must not overlook the fact that equal credit belongs to Dr. Julius Robert Mayer, who was engaged, at the same time, upon investigations which were of equal importance, though carried on in an entirely different manner. In 1840 he was a physician on the island of Java, and while there he noticed that the venous blood of his patients was unusually red. He pondered over this for some time, and concluded that it was owing to the fact that a less amount of oxidation of the tissues of the body would keep up the bodily heat in a hot country like Java, than would be required in a colder one. Following up this thought he at length came to the conclusion that a fixed relation must exist between heat and work. In 1842 he published a paper containing his views, and in this he made the attempt to determine this relation numerically. Professor Tyndall thus describes his reasoning: "It was known that a definite amount of air, in rising one degree in temperature, can take up two different amounts of heat. If its volume be kept constant, it takes up one amount: if its pressure be kept constant it takes up a different amount. These two amounts are called the specific heat under constant volume and under constant pressure. The ratio of the first to the second is as 1 : 1.421. No man, to my knowledge, prior to Dr. Mayer, penetrated the significance of these two numbers. He first saw that the excess .421 was not, as then universally supposed, heat actually lodged in the gas, but heat which had been actually consumed by the gas in expanding against pressure. The amount of work here performed was accurately known, the amount of heat consumed was also accurately known, and from these data Mayer determined the mechanical equivalent of heat. Even in this first paper he is able to direct attention to the enormous discrepancy between the theoretic power of the fuel consumed in steam engines, and their useful effect. Though this paper contains but the germ of his further labors, I think it may be safely assumed that, as regards the mechanical theory of heat, this obscure Heilbron physician, in the year 1842, was in advance of all the scientific men of the time."

Comparing Joule and Mayer, Professor Tyndall continues: "Withdrawn from mechanical appliances, Mayer fell back upon reflection, selecting with marvellous sagacity, from existing physical data, the single result on which could be founded a calculation of the mechanical equivalent of heat. In the midst of mechanical appliances, Joule resorted to experiment, and laid the broad and firm foundation which has secured for the mechanical theory the acceptance it now enjoys. A great portion of Joule's time was occupied in actual manipulation; freed from this, Mayer had time to follow the theory into its most abstruse and impressive applications. With their places reversed, however, Joule might have become Mayer, and Mayer might have become Joule."

Other distinguished experimenters have undertaken the determination of the mechanical equivalent of heat. Joule himself, as late as 1878, published results obtained by himself shortly before, from the thermal effects of the friction of water. In a paper read before the Royal Society in that year he stated that, taking the unit of heat as that which can raise a pound of water (weighed in a vacuum) from 60° to 61° of the mercurial thermometer, its mechanical equivalent, reduced to the sea level and to the latitude of Greenwich, is 772.55 foot-pounds. Of the other prominent physicists who have studied this constant, Favre deduced 753 from the friction of steel on steel, and 807 from the heat absorbed by an electromagnetic engine for the production of work; Hirn deduced 787 from the friction of liquids, and 775 from the compression of lead; Quintus Icilius deduced 714½ directly from the heat developed in an electric circuit. By comparing the work expended in revolving the plate of a Holtz electrical machine with the heat produced by the resulting current, Rosetti deduced 776.1 foot-pounds. Le Roux, from the heat produced by rotating a tube full of water in a magnetic field, found 835; Violle, by similar experiments on disks of metal in the place of water, found 793.2 with copper, 794.3 with tin, 797.3 with lead, and 792.7 with aluminium. The mean of these is 794.4; but M. Violle, feeling more confidence in some of his results than in others, gives his preference to the number 793. Bartoli deduced 771.12 from the friction of mercury in small tubes. No doubt many others have made good determinations of the mechanical equivalent of heat, whose results we do not have at hand. At least two experimenters that we have not yet mentioned have made highly important contributions to our knowledge of the subject. They are Regnault and Rowland. By a careful study of the velocity of sound in gases, Regnault determined the ratio of the two specific heats of gases, which ratio was used by Mayer in his first calculation. Regnault's result was 1.3945, instead of 1.421; and from this and certain other data Mayer's calculation was repeated, and the result was 794.8.

The difficulty of a determination of this kind is very great; and the differences among the results that we have called attention to are perhaps no greater than might be expected. Prof. Henry A. Rowland has made a classical determination of the equivalent, and his result is without doubt entitled to the fullest confidence. His investigations were very extensive and involved many difficult problems in thermometry. He found among other things, and contrary to the accepted belief, that the specific heat of water is greater near the freezing point than it is at and near 80°. Rowland's result is that the mechanical equivalent of heat is 778 foot-pounds at 39 2° F., if the temperature is measured by a mercurial thermometer, and 783 foot-pounds if by an air thermometer. The older number, 772, is so widely known that it will very likely be used among engineers for a long time yet, especially as it is sufficiently near the truth for most purposes; but sooner or later Rowland's value — 778 — will probably supersede it, and for this reason we used it in the beginning of this article in defining the first law of thermodynamics.

"Lloyd's."

In English books and papers we often find mention of "Lloyd's." Rules for designing flues, for staying furnaces, for proportioning safety-valves, and for multitudes of other things, are given under authority of this name, and we do not doubt that many of our readers have wondered what it means. "Lloyd's" is an association of merchants, ship-owners, underwriters, and ship and insurance brokers, having its headquarters in a suite of rooms in the northeast corner of the Royal Exchange, London. It is the center where the business of maritime insurance is transacted, and the earliest shipping intelligence from all parts of the world is posted there for the benefit of members and subscribers.

The first mention of this institution is found in the *London Gazette* of February 18, 1688. It was then a mere gathering of merchants, who met for business or gossip in a coffee-house in Tower Street, kept by Mr. Edward Lloyd. Four years later Lloyd removed to Lombard Street, in the very center of that portion of the old city of London that was most frequented by merchants of the highest class, and shortly afterwards he began the publication of a weekly newspaper, giving commercial and shipping news. It was known as *Lloyd's News*, and though it was not long-lived itself, it was the predecessor of the now well-known *Lloyd's List*, which is said to be the oldest paper in existence, excepting the *London Gazette*. *Lloyd's List* was printed as a weekly from 1716 to 1800; since that time it has been a daily, containing the fullest details of shipping from all parts of the world. In Lombard Street the business transacted at Lloyd's coffee-house grew steadily in extent and importance, but up to about the time of the Revolutionary War it does not appear that the association was a formal one, or that its members were subject to any rules. The rapid increase of the business transacted there ultimately obliged the members to find more commodious quarters, and after finding a temporary resting place in Pope's Head Alley, the organization moved into its present quarters in March, 1774.

One of the first improvements under the new *regime* was the introduction of a printed form of policy for marine insurance. A committee of members proposed a general form, and this was adopted on January 12, 1779, and with slight modifications it has now continued in use for over 110 years. In 1811 the association was reorganized, and in 1871 an act was passed, granting to Lloyd's all the rights and privileges of a corporation sanctioned by Parliament. "According to this act of incorporation, the three main objects for which the society exists are: First, the carrying out of the business of marine insurance; secondly, the protection of the interests of the members of the association; and thirdly, the collection, publication, and diffusion of intelligence and information with respect to shipping. In the promotion of the last-named object, (obviously the foundation upon which the entire superstructure rests,) an intelligence department has been gradually developed, which, for wideness of range and efficient working, has no parallel among private enterprises in any country."

The rooms of the association are open only to subscribers and members. The former pay an annual due of twenty-five dollars, and have no voice in the management of the institution; the latter are divided into two classes, according to the kind of business they transact. They that are underwriters pay an entrance fee of five hundred dollars; they that are not underwriters pay a fee of sixty dollars. Underwriting members are also required to deposit securities to the value of from twenty-five to fifty thousand dollars, according to circumstances, as a guarantee that they will fulfill their engagements. All the officials and agents of the association are appointed by the "committee on management," and the daily routine work is carried on by a secretary and a large staff of clerks. The insurance system is so arranged that the individual underwriters do not risk more than five hundred to eight hundred dollars on any single vessel, and the rates of insurance are not high. There is a vast "merchants' room," containing newspapers from all parts of the world, and a "captain's room," where auctions are held and convivial gatherings meet.

The name "Lloyd's" is also applied to other institutions of the same kind, in other parts of the world. The most celebrated of these are the Austrian Lloyd at Trieste, which was established in 1823, and the North German Lloyd at Bremen. The Austrian Lloyd has issued a *Giornale* ("journal") since 1834.

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

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Explosion of a Vulcanizing Press.

A curious and interesting explosion of a vulcanizing press recently came to our notice. The press is illustrated in Fig. 1. It consists of a number of plates of cast iron, each four inches thick, and forty inches square, which are contained in a stout framework, and forced upward from below by an 18-inch hydraulic ram, into which water is forced at a pressure of 3,000 lbs. to the square inch. The diameter of the plunger being 18 inches, its

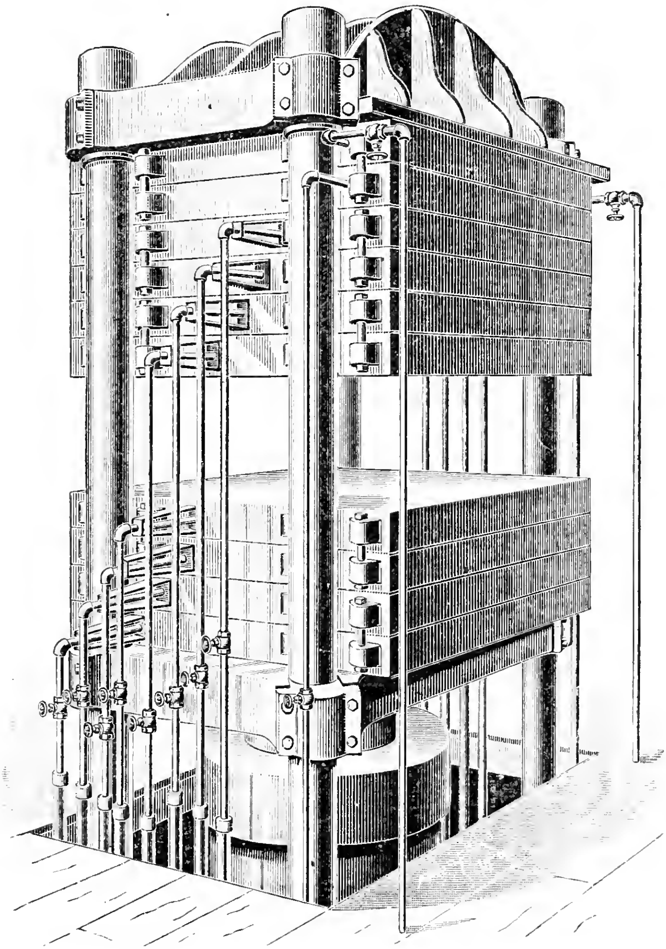


FIG. 1.—PERSPECTIVE VIEW OF PRESS.

area is 254 square inches, and the total pressure upon it was 254×3,000=762,000 lbs. Between the plates the articles to be vulcanized are placed. They generally consist of a mixture of asbestos and rubber, in varying proportions, according to the purpose for which the finished product is intended; and after being subjected to the desired pressure and temperature they become so dense and compact that they may readily be turned in a lathe in the same manner as iron.

The iron plates between which the articles are placed are cast hollow, one inch of iron being left all around, on top, bottom, sides, and ends; and into them steam, at 80 lbs. pressure, is introduced by means of a sow and a series of telescoping pipes, as shown in Fig. 1. Each pipe is braced to its plate, and each is provided with a cock so that the pressure may be removed from any desired plate at will. In this way a temperature of 324° F. is obtained, which is sufficient for the purpose required. The surface acted upon by the steam we will consider to be 38 inches square, or 38×38=1,444 square inches. The total pressure tending to burst the plate is therefore 1,444×80=115,520 lbs. This is so far within the collapsing pressure exerted by the water below that there is evidently no likelihood of the plates bursting in a vertical direction when the press is in operation, provided the articles to be compressed are properly arranged so as to distribute the stress over the surface of the plates, and not allow it to be concentrated on a small area anywhere.

Cast-iron staybolts an inch and a half in diameter extend from face to face of the plates. They are spaced six inches apart in both directions; there are thirty-six of them in all, and they form an integral part of the plate. When steam pressure is on and the hydraulic ram is in action, the staybolts sustain a compressive strain; and when the steam pressure is on and the ram is not in action, they are exposed to tension.

The press had been in use for about eight months, when one morning, after running for about twenty minutes, one of the plates fractured under the strain. A workman near by narrowly escaped death from a flying core bolt, and several others were so shaken up as to be unable to work for the rest of the day. The appearance of the fractured plate, after its removal from the press, is shown in Fig. 2. The upper portion of it was broken into two nearly equal parts, and the fracture along the edges of the fragments was bright and crystalline, and had the appearance of good cast iron. The same is true of the fractured surface of the outer row of staybolts, completely round the plate. The sixteen staybolts composing the inner rows, however, presented a very different appearance. In nearly every case the surface of separation was of a dull reddish brown, and on most of these bolts no sign of a bright fracture was to be seen. Some showed small bright spots at the center; and the appearance of all was as though flaws had started along the under surface of the plate, approaching the center of the bolt from all sides, and that in most cases the flaws had reached the centers of the bolts long before the time of the accident, while in a few cases the separation at the center was not yet quite complete. Some such action might possibly result from slight but repeated flexure of the surfaces of the plate by the unequal distribution of strains through the points of contact of the articles placed in the press to be vulcanized. It is hard to understand, however, why nearly all the bolts broke off at the same end, if the flaws resulted simply from the flexure of the plate; for in that case there is obviously no reason why the bolts would break off at either end in preference to the other end. Moreover, such of the fractures as were dull appear to have been so for a long time—probably for as long a time as the press has been in use.

In casting work like this it is hard enough to get a sound casting, even when every possible precaution is taken; but when the foundry is run under pressure, and the articles cast must be delivered almost immediately, there is a great temptation to uncover the molds and expose the contents to the air so as to facilitate their cooling. Castings cooled in this way have been known to explode with violence, and even to wreck the foundry in which they were lying. A plate like the one under consideration should be allowed at least twenty-four to thirty-six hours to cool in, and it is possible that its cooling was hastened by removing the sand above it, and that the observed fractures were caused in this way.

Another bad habit that some foundrymen have, in working on jobs of this kind, is to let them cool down almost to 212° F., and then introduce a little water into them. The steam so produced removes the sand from the interior in a lively manner, and considerable laborious digging and scooping is avoided. We should not like to say that the man who cast these plates adopted that method, but still it is possible, and if it *were* so we could hardly be surprised at finding the bolts broken off.

However the original fractures were made it is apparent that after the plate had been under hydraulic pressure for twenty minutes, it would hardly burst without some immediate cause; and it would be interesting to know what that cause was. By reference to Fig. 1 it will be seen that one end of the press was provided with steam pipes, and the other end with drip pipes to remove the water of condensation. Those attached to the near end

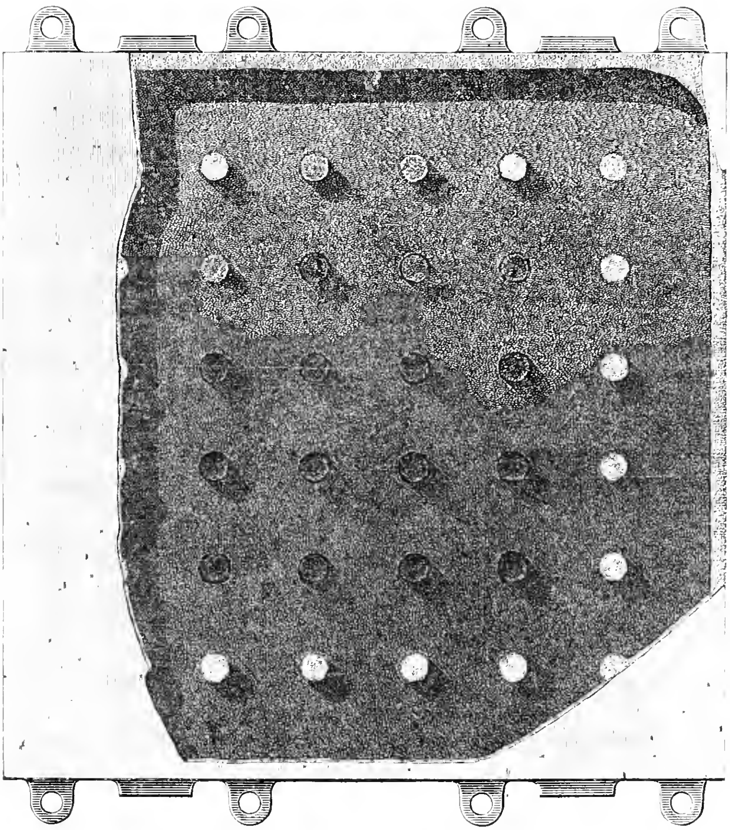


Fig. 2. — Appearance of Exploded Plate.

in the engraving are the drip pipes. They are braced in such a manner that it is convenient to have them enter the plates at about midway of their thickness; and an examination on the morning of the explosion showed what evidently must be the fact, namely, that every plate must be constantly half filled with water, since the drip pipes are so arranged that they cannot drain the lower part of any plate. It is probable, therefore, that with this large surface of water exposed, some sort of a water-hammer action was set up, which, acting in addition to local strain caused by the articles under treatment, caused the fracture. All drip pipes should open into the space to be drained at the lowest point.

One of the staybolts in the exploded plate was placed in a planer and cut apart longitudinally. The tool pushed its way through with a soft, unresisting sound; no chips were thrown off, but the tool pushed out before it a pulverized, dark-colored substance, very unlike the ordinary chips from common cast iron. This suggests that, under the peculiar condition of strain and temperature to which these staybolts were exposed, the metal may undergo a modification of structure. The staybolt in question was planed down and polished to a perfectly smooth surface and then immersed in an acid bath. It was etched all over very evenly, and seemed to be of very uniform composition.

In Fig. 2 the engraver has given a very good representation of the plate as it appeared after the accident, the brightness or dullness of each fracture being faithfully imitated by a corresponding shade in the wood cut.

Inspectors' Reports.

MARCH, 1889.

During this month our inspectors made 4,671 inspection trips, visited 9,692 boilers, inspected 3,824 both internally and externally, and subjected 533 to hydrostatic pressure. The whole number of defects reported reached 8,449, of which 652 were considered dangerous; 40 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	564	16
Cases of incrustation and scale,	939	24
Cases of internal grooving,	52	10
Cases of internal corrosion,	274	23
Cases of external corrosion,	613	60
Broken and loose braces and stays,	213	50
Settings defective,	192	19
Furnaces out of shape,	263	11
Fractured plates,	175	53
Burned plates,	160	22
Blistered plates,	412	24
Cases of defective riveting,	1,831	62
Defective heads,	75	23
Serious leakage around tube ends,	1,480	77
Serious leakage at seams,	451	31
Defective water-gauges,	166	35
Defective blow-offs,	81	18
Cases of deficiency of water,	21	6
Safety-valves overloaded,	51	14
Safety-valves defective in construction,	65	18
Pressure-gauges defective,	286	47
Boilers without pressure-gauges,	7	7
Unclassified defects,	78	2
Total,	8,449	652

On comparing the number of boilers examined by our inspectors during the past month with the numbers examined in the same month of previous years, we find the following:

Month.	Boilers Examined.	Month.	Boilers Examined.
March, 1889,	9,692	March, 1884,	5,368
" 1888,	7,682	" 1883,	4,964
" 1887,	7,445	" 1882,	4,642
" 1886,	6,038	" 1881,	3,976
" 1885,	6,060	" 1880,	4,155

These figures speak for themselves. It is gratifying to see such a progressive increase in the number of boilers under our care, as it shows that, as the public comes to understand the objects of our business, and our methods of conducting it, they are quick to avail themselves of the advantages it offers them.

Boiler Explosions.

MARCH, 1889.

SAW-MILL (33). A boiler explosion occurred at Amos Kent & Son's saw-mill, four miles from Tangipahoa, Fla., on Feb. 28th, demolishing the boiler-house and unroofing the buildings adjacent. The boiler was thrown a distance of 240 yards. The colored fireman was buried beneath the debris, but was taken out alive and will probably recover. Mr. Ingersoll, a Northern settler at Kentwood, was loading lumber about 100 yards from the boiler-house when the explosion occurred, and had his right leg broken below the knee by flying brick.

SAW-MILL (34). On March 8th the boiler in Warner's saw-mill, about one-half mile east of Wayne, Mich., exploded with terrific force, wrecking the building and instantly killing Engineer Westfall, whose terribly mangled body, with the head blown off and every bone broken, was found several yards from the boiler-room. There were six other men in the building, but none of them were seriously injured. The top of the boiler was found nearly 1,000 feet from the scene of the disaster, and parts of the machinery were thrown nearly as far. The damage to the mill and machinery is estimated at about $10,000.

FLOURING-MILL (35). The two boilers at the Victoria Flour-Mills, St. Louis, Mo., exploded on March 10th. One was hurled fifty yards in the air and fell in a stone-quarry a hundred feet away. The other was badly broken and scattered about, breaking a hole in a brick house four hundred feet distant. The mill was just about to be shut down for the day when the explosions occurred. Seven men were in the mill at the time. Patrick McMahon, the fireman, was literally cut to pieces, his head being blown off, his limbs torn away, and his body terribly crushed. Neill Brown, a former employe, who was in the engine room, was instantly killed, his head being crushed by falling bricks, and his body badly bruised. Ten others were more or less severely injured, and the boiler house was completely demolished.

ROLLING MILLS (36). A boiler thirty feet long in the forging department of the rolling mills in the southern part of the city of Cleveland, O., exploded on March 11th, with terrific force. One piece of it went west, and, crashing into Hugh Graham's house, 500 feet away, bounded off and buried itself beneath the foundations of a house a dozen yards distant. Graham was slightly hurt. Just before the fragment struck Graham's house it wrecked his coal house. In it were Mrs. John Scelaga and Mrs. Calaja, both of whom sustained scalp wounds. The other fragment of the boiler went west 1,600 feet and demolished an outhouse in which was Mary Vargo, four years old. Her left arm was broken. At the mill there were thirty men near the boiler when it exploded. James Barr and Thomas Dorsey were killed, and a dozen others received more or less serious wounds.

COLLIERY (37). On March 13th two boilers exploded at the St. Nicholas Colliery, Mahanoy City, Pa. A section of one of the boilers was hurled 600 feet down an embankment; another weighing 300 pounds was hurled through a blacksmith shop; a third cut off a huge tree five feet from the ground, while others mowed down fences and small outbuildings. Edward Seltzer was hurled into the air and had his skull fractured.

Edward Watts was struck in the back of the head and fatally wounded. Mary Hoffman of Mahanoy City, carrying a child in her arms, was passing on the road 150 feet away, and her hip was broken and her child killed. Patrick Wannes was driving a mine wagon, just ahead of the woman, and had his legs fractured by falling fragments. James Delaney, who was sitting alongside of him on the wagon seat, had his skull fractured. Michael Warner, a lad aged thirteen, sitting in the back of the wagon, had one of his thighs broken and his ankle dislocated. The wagon was upset and the mules ran away, throwing the wounded people into the dust. James Thomas, Henry Abrams, and Sol Thomas, employed at the works, were badly scalded, and a few others received slight injuries.

Boiler Works (38). A boiler at the West Point Boiler Works of R. Monroe & Sons, at Twenty-third and Smallman streets, Pittsburg, Pa., exploded on March 14th, completely wrecking the plant and burying a number of men in the ruins. The building was a large one-story brick structure, and was formerly occupied by William Smith & Sons, pipe manufacturers. The plant was a valuable one and will prove a complete loss. Nothing remains but a mass of brick, mortar, and timbers. The boiler was inspected six months ago and was thought to be in first-class condition. It was eight years old. The work of rescue was continued until late in the afternoon. All the employes have been accounted for. Of the sixty-five workmen, five were killed and fifteen others were injured. Some of the men said they heard the gauge tried just a few minutes before the explosion, and everything seemed all right. Every one expressed confidence in the engineer, and agreed that he was a careful and competent man, one who was unusually careful in his work. The loss will reach $30,000.

Rubber Works (39). A large boiler at Murray, Whitehead & Murray's rubber works, in Trenton, N. J., blew up on March 16th, blowing out the south side of the building in which it was located, and injuring James Mosedale, the engineer, and Adam Hayden and James Hoy, two workmen. The newspaper report says that "the boiler carried 180 pounds of steam, was ten by eighteen feet in size." [! !] It also adds that "parts of the boiler were hurled 300 feet to a vacant lot plowing up the ground like a cyclone"; but why the vacant lot was so vigorously engaged in agriculture does not appear.

Saw-Mill (40). The boiler in Whitney & Tuttle's saw-mill at Pound, Wis., exploded March 18th, wrecking the building. Otis Clement was killed, and six others were severely injured.

Cotton-Mill (41). A slight explosion took place at the Riverside Mills, in Olneyville, R. I., on March 22d. The front of the furnace was blown out, and for a time there was great excitement among the employes. The mills were not shut down. The damages amount to $1,500. No one was injured.

Foundry (42). A fatal explosion occurred on March 24th at the new Allis foundry on South Bay street, Milwaukee. A newly-completed boiler, intended for steam-heating purposes, was being tested by William Malone, a mechanic employed in the foundry. The boilers are subjected in testing to a greater pressure than they will ever be required to stand in practical use, and this one failed to bear the strain. It was tested by steam, and it burst with great violence. Malone was scalded by the rush of escaping steam and mangled by the fragments of flying iron, so that he died shortly after. The only other person hurt by the explosion was a Polish laborer, whose injuries are not serious. The extreme foolishness of testing a boiler in this way must be apparent to everyone, and we doubt if the owners of the foundry knew what was being done. The hydrostatic test would have been perfectly safe and perfectly satisfactory.

Pulp-Mill (43). On March 26th, a shell boiler, used in steaming pulp, exploded at the P. C. Cheney Company's pulp-mill, at Goffstown Centre, near Manchester, N. H. There were sixty pounds pressure on, and portions of the boiler were hurled through the roof. A large number of employes were in and about the building, but all escaped save one, Augustus Kidder, who was severely, but not fatally, injured.

Printing Office (44). A boiler in the *Fairfield Journal* office, Fairfield, Me., blew up on March 26th, completely demolishing the engine, scattering pieces in all directions, and breaking every square of glass in the office, but doing no injury to any person.

Saw-Mill (45). A boiler exploded on March 26th, in Sanford & Evans' saw-mill, near Helena, Mont. Four men were injured.

Shingle Mill (46). The boiler in Morgan's shingle at Hungerford, Mich., exploded March 28th, killing Edward Stewart, and fatally injuring his brother Charles.

Boiler Explosions --- The Causes and Remedies.

By A. J. Wright.

The several recent disastrous boiler explosions,— notably those at Hartford, Conn.; Scranton, Reading, and Pittsburgh, Pa.; St. Louis, Mo., and Cleveland, O., incurring an average loss of about ten lives, including many women and children, and other people wholly innocent of any responsibility for them, and destroying an average of over $30,000 worth of property,—have awakened great interest and anxiety not only among steam users but also among employés; and, in fact, on the part of the public in general. These six appalling explosions all occurred within the short period of four weeks,—the first, that at the Park Central Hotel, Hartford, Conn., occurring on February 18th, and the last, that at the West Point Boiler Works, Pittsburgh, on March 14th. There were several other explosions within this period, but they were of such an ordinary nature as to be completely overshadowed by those mentioned, which followed each other in such rapid succession that the uneasiness manifested is but natural.

These explosions were exceptional in many respects beside their magnitude. All of them, except the first, occurred in what may be termed first-class plants, all belonging to large corporations, where the boilers are generally well equipped and everything is supposed to be kept in repair, and where the best regulations prevail, one being in a silk mill, one in a colliery, one in a boiler works, which, by the way, enjoyed an enviable reputation for first-class work, one in a rolling mill, and one in a large flour mill. The newspaper reports, which furnish the only data for this article, and are probably not wholly accurate, also show that nearly if not all of these boilers, excepting in the hotel at Hartford, where there was a combination of enough carelessness and negligence to place this average also above the ordinary, were insured, and inspected periodically, as all boilers should be, and in at least two of the cases city inspection also prevails. [Our readers will remember that the Park Central was under State inspection.]

Such being the condition, it is necessary, in looking for the cause, to take a liberal, common-sense view, laying aside the too common charge of carelessness or negligence, which, it must be admitted, would be absurd as applied to a majority of these cases. What then is the cause?

It is, of course, impossible to go into the details of each case in the absence of definite and reliable information, but in such extremities, a general opinion based upon close observation must be interesting, and the fact of its coming from an interested source can hardly be regarded as prejudicial.

The annual report of the Hartford Steam Boiler Inspection & Insurance Company for the year 1888, shows that the inspectors of that company, in addition to 168 cases of deficiency of water, 54 of which were dangerous, found 1,702 burned plates, 255 of which were also reported dangerous. In other words, the inspectors of this one company found 309 boilers, which were in immediate danger of exploding, no matter how full of water, as a result of the water having been low at some previous time. When in this connection we consider the fact that this is only the report of one company, and, again, that only a small proportion and the best of the boilers in use are insured, and that there were, according to this company's reports, 8,658 other cases of danger found during the year, among the number being 473 dangerous cases of incrustation or scale, 306 cases of broken stays and loose braces, 178 defective settings, 1,588 cases of defective riveting, 417 cases of leakage at the seams, and 2,065 dangerous cases of leakage around tube ends, 233 cases of defective water gauges, 146 cases of overloaded and 176 cases of safety valves defective in construction, 361 cases of defective pressure gauges, and, "God save the mark," 92 boilers without pressure gauges, and several hundred miscellaneous defects,—a total of 8,967 cases of defects where there was absolute danger of immediate explosion,—it must be agreed that the only strange thing about the frequency of boiler explosions is that they are not more frequent.

But to return to the cause. There were 1,702 burned plates, 255 of which were dangerous, 15,122 cases of "serious leakage around tube ends," 2,065 dangerous; 4,552 cases of "serious leakage at seams," 417 dangerous; in addition to 168 cases of "deficiency of water," 54 of which were dangerous, all of which had weakened and shortened the lives of the boilers. Now, it is not improbable that a large number of these nearly 20,000 cases of leakage around the tubes and seams, were caused by unequal expansion due to low water at some previous time. Is it not a reasonable conclusion, therefore, that the water becomes low much more frequently than is generally supposed, and that it is the indirect cause of many boiler explosions not attributed to it, and that many competent and faithful engineers and firemen suffer, as a result of the ignorance and negligence of their predecessors. A boiler burned and dangerously weakened under one engineer may not explode until after he has been superseded by a most competent and painstaking one, who may be as innocent a sufferer as the many others killed by it, but we read in the columns of even the technical trade journals, as well as the dispatches of the Associated Press, that "the cause will probably never be known, as the engineer was killed outright."

Furthermore, we have evidence other than theoretical tending to the same conclusion. The experience of steam users with Reliance safety water columns is that they whistle for low water about once a month, on the average, even where the best help and most perfect regulations prevail. This may be hard for people without experience with reliable safeguards of this kind, to believe, but it is a fact which can be easily demonstrated, and to it is largely due the action of many of the large corporations in throwing out the ordinary combination and equipping all their boilers with these appliances, after learning their value through practical experience. It is clear that the water in steam boilers becomes low oftener than most people suppose, likewise that the boiler is weakened more or less every time it becomes low, and there is no room for doubt that it may ultimately give way with plenty of water in it and even without the contributory assistance of ignorance, negligence, or even over-pressure, in which event it is no less the result of low water than if it had occurred when the water was low.

In this conclusion, and the evidence leading to it, may, we believe, be found the true solution of many mysterious boiler explosions. What then is the remedy? First, no matter whether your boilers are new or old, get them insured in some company of recognized standing and noted particularly for the thoroughness of its inspection. This means a great deal more than appears on the face of the advice. It means that if the material or workmanship is defective, or in other words, if improperly riveted or insufficiently braced, you will find it out at once, and if the setting is defective or the furnaces out of shape you will be advised and will have to repair the defects before the company will accept the risk. Nor is this all. It means that if the safety-valve is overloaded or defective you will know it, or if your boilers have been dangerously burned, blistered, corroded, or grooved you will have an urgent opportunity to prevent loss of life and property by repairing them, before you can get the insurance, and that if they are seriously scaled or filled with sediment, that you will have to remove it at once, and then perchance have some patches put on. Perhaps your boilers may be condemned. The Hartford company condemned 426 boilers last year, and the benefits have now only begun. But you can go to bed and sleep at night with the satisfaction of knowing that the boilers are safe and that you have done a duty to yourself, your employés, and the public, and at the same time made a good investment, for it also means that so long as you keep your boilers insured the company will, in so far as possible, by periodical and systematic inspections, keep your plant in the condition in which it compels you to put it at the outset.

But how about the low water? The company's inspectors cannot prevent it except in so far as keeping the appliances in working order are concerned. The inspector may find your boiler in first-class condition to-day, and the water may get low and weaken it to-night while you sleep. Or the same result may be brought about by the stopping of a pump, by foaming, by leakage, or as a result of carelessness, ignorance, drunkenness, or what not, within the period between inspections, and may result in an explosion as disastrous and fatal as any of those which have horrified the country within the past month, before the inspector gets around again. A boiler may be inspected to-day and found to be safe under a working pressure of 100, and be weakened to-night by low water so as to be dangerous to-morrow with 50 pounds pressure. It may explode a month hence with 60 pounds pressure and plenty of water, but the cause is as certainly low water as if it had exploded when the water was low.

There is but one sure remedy, and it is a simple one. Put on a safety water column, not some complicated device which is pretty in theory and worse than worthless in practice, or some untried and perhaps inoperative low water detector, or a fusible plug which becomes coated with scale and fails to fuse, but a real safeguard, something simple, which has been tried and proven to be trustworthy by steam users whose judgment can be relied upon. The result will be highly gratifying. You will find a most pleasing result in the effect it will have on your firemen, who will be doubly watchful as a natural result of having this monitor over them. As a result of personal pride you yourself would watch the water closer with than without these safeguards. By and by some accident will happen and you will hear it whistle unexpectedly, and on investigation you will find that no one was directly blamable for the water becoming low, and will see that the little whistle brought brains to the rescue. You will sooner or later hear of its attracting the watchman's attention at night in ample time to obviate any serious results, and when you begin to get acquainted with the appliance and investigate its workings you will discover that it has saved its cost in fuel by keeping the water at the proper level, and at the end of the year you will find a very small item opposite the "repairs to boilers" in the expense account. These are not imaginary figures, they are actual experiences.

Both the insurance and the safety water columns have a like effect on the employés, which is of the utmost importance. They make those who might otherwise be careless or indifferent, watchful and careful, for any negligence is sure to be reported to the proprietor either by the inspector or the whistle. This extra watchfulness is of itself of vast importance, and will go a long way toward preventing "mysterious explosions," and solving the problem of safety.—*Iron Trade Review.*

The Locomotive.

HARTFORD, MAY, 1889.

J. M. Allen, *Editor.*

H. F. Smith, A. D. Risteen, } *Associate Editors.*

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.*

We have received the latest number of the *World Travel Gazette*, published by the World Travel Co., 207 Broadway, New York. It is a peculiar and interesting publication, copiously illustrated, and conducted in the interests of the traveler in all parts of the world. The present number is largely devoted to Switzerland and Hungary.

Mr. A. J. Wright, who wrote the article on "Boiler Explosions — the Causes and Remedies," in this issue, is manager of the Reliance Gauge Company, and is naturally interested in the sale of the appliance he represents. We do not often print articles of this nature, but this one is so fair and so temperately worded that we give it a place. We wish to say, however, that we never recommend any patented devices to our patrons, as we feel that such matters should be decided by the man who has to pay for them, and not by us. We are pretty apt to be heard from, however, when one of our patrons meditates buying a device that we consider unsafe.

It may be fair to say that we know of no objection to the appliance Mr. Wright advocates, if it is properly put on, *provided* the man in charge is as attentive as ever to his water-glass and gauge-cocks. We do not believe that any automatic apparatus, however excellent, can take the place of a good, live, capable, watchful engineer.

The *Scientific American* is responsible for the following very fishy statement. "There may be more method than madness in the longing of the American student for a finishing course at a German university. At a recent discourse on chemistry, Prof. Heinrich Hoffman of Berlin, illustrated the atomic constitution of organic compounds by the use of the ballet. Each girl was dressed in an individual solid color and represented an atom, and the grouping and movements of the atoms is said to have been very effective. Chemistry has now become a very popular study with the students, and the attendance at the lectures very full."

The *New York Sun* calls attention to the fact that the four new States recently admitted into the Union have an area about equal to that of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, Pennsylvania, Delaware, Maryland, Virginia, West Virginia, Ohio, Kentucky, and Indiana combined. It is an area three times as great as the British Islands, more than three times as great as Italy, more than a hundred and fifty thousand square miles in excess of Germany. A very thriving area it all is, too, which will soon add to the census wondrous figures of products and population as well as of acres.

Explosion in an English Colliery.

We have received from the Yorkshire Boiler Insurance and Steam Users' Company, of England, an interesting and illustrated account of an explosion at Drighlington. The following extracts from it may be of interest to our readers: "On the morning of March 19th a boiler exploded at Spring Gardens Colliery, under circumstances which I consider extraordinary. The explosion was fortunately unattended by loss of life, though one or two inhabited cottages were partially destroyed by portions of the exploded boiler in its flight. The boiler was cylindrical, egg-ended, and externally fired. It was about thirty-two years old, and the maker's name is not known. I am informed that the blowing-off pressure was 25 lbs. per square inch, and the probability is that the boiler has been run at a daily working pressure of 20 to 25 lbs. per square inch. For some years there has been a leakage on the left side of the shell, so that the plates have been reduced by corrosion from $\frac{7}{16}$ of an inch — their original thickness thirty years ago — to less than $\frac{1}{32}$ of an inch, or to about the thickness of a sixpence; and this over an area of about five square feet. It seems incredible that a boiler should be in this condition without the knowledge of the man in charge, or the owner of the colliery, for the law requires (1) that a certified manager shall have the 'control and daily supervision' of the mine, and all that pertains to it, and (2) that under special rules the man in charge 'must, *at least once a week*, carefully examine the engine, boilers, and appliances, and shall write a true report of the result of such examination in a book provided for the purpose, and shall sign the same.' In addition, it is also a rule in Yorkshire collieries that the engineer must see that each boiler is well cleaned at least once in three weeks. Notwithstanding these precautions, we have a boiler in daily use, with people in close proximity passing to and fro, and with inhabited houses within seventy yards of such boiler, working at a pressure of 20 to 25 lbs. per square inch, with plates the thickness of a sixpence!

"On the morning of the explosion the engineman had lowered the men into the pit and gone to the office to make his report; no doubt he would say all was 'right and in good working order,' sign his name, and experience some misgivings as to the correctness of his report, when he heard the explosion and saw the wrecked property around him. Now, what of the owner? When asked if he had ever had the boiler inspected by some outside competent authority, he said, in effect, 'Oh, no; I have a certified man to examine everything — a man in whom I placed implicit trust, and who seems thoroughly upset by the accident [!]. Boiler insurance companies have, through their agents, often canvassed me, but feeling such great confidence in the ability of my certificated man, together with my great confidence in a Power from on high, I have considered everything safe!'

"In conclusion, I may say that had this boiler been placed under competent inspection the explosion would never have occurred; and it is to be regretted that any boiler owners, for the sake of saving the small annual cost, should decline to avail themselves of the periodical inspection that steam boiler insurance companies offer."

Nitrogen.

There is a substance which is invisible, which has neither odor nor taste, and in fact possesses no qualities of matter except weight and bulk. This is the gas nitrogen, which constitutes four-fifths of the atmosphere which surrounds us. It is apparently a dead and inert form or manifestation of matter, and yet it is perhaps one of the most important and useful of the elements, and if it should vanish from the universe, life would cease to exist. This apparent paradox is explained by the fact that by its combination with other elements the remarkable characteristics of nitrogen are awakened into action. The gas is neither poisonous, corrosive, explosive, nutritious, nor medicinal; but combined with carbon and hydrogen it forms the deadly prussic acid; with oxygen and hydrogen, the strong corrosive nitric acid; with hydrogen alone, the strongly basic alkali ammonia; with carbon, hydrogen, and oxygen, the terrible explosive nitro-glycerine; and with the same elements in varying proportions, it forms the albuminoids, the gelatines, the glutens, and other strength-giving elements of our food, or the indispensable medicinal agents, quinine, morphine, atropine, strychnine, veratrine, cocaine, and many others.

Although nitrogen is tasteless, it forms an indispensable part of the flavors of the peach, plum, apricot, and other delicious fruits, as well as coffee, tea, chocolate, and tobacco. Without smell, it is found in many of the most powerful and delicious perfumes, as well as in the nauseating odors of putrefaction. Present in immense quantities in the air, it furnishes little or no support to vegetation, but combined with other elements the amount present in the soil determines its fertility, and the amount of crops that may be raised upon it. Colorless and invisible, nearly every dyestuff or coloring matter known contains it in a greater or less proportion. Harmless and powerless by itself, when combined with another non-explosive gas, chlorine, it forms the most powerful explosive known, of which a ray of sunlight is sufficient to arouse the terrible destructive power.

And yet, notwithstanding the pre-eminent importance of this element in the affairs of life, there are but few of its combinations which we can form directly. Millions of tons of nitrogen are all about us, but not a grain of morphine or theine, gelatine or albumen, aniline or naphthaline, can we make from it. Only the mysterious vital force working in the natural laboratory of the vegetable and animal organism can build up most of these molecules from their ultimate elements, and place the atoms of nitrogen in their proper position like the beams or stones of a building. Our wonder at the marvelous powers displayed by these organisms is none the less when we see what simple, common, and uncharacteristic elements are used by them in making up their wonderful products, and we can only say that it is a part of the great and unsoluble mystery of life.

Neither can we explain satisfactorily from a chemical standpoint the properties and reactions of this strange element. By itself it is nothing, but united with other elements, some almost equally inactive, the combinations thus produced manifest the most powerful and positive chemical and physical properties. It is like the springing into life of dead matter, but there is no system of chemical philosophy which can give a reason why it is so. It is the part of the chemist to observe and record the facts connected with the properties of different forms of matter, and in time we may from these facts construct a rational theory, but we are still a long way from a clear comprehension of the phenomena of the universe. There are about as many things in heaven and earth still undreamt of in our philosophy as there were in Shakespeare's time, and the further we advance toward the end, the more the field widens and appears to be of illimitable extent. — *Journal of Chemistry.*

Measuring the Earth.

There is a pretty general belief that the methods used by scientists to find out the size of the earth are beyond the comprehension of common people. Now this is a delusion, for although the actual execution of the work is full of the most perplexing difficulties, the general principle involved is exceedingly simple; and we are about to explain it.

It is a well-known fact that the further west one travels, the later the sun rises; and that by traveling completely around the world in a westerly direction we can make the sun apparently fall behindhand an entire day. The same is true of the stars and other heavenly bodies; and since it is more usual to use stars in the process of measuring the earth than to use the sun, we shall confine our attention to them. First we must understand that owing to the fact that the stars rise 3 min. 56 sec. earlier each night, the *sidereal* day is only 23 h. 56 m. 4 sec. long, instead of 24 h. Anyone can satisfy himself of this by noting that owing to the revolution of the earth around the sun, any given star will rise 366 times in a year, while the sun rises 365 times. The star will therefore gain 1-366th of a day each day; which is 236 sec., or 3 min. 56 sec.

Now let us imagine two observers, A and B, on the earth's equator, and diametrically opposite to one another. By means of a telegraph wire they can set their clocks exactly alike, and after they have done so it is plain that B will see Sirius rise exactly 12 hours later than A. Now suppose B moves his observatory eastward till he is only a quarter of the earth's circumference away from A; then it is plain that he will see Sirius rise *six* hours later than A. If B moves eastward again until he is only an eighth of the circumference away from A, he will see Sirius rise *three* hours later than A; and so on.

Suppose, now, that the two observers are only about thirty or forty miles apart, and that by careful observing it is found out that B sees the star rise precisely 2 m. 14.7 sec. later than A; and let us further suppose that when the distance is carefully measured with a steel tape it is found to be 38 miles, 1622 yards. Then

As the difference in time is to an entire day,
So is this distance to the circumference of the earth.

That is, 2 m. 14.7 sec. : 23 h. 56 m. 4 sec. :: 38 m. 1622 yds. : x

where x is the circumference desired. Expressing the times in seconds and the distances in yards, this becomes

$$134.7 : 86{,}164 :: 68{,}502 : x$$

whence $x = 43{,}818{,}900$ yards, or 24,897 miles. This corresponds to a diameter of 7,925 miles, which is the generally accepted figure.

This is the principle of the whole operation. In making the actual measurement, however, several modifications have to be introduced. For example, it is impossible to estimate the instant of a star's rising with the necessary accuracy, partly because the horizon is irregular in shape, and partly because the refraction due to the earth's atmosphere varies considerably. It is customary, therefore, to note the instant at which the star is exactly south of the observer. This can be done with extreme accuracy by means of a telescope mounted on a horizontal axis that is fixed in a true east and west position. Across the center of the field of view of the telescope a spider's thread extends; and when the star passes behind this it is exactly south.

It is curious to follow out the ideas that men have had as to the shape of the earth. At first it was supposed to be flat, and then, when this belief was found to be untenable, it was believed to be perfectly spherical. In the course of time it was seen that the rotation of the earth on its axis must cause it to bulge out at the equator. It was then believed to be of an elliptical outline. More recently still it has been shown that there are considerable deviations in the earth's contour from the elliptical form, and the accepted teaching at present is that it is of an irregular shape, approximating to an ellipsoid. The equator is not by any means a circle, though for practical purposes it may be regarded as such.

Pig Iron Production in 1888.

The total production of pig iron in the United States in 1888 was 7,269,628 net tons, or 6,490,739 gross tons, against 7,187,206 net tons, or 6,417,148 gross tons, in 1887. The production in 1888 was slightly in excess of that of 1887, and was the largest in our history. The extraordinary activity of the furnaces in the last few months of the year, notably in November and December, brought the total production far above the figures indicated by the statistical results of the first half of the year and by subsequent unofficial statements. While an increased production in the last half was anticipated, general surprise will be expressed upon learning how great it has been, which is shown as follows:

Production.	Gross tons.
First half of 1888	3,020,092
Second half of 1888	3,470,647

The total production of pig iron in this country since 1881 has been as follows, in gross tons:

Years.	Gross tons.	Years.	Gross tons.
1881	4,144,254	1885	4.044.526
1882	4.623.323	1886	5.683.329
1883	4.595.510	1887	6.417.148
1884	4,097,868	1888	6,490,739

Our production of pig iron in 1888, classified according to the fuel used, was as follows, compared with the production in 1885, 1886, and 1887:

Fuel—Net tons.	1885.	1886.	1887.	1888.
Bituminous	2 675.635	3.806.174	4.270.635	4.745.110
Anthracite	1.454.390	2.099.597	2.338.389	1.925.729
Charcoal	399,844	459,557	578.182	598,789

The anthracite figures include all pig iron made with mixed anthracite and coke, as well as that made with anthracite alone. The production of pig iron with anthracite alone is now annually less than that made with charcoal.

The production of pig iron in the Southern States in 1887 did not equal the general expectation, being only about 50,000 gross tons in excess of the production in 1886. But in 1888 the Southern pig-iron industry made a great stride forward. The production was as follows, compared with the production in 1885, 1886, and 1887:

States—Net tons.	1885.	1886.	1887.	1888.
Alabama	227.433	283.859	292.762	449.492
Tennessee	161.199	199.166	250.344	257.931
Virginia	163.782	156.250	175,715	197.596
West Virginia	69.007	98,618	82.311	95.259
Kentucky	37.553	54,844	41.907	56 790
Georgia	32 924	46.490	40.947	39.597
Maryland	17.299	30,502	37,427	17 606
Texas	1.843	3,250	4.383	6,587
North Carolina	1,790	2,200	3.640	2,400
Total	712,835	875,179	929,436	1,132,858

The increased production of pig iron in the Southern States in 1888 over 1887 was over 203,000 net tons. As late as 1865 the whole country made less pig iron than the South made in 1888.

Among the Northern and Western States that increased their production of pig iron in 1888 as compared with 1887, Pennsylvania is not to be counted; she made less in 1888 than in 1887. So did New York, New Jersey, Maryland, Wisconsin, and Missouri. Michigan's and Connecticut's figures for the two years do not materially vary. Illinois, Indiana, and Massachusetts show slight gains in 1888. Ohio shows a great gain, jumping from 975,539 net tons in 1887 to 1,103,818 net tons in 1888, and nearly equaling the production of the whole South.

Notwithstanding the large production of pig iron in the last few months of 1888, there was no increase of unsold stocks beyond the quantity on hand at the close of the first six months of the year; on the contrary, there was a decrease. The stocks of pig iron which were unsold in the hands of manufacturers or their agents at the close of 1888, *and which were not intended for the consumption of the manufacturers*, amounted to 336,161 net tons, against 401,266 net tons on June 30, 1888.—*From the Bulletin of the American Iron and Steel Association.*

A Water Immersion Ode.

A Rotifer, deep in an eddy-swept pool,
By the leaf-shaded shore of a rivulet cool,
Contentedly lived in her own minute style,
Invisible, voiceless, but active the while.

And starlight and moonlight, and sunshine and storm,
Lent their varying hues to her transparent form,
And the o'erhanging branches dropped green shadows down
On the flickering sands of the water-bed brown.

The minnows above her oft swam to and fro,
And naviculae sailed o'er the pebbles below,
Closterium segments divided anew,
And the horns of the fair scenedesmus grew.

The rayed rhizopoda clung lightly between
The filaments of the spirogyra green,
And actinophrys sol softly put forth his rays,
Glad that Old Sol's above made the warm, sunny days.

For the spring time had come with its warmth and its light,
And the cells of the desmids were verdant and bright,
For the season had sent its primordial thrill
Through all protoplasm and all chlorophyll.

And the Rotifer glad in her limpid retreat,
Wheeled through the fair water on cilia fleet,
Glad that the sunshine had melted her out,
And given her a chance to go waltzing about.

But a student whose nerve-cells and brain-matter gray
Were attuned to the touch of the sun's vernal ray,
Came wandering over the vivified sod,
To explore this fair pool with his bottle and rod.

And he gathered spores, larvæ, and desmids a few,
Some diatoms brown, and this Rotifer too.
Transferred to the slide on a microscope stage,
And held by a cover-glass close in her cage,

Did the Rotifer sigh for her home in the pool,
And for freedom to roam through its water-ways cool ?
In the close-compressed water and unchanging glare,
Did she long for green shadows and free-flowing air ?

If she did she exhibited no such emotion;
But by waltzing and turning she gave us a notion
She was rather enjoying the new situation,
Though too busy to rest from her old occupation.

And we said it was better this short life to yield
To the great cause of science in microscope field,
Than to live out its few days unseen and unknown
In ever so pleasant a pool of her own.

The Locomotive.

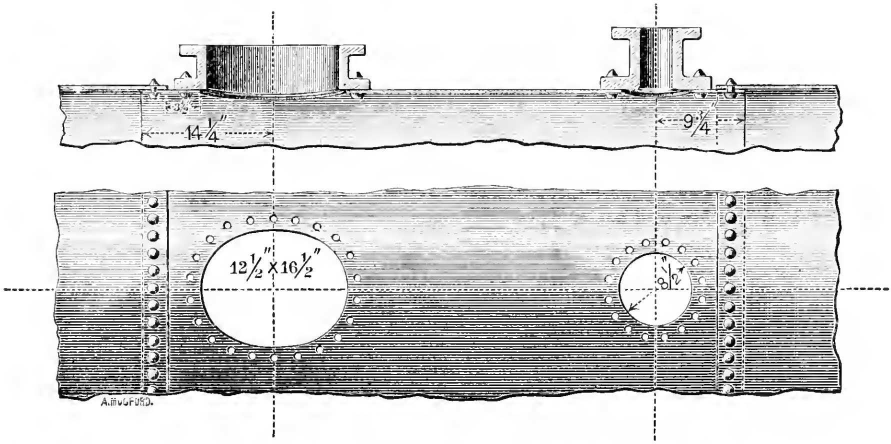
PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

NEW SERIES—VOL. X. HARTFORD, CONN., JUNE, 1889. No. 6.

Location of Man-holes and Steam-Nozzles.

A boiler recently came to our notice, in which the man-hole and steam-nozzle were both placed upon the middle sheet, as indicated in the engraving. The more usual way of arranging these openings is to place the man-hole in the middle of this sheet, and the steam-nozzle somewhere on one of the others.

The objection to placing both openings on the same sheet will be apparent upon a little reflection. When arranged as they are in the cut, fully thirty-seven per cent. of the sheet is cut away; and though the castings riveted to the shell are supposed to possess sufficient rigidity to make up for this loss of section in the plate, yet the strains resulting from such a disposition of the openings are not easily calculated, and it is evident that the failure of



LOCATION OF MAN-HOLES AND STEAM NOZZLES.

one or two rivets, either from imperfect workmanship or from undue stress, would alter the disposition of these strains materially. It is more usual, also, to have the length of the man-hole extend across the boiler, instead of longitudinally as shown in the cut. This gives us a greater area of plate along the line where it is most needed, and, moreover, it cuts away less of the *grain* of the metal. It is also harder to get into a boiler whose man-hole is placed as in the cut, and we cannot see that such a construction is any cheaper or easier.

The boiler in question exploded with disastrous effect; and though the explosion was due to other causes than the arrangement of the openings in the shell, yet it is significant that the primary rupture was in this middle sheet, and directly on the line of centers of the holes. The point that we wish to make is this: that although the explosion was abundantly explained by external causes, it is probable that a different arrangement of the openings would have allowed the boiler to hold together for a time longer, and perhaps until an attendant noticed the state of things under which it was working, and remedied them. That the fracture along the center line of these openings was the initial one, was shown by the reduction of plate there. It would be natural to expect that the first rupture would occur at the weakest spot, and that before the metal at that spot broke it would gradually stretch out and be reduced in thickness. Such was the actual fact; for the average thickness of the plate, measured with a micrometer, was 0.315 inch, but at the point where the man-hole is nearest the girth seam, the thickness was only 0 29 inch. As soon as the first fracture was developed, the stress that that part of the shell had previously withstood was suddenly transferred to other portions, and the result was that the succeeding fractures took place so quickly that the plates were literally *snapped* apart, and there was no time for the drawing out of the metal to take place; and therefore no reduction in thickness is observable along them.

Man-holes and steam-nozzle openings may of course be punched out either by hand or by machine. If the work is done by hand the holes can be cut at any part of the plate that is desired; but if it is done by machine, they must be located near the edge, since the arms of the machine punches have not sufficient reach to cut very far in towards the center of the plate. The expense of cutting them out by hand is somewhat greater than when it is done by machine, and this seems to be the only reason why the man-holes sometimes located near the edge of the sheet, as shown in the cut, instead of in the middle of the sheet, where it belongs.

Inspectors' Reports.

APRIL, 1889.

During this month our inspectors made 4,487 inspection trips, visited 9,031 boilers, inspected 4,148 both internally and externally, and subjected 589 to hydrostatic pressure. The whole number of defects reported reached 8,995, of which 644 were considered dangerous; 37 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	632	37
Cases of incrustation and scale,	920	38
Cases of internal grooving,	55	8
Cases of internal corrosion,	321	24
Cases of external corrosion,	529	42
Broken and loose braces and stays,	147	32
Settings defective,	225	15
Furnaces out of shape,	291	14
Fractured plates,	189	44
Burned plates,	135	15
Blistered plates,	332	21
Cases of defective riveting,	2,213	57
Defective heads,	77	8
Serious leakage around tube ends,	1,688	122
Serious leakage at seams,	409	56
Defective water-gauges,	208	18
Defective blow-offs,	109	19
Cases of deficiency of water,	13	3
Safety-valves overloaded,	32	12
Safety-valves defective in construction,	48	15
Pressure-gauges defective,	370	38
Boilers without pressure-gauges,	5	5
Unclassified defects,	47	1
Total,	8,995	644

Boiler Explosions.

April, 1889.

Saw-Mill (47). — A boiler in the saw-mill at Waverly, Pierce county, Wis., exploded March 30th, demolishing the mill and instantly killing the proprietor, Philip Blakely, and a workman named John Wilkins.

Saw-Mill (48). — The boiler at Mr. H. C. Caynor's saw-mill, situated near Bowling Green, Ky., burst, April 1st, wounding two white and four colored employés severely, besides destroying the mill. One of the men was blown 120 feet.

Electric Light Works (49). — The boiler in the Utica (N. Y.) Electric Light Works exploded April 5th, blowing off the roof of the boiler house, and scalding the engineer and two other employés. All the electric lights in the city were extinguished.

Steam Launch (50). — Six young men hired a steam launch for an excursion up the Kansas River, on April 7th. They had been gone but a short time when the boiler exploded, entirely demolishing the craft and throwing all hands into the river. Three of them were very seriously injured, and one of them will die. The others escaped with a ducking.

Saw-Mill (51). — Croft's saw-mill, near Junction City, Ky., was wrecked by a boiler explosion on April 8th, and four men were killed.

Hoisting Engine (52). — At Somerset, Mass., April 9th, the boiler of a hoisting engine used in unloading the schooner *Josie R. Burt*, at the "old mill" dock, exploded, and the boiler, boiler-house, and fragments of the engine were blown in all directions. The boiler landed on the deck of the *Burt*, 50 feet away, smashing her wheel and otherwise damaging her. The engineer, J. J. Brown, was found lying under the fly-wheel of the engine, shockingly wounded. Both legs appeared to be broken, and he was badly injured about his head and body. There is little likelihood that he will live.

Pumping Engine (53). — On April 9th, a terrible explosion took place on the ranch of C. Nelson, near Woodland, Cal., fatally wounding John Daniels, who died in about two hours after the accident. Two other men were blown about fifty feet, and were somewhat hurt. The boiler was used to pump water for irrigating purposes, and was twelve or fifteen years old, and supposed to be in a poor condition.

Locomotive (54). — On April 10th, just as the regular east-bound passenger train on the Chicago Santa Fé & California Railroad was leaving Lorenzo station, 50 miles from Chicago, the extra fast stock train following ran into it, telescoping the private car at the rear. The boiler of the stock train locomotive exploded at the same time, and the escaping steam badly scalded five persons, one of whom was J. F. Hart, mayor of Brookline, Mass. Four others were killed.

Grist-Mill (55). — On April 13th, the boiler in Mr. E. F. Peters's grist-mill, at DeKalb, Tex., exploded, filling the air for hundreds of feet with fragments of brick, flues, and timber, hurled with terrific force. The negro fireman was killed, and Mr. Peters, the proprietor, was severely injured internally. Three others were more or less hurt, and a horse, 150 feet away, had one leg nearly cut off by a flying fragment.

Tannery (56). — On April 18th, one of the boilers at Hollinger's tannery, Columbia, Pa., exploded. The noise awoke Mr. Hollinger, who lives in the house near the works, and he immediately dressed himself and went to the tannery to see what had happened. One boiler was found to be about three feet from its usual place, but the other was nowhere to be seen. A hunt was instituted and the other boiler was discovered fully 250 feet from the tannery, it having plowed its way through the yard, barking trees and knocking down fences, and landing in a lane on the other side of the Lancaster turnpike. The boiler-house was shattered, and not a brick in the setting was left standing. No one was injured.

Shingle-Mill (57). — A terrific explosion occurred at Davis Bros.' shingle mill, about six miles from Oakland, Md., on April 23d, by which Louis Johnson was fatally injured, and the mill and machinery totally wrecked. The explosion occurred just as the machinery was being started in the morning. Johnson was blown through the side wall of the building a distance of thirty-five yards, and was terribly scalded. He was a married man and had a large family. The mill was the property of ex-Senator H. G. Davis.

LOCOMOTIVE (58). — The boiler of locomotive No. 712, on the Lake Erie division of the Baltimore & Ohio Railroad, exploded near Utica, O., on April 23d. The fireman was slightly bruised, but nobody else was hurt.

SAW-MILL (59).— The boiler in an Ashland, Ky., saw-mill exploded at noon, April 25th. All hands were out of range, so that no lives were lost. The property loss was about $1,000. The proprietor of this discontented but not vicious boiler, Mr. James Runyon, expressed entire satisfaction with its movements, both as to the time of day, and as to the route selected, except in one particular. It did not go far enough by about 60 feet, and five dollars or so had to be expended on that account, so that it would not be in the way.

CITY HALL (60).— On April 30th, one of the boilers in the basement of the City Hall in Minneapolis, Minn., exploded. Two men were stunned by the shock, but they returned to consciousness in a few minutes and were not seriously hurt. The damage was not heavy.

The American Boiler Manufacturers' Association.

This association had its origin in Pittsburgh, among the local boiler manufacturers, but others from other States immediately showed great interest in the movement, and the first meeting was held at Hotel Anderson on the morning of April 16th, about forty members being present. The following resolutions, which were passed, will give a good idea of the objects of the organization:

RESOLUTIONS.

WHEREAS, No business calls for greater care, better material in the construction of its commodity, and more exact workmanship than ours; and in view of the fact that so many disastrous explosions have occurred in the past, where materials afterwards tested have been shown to be of an inferior quality, therefore, that we may better secure safety to the lives and the property of every community where boilers are used, be it

Resolved, That we will in all cases use the best material in the construction of boilers, refusing to accept contracts where specifications do not call for material of suitable quality.

Resolved, That it is the sense of this convention that the system of inspection prescribed by the United States Marine Laws should be adopted with but few exceptions.

Resolved, That we recommend all manufacturers of iron and steel boiler plate to make but one brand, which shall have a tensile strength of not less than 55,000 pounds to the square inch, and that the same be stamped with the initial letters found in the name of this association, *viz.*, A. B. M. A., and that this brand be sold to the members of the organization only.

Resolved, That we use all honorable means in influencing our representatives in Congress to procure the passage of such laws as will make it a criminal offense, punishable by fine and imprisonment, to manufacture or sell iron or steel of an inferior quality for boilers, and a similar offense, punishable in like manner, to make boilers, for any purpose, of a quality inferior to that specified by such laws.

Resolved, That we invite all manufacturers of boilers to join our association, knowing as we do that our object is purely philanthropic, and that we are bestowing one of the greatest blessings upon the public at large, who should look with distrust upon any manufacturer who, by reason of personal motives, refuses to take this important step.

The officers of the association for the ensuing year are as follows: President, James Lappan, of Pittsburgh; Vice-Presidents, Philip Rohan, of St. Louis; George Marshall, of Dayton, O.; Christopher Cunningham, of Brooklyn, N. Y.; Secretary, A. T. Douthett, of

Alleghany, Pa.; Treasurer, Richard Hammond, of Buffalo, N. Y. The next regular meeting will be held in New York on the first Tuesday in February, but a preliminary meeting will be held in Pittsburgh on Oct. 15th.

In addition to the officers named above, committees were appointed on the following subjects: On specifications and tests of materials, on proper rules for riveting and caulking, on proper dimensions and construction of man-holes and hand-holes, on braces and stays, on the attachment of valves, gauges, and fittings, on safety-valves, on uniformity in State boiler inspection laws, on boiler tubes, and on the rating of boilers by heating surface or otherwise.

This organization of boiler manufacturers cannot fail to interest every man who has anything to do with boilers; and we sincerely trust that the practical workings of the association may prove as beneficial to the public as the gentlemen interested in the movement hope to make it. Any step that leads to improvement in either workmanship or material ought to be hailed with joy.

The Six Day Line Passed.

The wonderful new steamer, the *City of Paris* of the Inman Line, has crossed the ocean in less than six days; the best previous time, made by the *Etruria* last June, being 6 days, 1 hour, and 55 minutes. Following is an abstract of the log, the distances being given in knots:

Date, 1889.	Wind.	Distance.	Latitude.	Longitude.	Remarks.
May 2.	Variable.				Left Queenstown at 1 h. 43 m. P. M.
3.	West.	445	50° 58′	19° 45′	Strong br. to mod. gale.
4.	N. W.	492	49 24	32 16	Fresh breeze.
5.	N.W. to W.S.W.	504	45 38	43 22	Mod. to light breeze.
6.	W.N.W.	505	42 48	54 06	Mod. to light breeze.
7.	Variable.	511	41 11	65 21	Light breeze.
8.		398	To Sandy	Hook.	Arrived at Sandy Hook Light Ship at 8 h. 15 m. A. M.
		2,855			

The apparent length of passage was therefore 5 days, 18 hours, and 32 minutes; but on correcting this for the 4 hours, 35 minutes difference in time between Sandy Hook and Queenstown, the actual time will be found to be 5 days, 23 hours, and 7 minutes. The strong head winds and consequent seas at the beginning of the trip appreciably impeded progress, and a fog near the American coast necessitated slowing up somewhat; but in spite of these difficulties the magnificent ship eclipsed all previous records and achieved what mariners have been looking forward to for many years.

On three successive days, too (the 5th, 6th, and 7th), the *City of Paris* surpassed everything recorded by the other ocean greyhounds as the best single day's run. Owing to the change in longitude, the actual time consumed from the 4th to the 5th was 24 hours, 44 minutes, from the 5th to the 6th, 24 hours, 43 minutes, and from the 6th to the 7th it was 24 hours, 45 minutes.

It is unnecessary to say that the passengers were highly enthusiastic. A meeting was held in the main cabin, and Commander Frederick Watkins and his assistants were highly complimented. Speeches were made and resolutions were adopted to the effect that "there never was such a vessel, such a captain, or such a crew before."

We regret to say that we have no exact data at hand concerning the machinery of the

City of Paris, but the following extract from *Engineering* (London) concerning her twin sister, the *City of New York*, will be of interest; for we are inclined to believe that the *City of Paris* differs from her only in having more boiler room:

"The adoption of the principle of twin-screws has been almost compulsory in this case, as it would be very difficult and probably very imprudent to construct single-screw engines having the enormous power that these combined twin-screw engines are intended to exert. The great advantage of the duplication of all parts is too obvious to be dwelt upon here, excepting to state that with only one of the engines running, sufficient power would be developed to propel the vessel at about 15 knots per hour. To indicate how the dimensions and power of the engines of the *City of New York* compare with those of the principal merchant single-screw steamers afloat we give a table compiled partly from a paper read by Mr. W. John, at the Liverpool meeting of the Institute of Naval Architects two years ago, and partly from the records of the trials of the steamers.

"It will readily be seen that the power to be developed in the *City of New York*, (20,000 indicated horse-power) is considerably in excess of that in the other steamers, and to have fitted a single set of engines, even supposing it had been advisable from every other standpoint, would have been a very questionable step to take. The two engines are separated by a longitudinal bulkhead reaching up to the main deck, communication being established by a sliding door, worked by a rack and pinion from above in case of need.

"The engines are built upon a very solid structure in the ship, but have, in addition, a cast steel bedplate. This bedplate is formed in three parts, each part weighing about 16 tons. The columns are also of cast steel and are of the "split type." The condensers, which usually form part of the main engine structure, are made, as in war ships, of brass, and are quite independent. The cylinders and their covers are cast iron, but the pistons are of cast steel of the dished type. The crankshafts are built of steel; the thrust, tunnel, and propeller shafts are also of steel. The crankshaft is 20¼ inches in diameter at the journal, and 21 inches at the pin; the tunnel shafting is 19¼ inches, and the propeller shafting 20¼ inches. The piston-rods and all the principal moving parts are of ingot steel. The piston-rods have tail-rods, and are attached to the pistons by flanged connections.

"The high, intermediate, and low-pressure cylinders are 45 inches, 71 inches, and 113 inches in diameter respectively, the stroke being 60 inches. All the valves are piston valves, there being one on the high, two on the intermediate, and four on the low-pressure cylinders. The adoption of the four sets of piston valves for the low-pressure cylinder is unique, and is necessitated by the large port area in this cylinder, and to avoid the strains due to the great overhang which would be caused by the adoption of two sets only. The valve gear is of the ordinary eccentric type, the eccentric straps being of cast steel lined with white metal. The equilibrium valve, which controls the inlet of steam, is worked by an independent engine which can be connected to the Dunlop governor. The adoption of this engine renders the handling of the main engine very much easier.

"The turning engine is of a new type, being simply a hydraulic ram working by a pawl on a ratchet wheel. This ram is vertical, and takes up very little space; but is at the same time very powerful.

"In addition to the usual draining from the jackets and casings, which is collected in the hot-well, there is a continuous flow through the casings from the high-pressure to the intermediate pressure casings, and from the intermediate pressure to the low-pressure casing. In the latter casing the drainage passes into the low-pressure cylinder in the form of vapor, there doing work, and finally passing into the condenser. By this means any accumulation of water is prevented in the casings when the engines are running, and the glands are always dry.

"The air pumps are the only auxiliaries driven from the main engine. There are two of them to each engine, of the ordinary vertical type, and they are worked by levers off the high-pressure and low-pressure crossheads. A small oil pump is also driven off the main engines. It is for keeping the crank-pits clear of oil, which is forced into the stern tubes.

"The boilers are fed by Worthington vertical pumps, four in number, associated with Gilmour's feed heater. These during the trial proved satisfactory, and in this connection it may not be uninteresting to indicate briefly their system. Each pump has two 12 inch steam cylinders, and 28½ inch double-acting water plungers, with a 10 inch stroke. There are two pumps in each engine-room. Of these one supplies the feed heater with water at the temperature of the hot-well. This water has its temperature raised in the feed heater by live steam from the boiler to nearly the boiler temperature, and the second pump delivers this heated feed water at a slightly increased pressure to the boiler. There is no advantage on the score of economy; but in so far as the feed water is introduced at boiler temperature there is complete absence of any possibility of strain due to irregular cooling of the boiler plates. The heater can be thrown out at any time and only one pump used, and as the capacity of each pump is sufficient of itself for boiler feeding, the other may be looked upon as an alternative in case of breakdown. In the ordinary arrangement, the first pump, which delivers from the hot-well into the feed heater, is controlled by a float in the tank, so that it will be impossible either to have overflow or an insufficient quantity in the hot-well. As all the water passing through the feed heater is at a high pressure, all impurities in the water are deposited in the latter, from which they are occasionally discharged by means of a blow-off, and since the heater itself is in no way cramped or confined by large tubes, its cleaning becomes a very easy matter. Indeed it is completely done by blowing off at regular intervals.

"There are two fire and bilge pumps in each engine-room for general ship purposes. These are also so arranged that they can be used as feed pumps in the event of the main getting out of order, and they are connected to the double-bottom system of piping, and are available for pumping the compartments between the bottoms should the circulating pumps be in use for other purposes. The water is circulated through each of the main condensers by two sets of 15 inch centrifugal pumps, either of which is more than capable of doing all the work required. There are fresh-water condensers in each engine-room, which have their own feeding and circulating pumps automatically worked. All these pumps are of the Worthington type.

"The hydraulic installation of the ship, which is the most extensive fitted on shipboard, has its pumping engines — two in number — in the engine-room. These engines work seven hoists, nine derricks, two warping ends, a windlass, and two warping capstans aft on the promenade deck.

"The steel boilers which supply the steam are nine in number, and are equally divided in three water-tight compartments. They are built of steel, the shell plates being $1\frac{9}{32}$ inches in thickness. The diameter of each boiler is 15 feet 6 inches, the length 19 feet, and the working pressure is 150 lbs. to the square inch. The boilers are double-ended, and have each six furnaces, whose mean diameter is 3 feet 11 inches. The tubes are 7 feet 6 inches long, 2⅜ inches in diameter, and in each boiler there are 1056 tubes or 9504 in the nine boilers. The total heating surface 50,040 square feet. The furnaces on each end have a common combustion chamber. Each boiler weighs 74 tons.

"The boilers are worked on what is known as the closed stokehold system. This is the first ship for the Atlantic passenger trade that has been worked on this system, and it necessarily introduces many novelties. There are no air hatches excepting those through which the fans draw down the air supply. The fans for supplying air to the furnaces are twelve in number, and are each 66 inches in diameter. They are the result of very exhaustive experiments. The application of forced draught has become so general that the designing of the engines for supplying it has become equal in importance with the designing of the engine for propelling the ship."

HULLS AND ENGINES OF ATLANTIC STEAMERS.

NAME.	Vessel's Dimension: Length.	Breadth.	Moulded Draught.	Engines: Indicated Horse-Power.	Engine Cylinders: Diameters.			Stroke.	Boilers: Heating Surface.	Area Firegrate.	Working Pressure.
	ft. in.	ft. in	ft. in					ft. in.	in sq. ft.	in sq. ft.	lbs.
S. S. City of Rome, ...	542 6	52 0	21 5½	11,890	3 / 46 in.		3 / 86 in.	6 0	29,286	1398	90
" Normandie, ...	459 4	49 11	19 9¾	6,959	3 / 35 7-16 in.		3 / 74⅛ in.	5 7	21,404	756	85
" Arizona, ...	450 0	45 1½	18 9	6,300	1 / 62 in.		2 / 90 in.	5 6	....	....	90
" Orient, ...	445 0	46 0	21 4½	5,433	1 / 60 in.		2 / 85 in.	5 0	....	....	75
" Sterling Castle, ...	420 0	50 0	22 3	8,396	1 / 62 in.		2 / 90 in.	5 6	21,161	787	100
" Elbe, ...	420 0	44 9	20 0	5,665	1 / 60 in.		2 / 85 in.	5 0	....	....	......
" Umbria and Etruria,	500 0	57 0	22 6	14,321	1 / 71 in.		2 / 105 in.	6 0	38,817	1606	110
" Anrania, ...	470 0	57 0	20 0	8,500	1 / 68 in.		2 / 91 in.	6 0	23,284	1001	90
" America, ...	432 0	51 0	26 0	7,354	1 / 63 in.		2 / 91 in.	5 6	22,750	882	95
" Servia, ...	515 0	52 0	23 3½	10,300	1 / 72 in.		2 / 100 in.	6 6	27,483	1014	90
" Alaska, ...	500 0	50 0	21 0	10,500	1 / 68 in.		2 / 100 in.	6 0	....	....	100
" Ems, ...	430 0	46 10	20 7½	7,251	1 / 62 in.		2 / 86 in.	5 0	19,700	780	100
" Aller, ...	438 0	48 0	21 0	7,974	1 / 44 in.	1 / 70 in.	1 / 100 in.	6 0	22,630	799	150
" Ormuz, ...	465 6	52 1½	.....	9,000	1 / 46 in.	1 / 73 in.	1 / 112 in.	6 0	26,000	850	150
" Lahn, ...	448 5	49 0	......	9,500	2 / 32½ in.	1 / 68 in.	2 / 85 in.	6 0	....	....	150
" City of New York..	560 0	63 3	25 0	20,000	2 / 45 in.	2 / 71 in.	2 / 113 in.	5 0	50,265	1293	150

Production of Gold and Silver in the United States in 1888.

The Director of the Mint has submitted to Congress his report on the production of gold and silver in the United States during the calendar year 1888.

The gold product was 1,604,927 fine ounces of the value of $33,175,000. This is about the same as in 1887, being an excess of only $175,000.

The silver product was 45,783,632 fine ounces of the commercial value of about $43,000,000, and of the coining value of $59,195,000. This is an increase of 4,515,327 fine ounces over the product in 1887.

In addition to the product of our own mines some 10,000,000 ounces of silver were extracted in the United States from foreign ores and base bullion, principally Mexican.

The total refined product of the United States was in gold 1,777,877 fine ounces, and of silver 53,128,698 fine ounces.

The average price of silver during the year was about ninety-four cents. At this price the bullion value of the silver contained in the silver dollar was $0.72·6; at the highest price of silver during the year the bullion value of the silver dollar was $0.75·5; and at the lowest price $0.70·5.

The government purchased 28,920,398 standard ounces of silver during the year, costing $24,491,340, an average price of ninety-four cents per fine ounce. The total amount of silver purchased for the coinage of the silver dollar since March 1, 1878, has been 275,007,939 standard ounces, costing $266,091,445, an average price of $1.07·5 per fine ounce, or $0.96·7 per standard ounce.

The value of the gold deposited at the mints during the year, not including re-deposits, was $41,496,410, or including re-deposits, $48,794,988. The foreign material comprised in this was $7,055,046.

The amount of silver deposited and purchased was 35,512,789 standard ounces of the coining value of $41,323,973, exclusive of re-deposits.

The coinage of the mints during the calendar year 1888, was as follows:

Gold,	$31,380,808
Silver dollars,	31,990,833
Subsidiary silver,	1,034,773
Minor,	912,201
Total,	$65,318,615

In addition to the coinage, bars were manufactured at the mints containing gold of the value of $21,650,798, and of silver, $7,635,490.

The import of gold bullion and coin was $11,031,941, and the exports $34,619,667: a loss by export of $23,587,726.

The import of silver was $21,592,062, and the export $29,895,222, a loss by export of $8,303,160.

The metallic stock of the United States, January 1, 1889, including bullion in the mints awaiting coinage, is estimated by the director to have been: gold, $705,061,975; silver, $403,516,756; total, $1,108,578,731.

The stock of coined and paper money in circulation January 1, 1889, was $1,396,106,154, against $1,376,930,003 on January 1, 1888, an increase of $19,175,151.

The director estimates the consumption of gold and silver in the industries in the United States during the calendar year 1888 to have been: Gold, $14,600,000; silver $5,280,000.

To the Editor of the Locomotive:

Sir: The "Microscopists' Serenade," published in the January number of the Locomotive, first appeared in the *bric-à-brac* department of *Scribner's Magazine*, in November, 1879. Charles H. Robinson.

Hartford, April 25th.

[We are pleased to give credit for the poem, even at this late day, and, as explained in the January number, we should have given credit for it at the time, had we known to whom it was due.—Ed.]

The Locomotive.

HARTFORD, JUNE, 1889.

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.

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

THE boiler of a steam dredging tug exploded in the harbor of Calais, France, on April 29th, killing seven men and badly injuring a number of others. The dredger was demolished.

A MODEL of the Park Central boiler has been on exhibition in this office for some time, and any of our friends who have not already seen it are cordially invited to call in and do so.

SOME of the gentlemen connected with the *Boston Journal of Commerce* have organized into a "Mechanical Specialties Manufacturing Company," and are selling the "arc indicator" described in a recent number of that paper. They also make a new style of planimeter, a reducing motion, a tube cleaner for vertical boilers, and an outfit for leveling shafting.

WE have received the fourteenth annual report of the Frankfurt (Germany) *Märkischer Verein* for the inspection and supervision of steam boilers. During the year 1888 this association has had 1,342 boilers under its care, 338 of which have been tested hydrostatically; 752 internal inspections were made, and 3,100 externals. The report contains, among other things, an interesting essay on the purification of water, in which the principal devices used in Germany for this purpose are illustrated and described.

The eighteenth report of the *Silesian Association* is also at hand. The number of boilers under the care of this association was 2,340 at the end of 1887, and at the end of 1888 it had increased to 2,506.

A RECENT number of the *Scientific American* contains two excellent engravings of a young Moi, twelve years of age, who has a tail nearly a foot long. Similar appendages have been observed in other members of the human race, but so far as we are aware, no case has been previously recorded in which the tail has reached such great length. Bartels enumerates twenty-one cases of such development in his memoire on the subject ("Ueber Menschenschwanze"), and in nearly every case the appendage is conical or spherical in shape. It is rarely cylindrical, as in the present case, is seldom more than three or four inches in length, and is generally curled at the end, something like a pig's tail. Professor Virchow dissected one specimen and found it to consist simply of fat and muscle, and no case is on record in which vertebrae were present.

Poisoned Arrows.

In the letter recently received by the Royal Geographical Society, the African explorer, Stanley, gives some very interesting information concerning the poison used on the arrow tips of the savages through whose country he had been traveling. Lieutenant Stairs and several others of the party were wounded with the arrows, and four persons in all died from the effects of the poison, almost immediately. Stanley greatly desired to know what is the nature of the poison that has such deadly effect. At Arisibba he found several packages of dried red ants, and the mystery was soon cleared up. It has long been known that formic acid exists in a free state in the bodies of these little creatures — indeed, the acid received its name from this fact, *formica* being the Latin name for the ant. Formic acid, in its pure state, readily blisters the skin, and without doubt it is the "deadly irritant by which so many men have been lost with such terrible suffering." In fact, Stanley learned the manner in which the poison is made ready for use. The unfortunate ants, after being dried, are pulverized and cooked in palm oil, and the resulting composition is smeared over the tips of the arrows. The savage that first prepared this deadly bug-juice was dolichocephalous indeed, and was looked up to, no doubt, as the Bismarck of his tribe.

The Heat Evolved by Animals.

At a recent meeting of the Berlin Physiological Society, Professor Rosenthal gave an account of experiments he has been carrying on for the past few years, concerning the heat given off by animals. According to *Nature* he placed the animal to be experimented upon in a copper vessel that could be easily ventilated, and surrounded this vessel by a reservoir containing air, whose expansion or contraction was to give the means of determining the heat given off from the animal within. Although the dog used in the experiments was fed in exactly the same way at each meal, the quantities of heat produced varied very largely, and no considerable uniformity could be had without taking the mean of a long series of observations. Up to about the third hour after the meal, the heat-production diminishes. It then rises rapidly and attains a maximum, after which (at about the eighth hour) it begins to fall again, irregularly, until the next meal. When an excess of food was given, the heat produced was always less than that calculated from the oxidation of the food; but, with a uniformly constant diet, the mean value of the heat produced corresponded to the amount calculated. When the surrounding air varied in temperature between 41° Fah. and 77° Fah., all other conditions remaining the same, a minimum production of heat was observed at 59° Fah. From this point it increased uniformly in both directions — not only when the temperature fell to 41°, but also when it rose to 77°. The amount of carbonic acid gas given off by the animal agreed with the theoretical amount when the experiments were continued over a considerable length of time.

An Experimental Test of a New Steel Boiler.

A paper recently read before the Institution of Naval Engineers (England) by Mr. John Scott, F.R S.E., contains some interesting facts concerning the strength of boilers, and the following abstract is made from it.

A number of iron boilers have been experimentally submitted to bursting pressure, from time to time, by various engineers. No record, however, appears to exist of any bursting experiment made with the shell of a new boiler of a size used in actual practice, constructed of steel, and intended to work at the high pressures that modern engineers are demanding. Such an experiment was accordingly resolved upon, and was carried out at the Greenock foundry.

Last summer boilers were built at that establishment for Her Majesty's gunboats

Sparrow and *Thrush*, intended for a working pressure by Admiralty specification of 145 lbs. per square inch. The diameter of these boilers was such that an experiment on a duplicate shell could be conducted without too serious expense. Such a one was accordingly prepared, the design and dimensions being as follows: Plain cylindrical shell, length 11 feet, mean diameter 7 feet, 8$\frac{3}{16}$ inches; double staggered riveted girth seams, triple staggered riveted butt-joints for the longitudinal seams; thickness of shell plates $\frac{19}{32}$ inch; of butt straps, $\frac{1}{2}$ inch; of heads, $\frac{5}{8}$ inch; of washers, $\frac{5}{8}$ inch; of man-hole strengthening plate, $\frac{5}{8}$ inch. The plates and stays used were subjected to the usual Admiralty tests for tension and elongation, with results as follows:

For What Part Used.	Tensile Strength in Tons per Square Inch.	Elongation in 10 in. Per Cent.
Flanged ends,	28.1	25
" "	27.3	25
End plate of shell,	26.9	29
" "	27.8	25
Middle plate of shell,	27.7	25.2
Butt straps,	26.2	27
Man-hole strengthening plate,	26.7	26.6*
Boiler stays,	26.8	

* In 8 in.

No special precautions were taken in regard to workmanship. The flanged ends were pressed by hydraulic pressure at one heat, and were not annealed. The shell plates were bent cold. The rivet holes were drilled in place after bending. The shell plates and one end were riveted by a hydraulic machine, with a pressure of 120 tons per rivet. The closing end was riveted by hand. The boiler was caulked in the usual way, and prior to commencing the experiment it was tested for tightness to the pressure required by the Admiralty specification for this class of boiler: that is, to 235 lbs. per square inch.

In the first trial the pressure was raised to 145 lbs., the intended working pressure. A slight alteration in form was noticed, which was due, no doubt, to the effort of the boiler to assume a true cylindrical shape. The diameter of the boiler appeared to increase at some points, and to decrease at others. The pressure was then increased to 235 lbs., the Admiralty test pressure. The greatest deflection of the plate outward at this pressure was $\frac{1}{8}$ of an inch, and the greatest deflection inward was likewise $\frac{1}{8}$ of an inch. No leak occurred at 300 lbs., which was as high as the pressure was carried in the first experiment. The pressure was then removed, and the boiler was found to return to its original state, no permanent set being observable.

In the next experiment the pressure was gently raised up to 330 lbs., when leaking commenced to a small extent through the man-hole; all other portions of the boiler remained tight. Pumping was then continued until 450 lbs. was reached, at which point the volume of water supplied by the four pumps was equaled by the leakage from the man-hole, and the trial had to be suspended. The remainder of the boiler was tight, except a very small leak from one of the corners of each of the two butts. On examination it was found that the strengthening plate surrounding the man-hole was buckled, and the caulking around the edges started. This plate was then removed and a larger one was riveted on in its place. No other repair was made. The greatest permanent bulge produced by this pressure (450 lbs.) was $\frac{1}{4}$ of an inch on the shell, and $\frac{5}{16}$ of an inch on the heads.

In the next experiment the pressure rose to 350 lbs. without any leakage. At this stage, a slight leak was noticed at the man-hole again. The pressure was then carried up to 520 lbs., when the leakage again overcame the supply from the pumps. In addition to that at the man-hole, leaks of some extent were visible at the ends of all the butt straps, but all other portions of the boiler remained tight. A permanent bulge of slightly over one inch was observed on one of the heads, but the greatest set on the shell was $\frac{7}{16}$ inch. An examination internally showed that the greatest elongation of the stays was $2\frac{1}{32}$ inches, and the greatest reduction in diameter was $\frac{1}{64}$ inch. All the center stays were reduced by this amount, and throughout the experiments it was observed that the reduction in diameter of the stays was uniform throughout their length, until within 8 inches of the ends; they then tapered gradually up to their original diameter. The center line of the boiler had increased about one inch at each end. No starting of the butt straps was observed, either internally or externally. They were caulked at the ends, and an increased number of bolts was fitted to the man-hole door, which was recaulked.

In the fourth experiment no leak was observed at 350 lbs., but at 580 lbs. the leakage was once more equal to the supply, and the experiment could not be pushed further. It commenced at the man-hole, as before, at 360 lbs., and gradually increased. Larger leaks than before were observed at the ends of the butts, and some slight leaks were seen at the sides of the butt-straps, and about the nuts that secured the stays. An examination showed that no visible change had taken place in the caulking of the butts outside, but the ends of the inside straps were $\frac{1}{64}$ inch open, and the caulking of the inside straps had started so as to be visible, but the thinnest testing knife could not be inserted. Some of the stays had been reduced nearly $\frac{1}{32}$ inch in diameter, throughout their length. The heads had bulged, permanently, $1\frac{3}{8}$ inches each, and the greatest bulge on the shell was 1 inch. At one point, the diameter of the boiler had increased $1\frac{3}{8}$ inches, and the greatest observed set of the stays was $3\frac{1}{8}$ inches. The butts were caulked and three additional pumps were connected, to increase the supply of water.

In the next trial, which was also the last, a slight leak appeared just before 400 lbs. was reached. The leakage at the sides and ends of the butt-straps increased up to 620 lbs., which pressure was maintained for five minutes, but could not be increased. With the exception of one or two slight leaks the rivets remained unimpaired throughout the experiments, and no difference in this respect was observable between the hand and machine riveting. The greatest permanent bulge of the heads was $1\frac{15}{32}$ inches; and of the shell, 1 inch. The greatest observed increase in diameter was $1\frac{13}{16}$ inches. The greatest elongation of stay bolts was $3\frac{5}{8}$ inches, and the greatest reduction in diameter was $\frac{1}{16}$ inch.

The stresses on the boiler at various pressures are given in the table below:

Stresses on Boiler at Various Pressures.

Internal pressure in pounds per square inch.	130	135	145	235	300	450	520	580	620
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
Stress on shell per square inch of solid plate, . . .	10,092	10,840	11,256	18,243	23,288	34,933	40.367	45,025	48,130
Stress per square inch of section left after rivet holes are drilled, ...	12,057	12,521	13,448	21,796	27,824	41,737	48.229	53,794	57.504
Stress on rivets in longitudinal seams per square inch of section (double shear), .	8,320	8,640	9,280	15,040	19,200	28,800	33,280	37,120	39,680
Stress on stays per square inch of section, ...	8.910	9,253	9,938	16,107	20,562	30,843	35,640	39,753	42,494

The mean tensile strength of the shell-plates and butt-straps, before bending, may be taken at 61,500 lbs. to the square inch. It will be seen from the table that when the pressure was 620 lbs., the section of plate left after drilling the rivet holes withstood a strain of 57,504 lbs. per square inch, without rupture or serious disturbance of the structure. This corresponds to a strength of joint equal to $93\frac{1}{2}$ per cent. It is interesting to note, also, that at the end of the experiments the heads of the boiler had bulged into a fairly regular curve from circumference to center.

In concluding our account of these experiments, we will say that in our opinion this was a very exceptional boiler — almost as exceptional as Dr. Holmes' "one hoss shay." We do not believe that one new boiler in twenty would show such equal strength all over. Moreover, this boiler had neither tubes, nor flues, nor furnaces, as they were not considered essential to the investigation. In designing boilers, too, it is necessary to take into account the extra strains that may be accidentally brought to bear on them, as well as the possible reduction of metal by corrosion, and many other things; and the wisdom of using a factor of safety of five or six will be apparent. The factor of safety on this boiler seems to have been about 4½; and the testing pressure was carried nearly up to the theoretical bursting point.

A Legal Foundryman.

It has been said that a lawyer in practice should know something of everything, because he would sooner or later be required to use that knowledge in some details of the litigations with which he might be connected. An illustration of this fact occurred in Providence, R. I., during the progress of an important patent suit on spinning machinery, in which the maintenance of the rights patented were contested on the ground that the patent was not a valid one, as it lacked the element of novelty, by reason of its having been anticipated by a spinning frame, containing the identical features, which had been built and operated some twenty years before.

The lawyer retained by the patentees had in his boyhood days played in his father's foundry and machine shop. He had often made patterns out of wood and moulded them in the sand. When the men were casting in the foundry, some of the iron would be poured into these moulds, and in turn the boy would finish his castings into various wheels for carts and other toys. In this manner he obtained, by close observation and practice, a good knowledge of the principles of moulding.

In the case referred to, the testimony in opposition to the patent was all given by one man, who claimed to have made, some twenty years before, a spinning frame which was an absolute anticipation of the one in litigation. He explained in great detail that he was at the time the superintendent of a mill owned by a father and several sons, and that the spinning frame had been made in the repair shop of the mill, the men working on it at times when there was no especial need of other work. He further testified that the frame had operated satisfactorily, but that the young men became jealous and used their influence with their father to an extent which prevented the construction of any more frames. In course of time the machine became worn out, and was broken up for old iron.

The parties owning the mill had all died, so that there was no testimony beyond this man's bare assertion, with the exception of a small portion of the spinning frame, termed the bolster, which contains the upper bearing on each spindle. This pattern was a small piece of wood about an inch in diameter and six inches in length. The witness testified that he had never made any drawing for this bolster pattern, but had turned it out himself. He stated that it was the identical pattern used in casting all the bolsters for the frame, and that after its use he had kept it in his office, and on leaving the establishment took it with him, this being the only portion of anything relating to the spinning frame which was in existence.

If his statements could have been substantiated, it would have defeated the suit, because it contained salient features which were essential to the patent owned by the plaintiffs. During the cross-examination the lawyer scrutinized the pattern, and from his knowledge of the practice in foundries, perceived that it had never been used to make a mould. It was of such a form that if it had been placed in the sand it could not have been removed by the fingers, but would have been taken out by a small awl, called a pick, which would have been inserted to remove it, and this pattern bore no evidence whatever of having been scarred by the sharp point of such an instrument; therefore, after the witness had thoroughly identified the pattern as the one used in making the mould for casting the bolsters, the lawyer demanded that the pick-mark should be shown. The witness was confused, and the lawyer again requested him to show the pick-mark. This unexpected technical knowledge on the part of the counsel broke down the witness, who, like all perjurers, had neglected to make his story complete.

The next action in the case was the summoning into the court the foremen of the principal foundries in the vicinity, all of whom asserted that the pattern had never been used in making a mould, as it would have been impossible to remove a pattern of that form from the sand without a pick. A pick had never been used on that pattern, and therefore the pattern had never been used in moulding.

It was the unanticipated information possessed by the lawyer which enabled him to win a very important lawsuit. On the other hand, it is doubtful if any one can conceive how many cases of litigation have been lost for the lack of suitable practical knowledge on the part of the counsel. It was a feature of the practice of the late William H. Seward, in his prime, that, whenever he was engaged in a case involving any practical application of mechanical principles, he would go to workmen in that specific line and learn from them all that was possible in regard to the practical features of the work. He carried this practice to such an extent as to introduce new methods in the conduct of patent litigations. — *C. J. H. Woodbury, in American Machinist.*

If the salvation of the human race could be attained by talk, we should be on the verge of the millenium. During the period of the Paris Exposition, no less than sixty-nine international congresses will meet under government patronage, besides a good many which will lack official sanction. Nearly every imaginable subject will be under discussion, before audiences which will be freer from conservative ideas than those that attend fashionable congresses in this country [England]. Politics and religion are the only matters that are absolutely forbidden; everything else may be investigated and criticized, and any one may become a member of this vast debating society by the payment of twenty francs [four dollars].— *Engineering.*

At a recent meeting of the Royal Society, Dr. Hugo Miller, F.R.S., showed specimens of the new metal gnomium, recently discovered by Krüss and Schmidt of Munich. These gentlemen have shown that both cobalt and nickel are always associated with gnomium, which substance they have isolated for the first time, as announced in the Locomotive for April.

No Time for Fun — You will frequently hear people complaining that this or that man is discourteous or self-important, simply because he does not enter upon a discussion of unimportant topics whenever approached by an acquaintance. The accusation in 99 out of 100 cases is unjust. A man may be ever so sociable when he has the leisure time to devote to sociability, but when business is to be looked after he cannot afford to be so, even at the expense of friendship. Take the managing or executive head of any great business, and when approached during business hours for sociable purposes, he will almost invariably receive the thoughtless intruder very coldly. Take this same man at leisure and he may be a Chesterfield. Forty years ago, there was time to talk. To-day there is scarcely time for action. When the boy of to-day has attained the age of 40 he will fully appreciate this fact, and in half a century from now the man who expects his neighbor to devote an hour or so of his business time to social conversation will be considered insane. — *St. Louis Globe-Democrat.*

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Defects in Boilers.

Many seem to think that no great amount of skill is required to qualify one as an inspector of steam boilers, but this is a very erroneous impression. The reports of the inspectors of the Hartford Steam Boiler Inspection and Insurance Company, published each

FIG. 1.

month in THE LOCOMOTIVE, afford abundant evidence that the ills to which boilers are heirs are very numerous and varied; and each inspector must constantly be on his guard, so that the slightest detail may not escape him. He must, in the first place, possess all the qualities that go to make up a first-class steam engineer; and secondly, he must have a clear head and a sound judgment. He must not only observe every defect that exists in a boiler; he must also be able to tell at once whether any defect that he may find is dangerous or not, and whether it is likely to become so by continued use. He has, on the one

Fig. 2.

hand, to warn the owner of the boiler of the slightest defect that may cause damage of any kind, and on the other hand, he must be careful not to advise the making of repairs that are not in reality necessary.

Fig. 2, in this issue, shows a piece of a boiler that had been examined (but not by one of our inspectors) and pronounced in good condition. It ran for three weeks, at the end of which time it showed evident signs of weakness, and the proprietor, realizing its condition, immediately summoned an inspector of this company, and requested him to look it over and see what was the trouble. The plate at the back end of the boiler was eaten entirely through by corrosion, in one place, as is shown at *A*; and around the blow-off pipe at *B* the plate was so weakened from the same cause that the inspector *pulled the blow-off out by hand.* Here was an instance in which a man who no doubt knew considerable about boilers, and was considered competent to decide on their fitness for use, entirely overlooked a dangerous and very marked defect that might have produced disastrous consequences had our inspector not found it.

Fig. 1 shows, full-size, a defect that occurred in the same neighborhood, and which illustrates the necessity of sound judgment on the part of the inspector. One of our men, in examining the boiler, found a small, very thin internal blister in the steam space, and with a cold chisel and hammer he trimmed it up in the usual way. All that then remained of it was the tongue-shaped depression extending from about the center of the engraving up to upper right hand edge. The blister was small, slight, and local, and could not possibly give any trouble. Afterward some one who was examining the boiler (it was not one of our men), found it, and although it had not changed its appearance in the slightest, and had never given the least trouble, he recommended the proprietor to have it cut out and replaced by a patch. The piece that was cut out is shown in the engraving. The metal was sound and strong, and the hole through the middle of the piece indicated by the white spot, was made with difficulty. In a word, the expense of cutting out this piece was wholly unnecessary, and the plate with the patch on it is not as strong nor as durable as the original plate with the blister.

Our inspectors are all trained men, and are selected with special reference to the qualities that a first-class inspector needs to have. Our patrons can trust their judgment fully.

Inspectors' Reports.

May, 1889.

During this month our inspectors made 4,795 inspection trips, visited 9,062 boilers, inspected 3,941 both internally and externally, and subjected 580 to hydrostatic pressure. The whole number of defects reported reached 11,308, of which 605 were considered dangerous; 61 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	597	34
Cases of incrustation and scale,	866	35
Cases of internal grooving,	43	13
Cases of internal corrosion,	285	16
Cases of external corrosion,	571	36
Broken and loose braces and stays,	131	38
Settings defective,	242	27
Furnaces out of shape,	314	21
Fractured plates,	156	54
Burned plates,	149	18
Blistered plates,	312	16
Cases of defective riveting,	4,710	41
Defective heads,	71	17
Serious leakage around tube ends,	1,675	91
Serious leakage at seams,	378	25
Defective water-gauges,	161	26
Defective blow-offs,	108	21

Nature of Defects.	Whole Number.	Dangerous.
Cases of deficiency of water,	11	4
Safety-valves overloaded,	31	14
Safety-valves defective in construction,	67	25
Pressure-gauges defective,	341	26
Boilers without pressure-gauges,	4	4
Unclassified defects,	85	3
Total,	11,308	605

Boiler Explosions.

MAY, 1889.

SLEEPING CAR (61). — A Baker steam heater in the sleeping car *Riverton* exploded March 30th, at the Union depot, Cleveland, O. F. Farrell, the porter, was at work in the car at the time, and two passengers, one of whom was Charles W. Reed of Buffalo, were asleep in their berths. No serious damage was done. (We did not learn of this explosion early enough to include it in its proper place.)

IRON FOUNDRY (62). — On May 5th a boiler explosion occurred at Lowell's iron foundry and machine shop, Manchester, N. H. The building was brick, three stories high, and 40 x 50 feet on the ground, and it was totally wrecked. Only the chimney is standing. A section of the boiler was blown through the wall in the rear of boiler, and a second piece was shot into the air and came down through the roof of the S. C. Forsyth Machine Company's foundry. Charles Ouimette, the engineer, was standing in front of the boiler and was knocked insensible, but was not seriously injured. Three other persons were about the building at the time. Had the explosion occurred on a week-day, the loss of life would have been very large, as a heavy force is employed. The loss will nearly be total.

BOX FACTORY (63). — Late in the afternoon of May 9th a boiler exploded in the box factory of A. A. Foster, Racine, Wis. The engine-house and rear of the two-story brick factory were wrecked, and several hundred windows in the Racine basket factory building adjoining were shattered. George Wheeler, engineer, and Wright, an employee, escaped with slight injuries. Mr. Foster and Martin Peterson received internal injuries that may prove fatal. William McHale was also seriously injured.

BOX FACTORY (64). — A mud drum exploded on May 9th in the basement of the Spooner Paper Box Manufacturing Company, No. 252 West Twenty-seventh Street, New York, and a German laborer named Daniel Klupka was killed. The building received $75 damage, and the stock $500. The most notable thing about the accident was the conduct of the 300 girls employed in the place. When the explosion occurred the superintendent ran up stairs, and after quietly telling the girls that an accident had happened, formed them into two lines and marched them down stairs to the street, and across to the other side to a place of safety.

SAW-MILL (65). — A boiler in Seward Davis' mill, Payne, O., exploded May 13th, killing Edward Hartshorn and William Tarley, and seriously injuring four others.

LOCOMOTIVE (66). — A locomotive boiler on the North Pacific Coast Railroad exploded near Occidental, Sonoma Co., Cal., on May 15th. The water tank at that place was wrecked, but nobody was killed. (Occidental is a small place about 30 or 35 miles north of San Francisco.)

WRECKING STEAMER (67). — On May 17th, while the wrecking steamer *Florence* was aiding to float the bark *Mary K. Campbell* ashore at Matane (Quebec), the boiler of the *Florence* exploded, scalding Engineer Charrier and throwing two other men into the hold of the vessel. All were very severely injured.

Printing House (68). A boiler exploded in a printing and publishing house in Cincinnati, on May 23d. Further particulars of this explosion are given in our Cincinnati letter in this issue.

Steam Shovel (69). — On May 25th, while three men were engaged at work in the engine room of the steam shovel which is being used for loading ballast on the cars at Wales, Ont., for grading purposes on the Grand Trunk Railway double track, the boiler exploded, seriously injuring two of the men, one of whom, McIntosh, is expected to die.

Portable Saw-Mill (70). — The boiler of Gilfilen & Gibson's portable saw-mill, situated on Poindexter's creek, near Winfield, W. Va., blew up on the morning of May 31st, with terrific force. William Doss was instantly killed: George Gilfilen died two days later from a crushed skull, broken collar bone, and other injuries; Burns Wooten was badly bruised and scalded, and cannot recover; David Chambers, the sawyer, received several injuries about the body and head, none of which are serious. Several of John Gibson's bones were broken, and he was otherwise seriously but not dangerously hurt. One of John Niberl's eyes was blown out, and he was badly burned about the body. The lumber inspector of the McLaughlin Timber Company, of Columbus, O., happened to be on the grounds, and was seriously hurt. Engineer Wolford, who was slightly injured, fled to the woods after the accident, and has not been seen since. About five feet of that portion of the boiler to which the fire-box is attached was blown about one hundred feet in the air, coming down about one hundred yards from the mill, imbedding itself into the ground three feet. The mill, which is estimated to have been worth two thousand dollars, is a total wreck.

On the Longitudinal Riveted Joints of Steam-Boiler Shells.*

BY JOHN H. COOPER, PHILADELPHIA, PA.

The initial statement to the English Lloyd's rules for steam-boilers is embodied in the following words: "The strength of circular shells to be calculated from the strength of longitudinal joints," which assures us that this part of the boiler should be properly proportioned. To these rules a memorandum is added: "In any case where the strength of the longitudinal joint is satisfactorily shown by experiment to be greater than given by this formula (Lloyd's), the actual strength may be taken in the calculation." Later on, Lloyd's rules (under the head of "Periodical Surveys," regarding the examination of boilers after they have been several years in service) say: "The safe working pressure is to be determined by their actual condition." These statements lie in the line of practical efficiency, and point to the necessity of providing material in accordance with the requirement of the load to be carried.

Any one who takes the trouble to collect and compare data on this subject cannot fail to notice the great disparity of rules for determining the working pressure permissible for boilers. The case is clear by simple reasoning on the data collected, that boilers are held together, it would seem, more by conformity to rule than by the materials of which they are made. But of course the true course to pursue is to give to each member its proper allowance of section, in order that the components of the joint shall have an equal chance under strain according to its resisting power. The diminished strength of the shell of a boiler by a longitudinal joint is well known, and it becomes good engineering so to proportion its parts as to obtain the greatest strength possible within the limits of practical economy.

When it became necessary to assure themselves confidently of the permanent safety of a structure composed of plates held together by rivets, engineers were not long in finding out that a certain allotment of rivet section to plate section at the joints was necessary, and that these sections were found to be nearly equal in the strongest joints. The experiments

* Communicated to the Locomotive by the author.

of Fairbairn, conducted in the year 1838, proved that — "the sectional area of the rivets in a joint was nearly equal to the sectional area of the plate through the rivet holes." Subsequent experiments by Clark on riveted plates for the Britannia and Conway Tubular Bridge fully corroborate the above statement; his conclusion was: "The collective area of the rivets is equal to the sectional area of the plate through the rivet-holes." This relation of the components of the joint in course of time became embodied in the English Board of Trade rules and in Lloyd's rules now in force, regulating the construction of steam-boilers. It also forms the basis of the Philadelphia steam-boiler inspection ordinance, first formulated in 1882.

Referring now to those rules only which relate to the proportions of the longitudinal joints of the cylindrical shells of boilers, we are prepared to say they may be most conveniently presented by the following notation and formulæ:

A = Percentage of punched plate to the solid plate.
B = Percentage of driven rivet section to the solid plate.
C = The pressure in lbs. per square inch which the boiler is allowed to carry.
a = Area of driven rivet, or rivet-hole.
d = Diameter of rivet-hole.
n = Number of rows of rivets.
p = Pitch of rivets.
t = Thickness of plates.
R = Radius of boiler shell.
S = Ultimate shearing strength of rivets in lbs. per square inch of section.
T = Ultimate tensile strength of plates in lbs. per square inch of section.
f = Factor of safety.
E = Limit of elasticity in the plates in lbs. per square inch.
$\%$ = Percentage of joint strength.

The least of A or B should be inserted in the formula for finding C. All dimensions are in inches. The notation and the formulæ mutually explain each other.

$$A = \frac{p - d}{p} \quad . \quad . \quad . \quad . \quad . \quad (1),$$

$$B = \frac{a\ n}{p\ t} \quad . \quad . \quad . \quad . \quad . \quad (2),$$

$$C = \frac{t\ (A \text{ or } B)\ T}{5\ R} \quad . \quad . \quad (3).$$

These formulæ are intended exclusively for the guidance of the inspector in ascertaining the exact strength of the joints in the boilers which come under his care, and which enable him to determine the working pressure of steam allowable under the rules. They do not, however, enable the boiler-maker to determine directly that proportion of pitch which he should use with any given plate thickness and rivet diameter, in order to secure the strongest joint and which will also pass the highest inspection. To secure these results, the following simple formulæ were devised by the writer (early in 1882), in which the notation given above is similarly employed, and which may be thus expressed. For single riveted joints, when iron plates are secured by iron rivets and when the plate thickness and rivet diameter are given, it is desired to find a pitch that will secure equality of plate and rivet section — the formulæ will be:

$$p = \frac{a}{t} + d \quad . \quad . \quad . \quad . \quad . \quad . \quad (4).$$

This plainly means that the pitch is equal to the area of the rivet hole, divided by the thickness of the plate, and to the result of which the diameter of the rivet hole must be added.

For multiple riveted joints, when iron plates are secured by iron rivets, the same formula is used with the addition only of n, representing the number of rows of rivets, thus.

$$p = \frac{n\ a}{t} + d \quad . \quad . \quad . \quad . \quad (5).$$

The different resisting power of equal areas of section, as many times found by tests of the shearing stress of the rivets and the tensile stress of the plates, is not taken into account in the make-up of these rules. They are treated in all cases as equals under the strains of continued use. That is to say — The Philadelphia Boiler Ordinance and the English rules alike impliedly declare : The shearing strength of the rivets is just equal to the tensional strength of the plates per square inch of area in boilers made of iron plates and iron rivets.

If any one takes exception to this treatment of the two strains, the formulæ permit him to introduce his own figures of difference into their make-up, by which he can get a result in accordance with his own belief ; but of the mathematical base embodied in the formulæ, we are sure.

For single and multiple riveted joints when steel plates are secured by iron or steel rivets, the relative resistance of the plates to tension and of the rivets to shear must be inserted in the formula. First, let us assume, as the rules for inspection have done and do in all cases, that, area for area subjected to stress and acting together, iron plates and iron rivets are equal in resistance. The best Staffordshire iron boiler plates will stand 48,000 lbs. tension per square inch of section ; but the Board of Trade and Lloyd's limit all best iron plates and rivets alike to 47,000 lbs. The Philadelphia Ordinance will pass iron plates which have shown on test a tension of 50,000 lbs. per square inch, but will allow no more whatever the plates may show, and will give full credit to a joint in which the driven rivets have equal section to the punched plates And yet we well know it to be a matter of fact that the shearing strength is less than the tensile strength of the same material. Mr. William H. Shock's experiments on American iron gave as a mean for single shear 41,033 lbs. per square inch, and 78,030 lbs. for double shear, these experiments being made upon iron bolts in a shearing device which did not include the uncertain element of friction by the rough surfaces of the plates when bound closely by the rivets of a riveted joint made in the usual way.

When iron rivets are used with steel plates they are accepted under the rules for just what they are worth under shear and no more. The English rules say: "Iron rivets in steel boilers should have a section of $\frac{13}{5}$ of the plate section." Steel rivets must be calculated from their actual strength to resist shearing ; and for these the fraction $\frac{28}{23}$ will express the larger area they must have to the plates with which they are used to make joints, simply because steel plates show an ultimate tensile strength of 28 tons, and steel rivets an ultimate shearing strength of 23 tons per square inch of section The old rules published by Fairbairn, and used by him and by many boiler-makers since, are obsolete now, in the light of the later method of proportioning joints and the laws which sanction their use, although he furnished the first material for the base upon which this law has been built. From an extended list of all iron single joints, proportioned on the principle of equality of sectional areas, the percentage of joint strength to the solid plate will reach to .64 and in double joints to .78 and be practically tight under pressures up to say 100 lbs. of steam per square inch — a material increase over the oft-quoted figures of .56 and .70 originated and recommended by Fairbairn.

If we accept the inspection laws referred to, assuming even results of the two strains, then rules 4 and 5 will find the proper pitches for boiler joints made of iron plates and iron rivets ; but in composite boiler shells, the introduction of symbols representing the actual powers of resistance of the components, will be necessary : we will then have for double or multiple joints :

$$p = \frac{n\ a\ S}{t\ T} + d \quad . \quad . \quad . \quad . \quad (6),$$

which can be applied also to an all-iron joint or to joints made of other materials than the usual iron and steel. If we desire to find the pitch of the rivets, when the rivet diameter and a certain percentage of joint strength are given, we may use the following formula:

$$p = \frac{d \times \%}{(100 - \%)} + d \quad . \quad . \quad . \quad . \quad (7).$$

This does not include the thickness of the plates; it relates only to the proportion existing between the distance from center to center of the rivet holes and the space between the holes.

Other convenient formulæ are readily obtained from A, B, and C, by transposition; as, for instance, if it is desired to know the shear to which the rivets are exposed in any particular case after all the elements have been obtained — the formula will take this shape:

$$Shear = \frac{C \times R \times f}{t \times B}, \quad . \quad . \quad . \quad . \quad (8),$$

and will give the lbs. per square inch of cross-section to which the rivets are subjected in the seam by the steam pressure C, which has been obtained by the Ordinance formula.

The *rivet hole* determines the size and measure of the rivet after it is driven, because it is then filled by it; and in making calculations with the aid of these formulæ, the trade sizes of the rivets *must not* be taken. In punching holes for rivets in boiler plates, it is the usual practice to use punches $\frac{1}{16}$ of an inch greater in diameter than the trade diameter of the rivets, and it is also usual to make the dies which are used with the punches $\frac{1}{32}$ of an inch larger in diameter than the punches to be used with them. The result of this method is to make conical holes in the plates, corresponding to the sizes of punch and die. If the punched holes are net to the dimensions of the punch and die here given, and if the material of the plate immediately around the hole has not suffered in the act of punching, then the proper size of holes to be used in the formula would be the *mean* diameter of the conical holes so made, instead of $\frac{1}{16}''$ larger than the punch, as they are usually assumed to be. It is well known, however, that the material of the plates bordering the holes is weakened by the detrusion of the punch; to what distance this reaches from the surface of visible separation of the metal may not be definitely known, and must necessarily be different with different materials and punches — but it is certain to be a small measurable distance into the plate around the hole. If we take the diameter of the punched holes to be equal to that of the die, we will not be far from the actual state of the case, especially as some of this disturbed metal is removed by the reamer or crushed by the drift-pin. We are safe in this assumption in so far as the ultimate strength of the joint is concerned, because, as usually happens in rupture, the plates give way, while the rivets rarely fail; and again, the plates suffer loss of substance by wear and waste, while the rivets are preserved against deterioration, and therefore the initial strength of the plates ought to be favored.

In view of these facts, the suggestion is here made that when we wish to determine pitches from given plates and rivets, that we use the *greater diameter* of the punched hole, whatever that may be, for the quantity expressed by a in all of these formulæ, and that we assume the rivet diameter to be that of the lesser diameter, or reamed-out diameter of the rivet-hole. The result of this apportionment of the material will be effectively to strengthen the plates, which all experience has proven to be necessary; so that while this decision appears to be against reason and the isolated facts of experiment — the resistance to shearing always proving less than that to direct tension in the same material — it must be constantly borne in mind that the strain on the plates and rivets are not *direct* in the ordinary lap-joint as they are used in a boiler, the plates being subjected to some transverse strain while under tension, and the rivets to some tensile strain while under shear. Strictly speaking, the plate loses what is punched out of it, together with the metal destroyed around the punched hole, and the rivet gains by whatever increased diameter it gets in the process of riveting. They should be estimated upon what they actually are when the joint is made up.

The Ocean Greyhounds.

After the remarkable passage of the peerless *City of Paris*, noticed in our last issue, the officers of the Cunard steamer *Etruria*, whose record had previously been the best, had something to say about the trip. It was stated that a correct figuring of the time allowance for longitude, and of the actual time of the departure and arrival of the *City of Paris*, would show that the *Etruria's* best time was still two minutes less than that made by the *City of Paris*. The time given for the departure of the *City of Paris* from Queenstown, they say, was the time of her passing a point considerably outside the harbor, and it is further asserted that her officers do not know, surely, what time she arrived off Sandy Hook. It is claimed that she was not reported by the observer there, and that she was so much in the dark about her exact position that when the fog lifted, about 10 o'clock, she was off the Long Branch coast. The time fixed upon as that of her arrival at the Hook, they say, is calculated from data furnished by the pilot when he came aboard.

However these things may have been, the officers of the *Etruria* were for the most part willing to admit that the *City of Paris* can beat the record under favorable circumstances before the season ends; and a few days later the wisdom of their admission was proven. On her return trip to England the *City of Paris* passed Sandy Hook, outward bound, at 7.20 P.M., Wednesday, May 15th. She passed Brow Head on the following Tuesday at 10.15 P.M., and three hours later she arrived off Roche's Point, Queenstown, which is the point to which time is always taken in the ocean races. According to the official log the actual time from Sandy Hook to Roche's Point was 6 days and 29 minutes; but the early reports of the Maritime Exchange make it 6 days, 2 hours, and 4 minutes. There is evidently a mistake somewhere, but whichever is right, the record was beaten, for the fastest eastward passage ever made before was made by the Cunarder *Umbria*, whose record is 6 days, 2 hours, and 22 minutes.

Once arrived at Liverpool, the passengers were put on a special train and whisked off to London. They left New York on one Wednesday night and dined in London the next. Nobody ever did that before.

The runs for the several days were as follows: First day, 300 miles; second, 450; third, 463; fourth, 471; fifth, 470; sixth, 476; and the part of the seventh day, 264. The total is 2,894 miles, or 39 miles more than the distance passed over on her previous westward trip. The Inman people hint that they hope to reach 5 days, 12 hours on some trip when the *City of Paris* has gotten fairly at work, and when she has favorable weather; but 5 days and 12 hours is yet a long way off.

THE canal across the Isthmus of Corinth that was begun by the Romans, under Nero, is now being completed. It has been in process of construction for over 1700 years. When completed it will be four miles long and 26 feet deep, and will allow the passage of the largest vessels used in the Greek traffic. It does not amount to much from an international point of view, but it will be a great thing for Modern Greece.

Two well known clergymen missed their train, upon which one of them took out his watch, and finding it to blame for the mishap, said he would no longer have any faith in it.

"But," said the other, "isn't it a question, not of faith, but of works?"—*Living Church.*

The Locomotive.

HARTFORD, JULY, 1889.

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.

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UNDER the head of "Great Innovations of the Past Sixty Years," the first number of which appears in this issue, we propose to describe a few of the remarkable inventions and discoveries that have been made during that period. The railway system, the telegraph, the telephone, phonograph, electric light, and other equally well known inventions, we shall not touch upon, because excellent accounts of their history and workings may be found in books that are accessible to all. We shall treat only of achievements that are less known to the public in general.

MR. E. J. MURPHY, who has for the past nine years been connected with The Colt Patent Fire Arms Manufacturing Company as mechanical engineer, has lately been employed by the Hartford Steam Boiler Inspection & Insurance Company. He will occupy the position of mechanical and consulting engineer. Mr. Murphy has had a wide experience in steam engineering. He was chief draughtsman of the Woodruff & Beach Iron Works from 1855 until the dissolution of that firm. He was then appointed secretary and treasurer of the Hartford Foundry & Machine Company, and subsequently filled the position of president and superintendent of the Hartford City Water Works. His experience and abilities will be valuable in his new position.

IN examining a boiler recently, that was offered us for inspection and insurance, we found the following state of things: The fire line extended above the water line, the back head was insufficiently braced, and there was a stop-valve between the boiler and the safety-valve. Of course we directed that the fire-lines be lowered to the top of the tubes, that the back head be covered above the tubes, and that the stop-valve be removed, or else that the safety-valve be put directly in the dome. It was also directed that three additional braces be put in on the back head, and it was advised that the feed-pipe be changed to the top so that the inflowing water might not chill the shell, and that the blow-off be inserted on the bottom of the shell instead of through the head as at present. We meet with all of these defects very often, but it is rare that so many of them are found at the same time in one boiler. This boiler is in a planing mill. It is comparatively new, and is fired with shavings.

OUR readers are doubtless all familiar with the shocking disaster at Johnstown last month. No such calamity ever befel us before, though there have been several equally destructive floods in China in recent years. We are not yet well enough acquainted with China to have any very warm sympathy for her subjects in their adversity, but when the waters sweep away ten thousand of our own citizens we are appalled. After the news of the disaster was received, it was particularly gratifying to see the readiness and the generosity with which contributions for the relief of the sufferers were made. In Pittsburgh alone a quarter of a million of dollars was subscribed within 24 hours; and similar amounts came from other cities. The American public is warm-hearted and sympathetic: of this fact it has furnished abundant and magnificent proof.

The Royal Society Soiree.

On Wednesday, May 8th, the customary annual conversazione was given by the President of the Royal Society. These conversaziones are very swell affairs. A young man, now living in Massachusetts, was over in London a few years ago, and learning that he was just in time to attend one of them, he sought vainly for a card of admission. Failing in his effort to secure one, he wrote a note to Tyndall explaining his difficulty and asking if something could not be done. Tyndall replied very courteously, inclosing two cards of invitation, and stating that it gave him great pleasure to afford one of his American friends an opportunity of attending Now the young man in question had bought him a dress suit shortly before, and as he was soon to return to this country he wanted to be able to swear that he had worn it. So with some hesitation he put it on. "I shall be out of place," he thought : "I shall be conspicuous ; but I have got to wear this suit some time or other before I quit England, and I don't see any better time than now." Well, he was ushered into a room blazing with light and filled with the cream of English scientific society, all arrayed in spotless evening dress. The elegance of the affair astounded him.

As usual on such occasions, a large number of objects of special scientific interest were exhibited. A magnificent collection of instantaneous photographs illustrative of the various phases of animal locomotion were shown on the screen by an electric lantern, and were witnessed by a large and distinguished audience. They were taken by Mr. Eadweard Muybridge in the course of his elaborate researches on the subject. Mr. E. S. Bruce showed an ingenious method of illustrating the persistence of images on the retina of the eye. He caused a whitened lath to rotate rapidly so that it took the appearance of a round, fixed white screen. He then projected pictures on this screen by means of a lantern in the ordinary way, and the effect was as if a transparent, filmy image was suspended in the air. As objects could also be distinctly seen through the revolving lath, the pictures shown on it are said to be peculiarly ghost-like. Mr. C. V. Boys exhibited a very delicate and interesting piece of apparatus, designed to show the force of gravitation between two pieces of lead. Many other interesting things were shown, and the meeting was a great success.

A Cincinnati Explosion.

[FROM THE LOCOMOTIVE'S CINCINNATI CORRESPONDENT.]

A boiler explosion -- or, more correctly, a rupture — occurred in this city about noon on May 23d. The boiler did not move from its setting, nor was any person injured by escaping steam, although the boiler was running under sixty pounds pressure at the time. It was run in conjunction with an adjoining boiler, *and the only connection between the two* was a single pipe running from one steam dome to the other. This pipe has a stop-valve, so that if necessary one boiler can be operated alone. The engineer closed this valve when the accident occurred, so that the machinery in the building was stopped only a few moments.

Any person examining the ruptured boiler with the great buckle in the two fire sheets must wonder why the boiler did not move out and carry along everything that is harnessed to it. Had it done this, great loss of life would have been inevitable, and the property loss would probably have been from $30,000 to $40,000.

The boiler has six flues, and there is every evidence that the water line was about opposite the middle of the lower flues at the moment of rupture. Float water-gauges are used on these boilers, and an examination showed that they were in good condition. They will, however, be discontinued. The float-gauge on the ruptured boiler was farthest from the engineer, and the other gauge was noticed more, and was relied upon to indicate the water-level in both boilers ; which is somewhat strange, considering the fact that the boilers were connected only as previously stated.

Good Work on the Railroads.

Public attention has been once more called to rivalry between English and American locomotives by the purchase of the compound English locomotive, *Dreadnaught*, by the Pennsyvania Railroad, from the London & Northern Railway Company. This locomotive is one of those with which such excellent time is made between London and Edinburgh, and it is proposed to made a thorough test of her on the Pennsylvania Company's tracks. She has three cylinders — a low-pressure one inside and two high-pressure ones outside,— and two pairs of unconnected driving wheels. In the place of the old-time link motion with eccentrics on the driving axle, she has a valve gear which takes its motion directly from the connecting rod. She is run by an English engineer, and a machinist is constantly in attendance to see that she has all the advantages that the road offers. On one occasion recently she made the seventy-three miles between Johnstown and Pittsburgh in three hours and thirty-three minutes (the usual time), loaded with an unusually heavy train.

According to Superintendent Pitcairn the *Dreadnaught* is doing very well, and the only difficulty thus far is that she does not start very quickly, especially on the heavy grades. This difficulty arises from the fact that in starting she can only make use of her high-pressure cylinders, as the low-pressure cylinder remains inactive until the high-pressure pistons have made a couple of strokes and supplied it with steam.

When in working order the *Dreadnaught* weighs 95,200 pounds, and her tender, when empty, weighs 27,000 pounds He driving wheels are 6 ft. 3 in. in diameter. Her outer cylinders are 14″ x 24″ and her inner cylinder is 30″ x 24″. She has taken a train weighing, with engine and tender, 464,000 pounds, up a grade of 70 feet to the mile, four and one quarter miles long, at the rate of 33 miles an hour. She has pulled a train weighing 544,000 pounds from Euston to Crewe, 158 miles, in 3 hours and 34 minutes, including stops, or at the rate of 44.3 miles an hour. Leaving out stoppages this corresponds to 46 miles an hour, which is excellent for a train of that weight. The *Dreadnaught* evaporates 9¼ pounds of water per pound of coal, and, with ordinary loads, her average coal consumption per mile, we understand, has been 29 pounds, against about 37 pounds consumed by the ordinary locomotives of the Pennsylvania Company when doing the same work.

While we are speaking of railroads and locomotives, it will be interesting to examine some of the remarkable runs in this country and in England, and the conditions under which they are made. The best run in Great Britain, according to the *New York Sun*, is from London to Edinburgh, 400 miles, in 7 hours and 25 minutes actual running time, excluding stops, or about 53.6 miles an hour, average speed. This train, however, consisted of only four small cars, weighing 80 tons when loaded. Four American cars will weigh 108 tons when empty, and the engines used in this country are heavier also. Moreover, the grades and curves in England are much lighter than here. "When the construction of railroads was first begun in England," says the *Sun*, "George Stephenson, who produced the famous *Rocket*, advocated the expenditure of vast sums to make the road-beds straight and level, his object being to keep down the cost of operating. The ideal railway would be built on a perfectly direct and horizontal line, and to closely approach this model was Stephenson's desire. The Great Western road, from London to Liverpool, was made after his ideas, and the grades on it rise only four feet to the mile for most of the way. The Great Northern Railway, that on which the *Flying Scotchman* speeds along, is built with gradients of 1 in 200, or 26.4 feet to the mile. Heavy as these latter seem in comparison to the phenomenally light grades previously mentioned, they would be considered extremely easy in this country. As to curves, for many years an act of Parliament prevailed in England prohibiting the construction of any railroad curve with less than half a mile radius. On one of the great American trunk lines in the Alleghanies will be found curves of 400 feet radius, and it was in the devising of engines to pull trains rapidly over such lines as that that American ingenuity succeeded in producing a type of locomotive that for general excellence is unequaled anywhere else in the world."

Although England has unquestionably the fastest long-distance trains in the world, it is interesting to note a few of the runs that we make in this country, under the disadvantages above pointed out. The Baltimore & Ohio Railroad runs a train from Washington to Baltimore, 40 miles, in 43 minutes. This is at the rate of 55.8 miles an hour, which is pretty good speed, although it is not fair to compare it with the run from London to Edinburgh, as it is only one-tenth as long. One of the Baltimore & Ohio engines, with 69-inch drivers, and cylinders 19" x 24", has run a train of average weight from Locust Point, Baltimore, to Washington, 42½ miles, in 40 minutes, including one stop. This is at a through rate of 64.3 miles an hour.

In England the express trains and trains carrying the mails run at an average speed of 40 miles or more an hour, but accommodation trains run no faster than similar trains do here. A few of the regular runs in England are these: 105¼ miles in 1 hour 58 minutes, or 53½ miles an hour; 77¼ miles in 1 hour 27 minutes, or 53¼ miles per hour; 76 miles in 1 hour 27 minutes, or 52¾ miles per hour. In America the Pennsylvania limited runs from Jersey City to Trenton, 55¾ miles, in 64 minutes, or at an average speed of 52.3 miles an hour, which is about equal to the English runs just mentioned; and the train is much heavier.

Great Discoveries and Innovations of the Past Sixty Years.

I. The Spectroscope.

It has long been known that white light is a mixture of light of many colors, and that it may be split up into these constituent colors by means of a prism. Newton was the first man to declare the compound nature of white light, and he was also the first to give an explanation of the action of the prism. His explanation was, that in passing through the prism, the different component colors are deflected from a straight course in varying degrees, violet light being most turned aside and red the least, so that after emerging from the prism the colors follow different courses, and instead of all falling on the wall at the same spot and giving us the mixed sensation that we call white, they fall each on a different spot, and form a gorgeous band of color that we call a *spectrum*. Under certain conditions drops of rain act like prisms, and a spectrum is produced in the clouds by Nature. We call this natural spectrum a rainbow.

There are generally considered to be seven principal colors in the spectrum — red, orange, yellow, green, blue, indigo, and violet; but these merge into one another so gradually, and through such a delicate and uniform succession of tints, that in reality there is an infinite number of colors between the red at one extreme and the violet at the other.

The wonderful discovery on which the spectroscope is based was made by Wollaston in 1802. He found that when a ray of sunlight is let into a dark room through a very narrow slit, and then passed through a prism, the band of color is produced on the wall as before; but he noticed, what previous observers had not noticed, that a number of the tints are missing. So definitely and sharply marked are the gaps, that the spectrum looks as though some one had purposely drawn black lines across it. These lines are known as "Fraunhofer's lines," from Fraunhofer, a celebrated optician of Munich, who first studied them and gave a detailed description of them.

Fraunhofer counted, in the spectrum of sunlight, upwards of 600 of these dark lines Brewster counted 2,000, and Professor Rowland's beautiful photographs show many thousands. The lines are perfectly definite in position, and they are very constant. They are not distributed evenly throughout the spectrum, but occur grouped and scattered without the slightest perceptible trace of order. Some of them are very strongly marked, and others are so faint that they can be seen only with the best of apparatus, and under exceptional circumstances.

It was natural, when the existence of dark lines in the sun's spectrum had been proven, to examine the spectrum of other kinds of light. It was found that white-hot iron, and in fact, all white-hot solids with two rare exceptions, give a continuous spectrum without any dark lines. In examining the light of the stars it was found that similar lines are present, but that they are differently grouped. In the electric light *bright* lines were found, and various colored flames gave very brilliant bright lines, whose positions varied according to the substance that was used to give the flame its color.

These facts naturally suggested the theory that each substance is capable of producing lines peculiar to itself. Sir John Herschel, in 1822, remarked that certain substances, when volatilized in a gas flame, impart such characteristic colors to certain of the dark lines in the spectrum that they can readily be detected by this means; and in 1834, Mr. Fox Talbot suggested that if this optical method were developed, it would probably furnish a very delicate method of detecting substances which are present only in very small quantities. But it is to the labors of Messrs. Kirchhoff and Bunsen that we owe the present method of spectrum analysis. They showed that compounds of the same metal, when introduced into a flame, give rise to spectral lines that are constant in color and in position for each metal, but which vary in color, position, and number for different metals. And, lastly, they showed that this new method of analysis, known as "spectrum analysis," is of almost incredible delicacy. The millionth part of a *grain* of lime or strontia can easily be detected. Lithium, a metal that was found formerly in only four minerals, has been shown by the new method to be one of the most widely distributed elements. According to Roscoe, it exists in almost all rocks, in sea-water and river-water, in milk, in blood, and in muscular tissue; and the six-millionth part of a grain of it can be detected with certainty. Sodium, which forms the basis of common salt, is the most easily detected of all substances; for the *one-hundred and eighty-millionth part of a grain* of sodium makes itself distinctly visible.

The delicacy of the new method is still further illustrated by the following, quoted by Roscoe: Several persons who were to be operated on for cataract were caused to partake of lithia water containing, perhaps, twenty grains of carbonate of lithium. Three hours and a half afterward, when a portion of the lens of the eye was tested, a distinctly perceptible quantity of lithia was found in it. "It was thus seen that in the human body twenty grains of carbonate of lithium will, in three hours and a half, penetrate through every part of the body, and be capable of detection even in each particle of the lens of the eye."

It will readily be believed, after what has been said, that spectrum analysis has shown the existence of numerous elements that we formerly knew nothing at all about. About 30 years ago, Professor Bunsen, in examining the alkalies left from the evaporation of a large quantity of water from a certain mineral spring, noticed in his spectroscope some bright lines that he had never seen before, and which he at once concluded were due to some new substance. He proceeded to evaporate some more water, in the hope of being able to procure some of the new substance for more detailed examination; but he was obliged to evaporate no less than forty-four tons of water before he obtained 200 grains of it. He then found that it was not a simple substance, but consisted of a mixture of the chlorides of *two* new metals, which are now known by the names "cæsium" and "rubidium." Several other elements have since been added to the list in a similar manner. Thallium, discovered by William Crookes, and gallium, discovered by Lecoq de Boisbaudran, are perhaps the best known of them. Indium, discovered by Reich and Richter, is also comparatively well known, and its properties have been fairly well investigated. There are a host of other claimants for admission among the generally accepted list of elements — gnomium, one of the most recent, having already been mentioned in this paper — but chemists are very conservative on the subject of elements, and as most of the alleged new substances are very rare, there is some difficulty in finding out whether their claims are good or not.

One of the most beautiful applications of spectrum analysis, is to the determination of the composition of the sun and the stars, for, by the optical method, we do not need to have the substance to be analyzed near by us, and it is a great deal more comfortable, for instance, to analyze the sun from our present distance of 95,000,000 miles, than it would be to analyze him at close quarters. Kirchhoff showed that the sun contains iron, calcium, magnesium, sodium, chromium, nickel, barium, copper, zinc, and possibly cobalt. Angström and Thalen added hydrogen, manganese, aluminum, and titanium, to the list, and Lockyer added cobalt, lead, cadmium, potassium, cerium, strontium, uranium, vanadium, and probably lithium, rubidium, cæsium, tin, bismuth, and silver. There are, therefore, twenty-seven of our known elements present in the sun, and the others are very likely there, only in such a condition that we have not yet recognized them. In the stars, also, some of our familiar terrestrial substances have been found, and the sudden flashes of light that take place among the stars sometimes giving us "new stars" as we call them, have been found to be due to outbursts of white-hot hydrogen gas.

But the spectroscope has other applications in astronomy besides celestial analysis. It enables us to judge of the speed with which the stars are approaching us or receding from us. Many of our readers have probably noticed the sudden lowering in pitch of the sound given out by the bell of a locomotive that passes rapidly by. When the train is approaching the pitch of the bell seems slightly higher than it is in reality, and when the train is receding the pitch seems lower than it is. This is known as "Doppler's principle," and it is true of light as well as sound. When a star is approaching us the light waves that we receive from it come to us a little more rapidly than they would if the star was still, and this causes each ray of the light to be a little more refracted by the prism in the spectroscope. Thus the lines in the spectrum of a star all appear to be shifted slightly toward the blue or toward the red according as that star is approaching us or receding; and the amount by which the sodium lines, for example, are displaced from the position they would have if the star was still, gives us a measure of the velocity of the star's motion in miles per second; and this measurement can be made equally well whether we know the distance of the star, or whether it is buried in unfathomable depths of space. Thus it has been ascertained that Sirius is receding from the sun with a velocity of 18 to 22 miles per second, and Castor with a velocity of 23 to 28 miles per second, while most of the stars of the great dipper are receding at from 17 to 21 miles a second. On the other hand, Arcturus is approaching with a speed of 55 miles per second, Vega is approaching at the rate of 44 to 54 miles, *a Cygni* at 39 miles, Pollux at 49 miles, and *a Ursæ Majoris* at from 46 to 60.

Not the least interesting of the discoveries of the spectroscope is one made on our little neighboring world across the way, Mars. We knew long ago, that there was a liquid of some kind on Mars, for we could see fields of snow and ice, and masses of clouds, but it was left for the spectroscope to show that that liquid is really water, such as we have here.

Lastly, the spectroscope has opened up before us a vast amount of information concerning the structure and nature of matter, the only trouble being, that thus far no man has been found who is wise enough to understand what the spectroscope is trying to tell. There must be some reason in the nature of things, why each substance gives certain lines, particular lines peculiar to itself. Many of the lines that were at first thought to be single, have been found to be double or triple, or even to consist of a multitude of delicate parallel lines. Thus the line in the orange-yellow, due to sodium, is easily resolved into two parallel, equal lines. (The writer has seen these two lines so well separated in the spectrum of the sun that he could distinguish *nine* other exceedingly faint lines between them.) With care many other lines in the sodium spectrum can be seen, and in every instance they are double. The calcium spectrum contains many very beautiful triple lines, and the spectrum of nitrogen consists of a succession of lines distributed at very nearly uniform distances. Many physicists have attempted to explain the peculiar arrangement of the lines, but thus far they have met with very little success. It is plain to every one who has studied the subject that spectrum analysis is like a big storehouse, full of important discoveries, and before long we may find the key. Although the results of Wollaston's discovery are already marvelous, they are as nothing when compared with those that await us.

The Locomotive.

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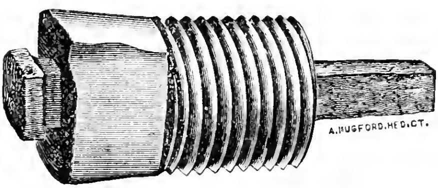
On Fusible Plugs.

The fusible plug is one of the most abused appliances to be met with around boiler rooms. It is so small, and in such an out-of-the-way position that there is great temptation to let it take care of itself. Again, it is so seldom heard from that a fireman who is not very watchful is liable to forget about it. Yet when it is properly cared for the fusible plug is a most important safeguard.

In the event of an explosion, too, it often furnishes valuable evidence concerning the immediate cause of the explosion. Thus, after the disastrous explosion at the Park Central Hotel in this city, described and illustrated in the March LOCOMOTIVE, the fusible plug was found intact; and by placing it in a retort and carefully ascertaining the melting point of the filling, it was easily shown that at the time of the explosion the water in the boiler was several inches over the tubes. That is, direct proof was obtained that the water in the boiler was not lower than it should have been.



The "fusible" plug illustrated in this number of the LOCOMOTIVE was found in a boiler in the South. The water in this boiler got low one day, and of course the fusible filling melted out and gave the alarm. The owner not having time to have it refilled, and not having another one on hand, drove a nail into it and went ahead as usual until the water got low a second time; when as the nail was not any more fusible than the boiler, both got red hot at the same time. Fortunately this caused such a leak around the nail that the escape of steam relieved the pressure somewhat, and the repairs cost only about seventy-five dollars. The boiler was 42 inches in diameter and eight feet long, with an internal flue used as a fire-box. The chances are that the owner will not drive any more nails into fusible plugs.

We remember another instance, in which the fireman had driven an iron rivet into the plug in a similar manner. When we remonstrated with him he answered: "By gar, she do be melting out all the time." We told him if he would be more watchful of his water-line that would not happen, but he insisted that the water had never been low since he had been fireman.

In Massachusetts the law concerning safety-plugs reads as follows: "No person shall manufacture, set up, use or cause to be used, a steam-boiler, unless it is provided with a fusible safety-plug, made of lead or some other equally fusible material, and of a diameter of not less than one half an inch, placed in the roof of the fire-box, when a fire-box is used, and in all cases in a part of the boiler fully exposed to the action of the fire, and as near the top of the water-line as any part of the fire-surface of the boiler. . . . Whoever without just and proper cause removes from a boiler the safety-plug thereof, or substitutes therefor any material more capable of resisting the action of the fire than the plug so removed, shall be punished by fine not exceeding one thousand dollars. Whoever manufactures, sets up, or knowingly uses or causes to be used for six consecutive days a steam-boiler unprovided with a safety fusible plug. . . . shall be punished by fine not exceeding one thousand dollars." And it seems to us that it would be wise to have similar laws in all the States.

When fusible alloys are used for filling safety-plugs it is found that their melting point is often considerably raised by long exposure to the heat. The exact cause of this rise in the melting point does not appear to be clearly known. It has been suggested that the metals composing the alloy are gradually separated or crystallized out from one another by the prolonged action of heat. However this may be, it is certain that pure Banca tin is a much more reliable material to use for filling. As tin is an element its melting point remains constant, and it is low enough — 420° Fah. — to adapt it perfectly for use in fusible plugs.

In order to prevent delay, in case a plug should melt out, all owners of boilers should see to it that extra ones are constantly kept on hand so that they can be put in place at short notice.

Inspectors' Reports.

JUNE, 1889.

During this month our inspectors made 4,695 inspection trips, visited 9,302 boilers, inspected 3,946 both internally and externally, and subjected 618 to hydrostatic pressure. The whole number of defects reported reached 8,332, of which 700 were considered dangerous; 26 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	499	20
Cases of incrustation and scale,	776	32
Cases of internal grooving,	55	6
Cases of internal corrosion,	323	24
Cases of external corrosion,	738	44
Broken and loose braces and stays,	62	13
Settings defective,	176	16
Furnaces out of shape,	376	11
Fractured plates,	189	89
Burned plates,	116	25
Blistered plates,	240	21
Cases of defective riveting,	2,129	103
Defective heads,	55	23
Serious leakage around tube ends,	1,457	103
Serious leakage at seams,	401	67
Defective water-gauges,	126	12
Defective blow-offs,	62	24
Cases of deficiency of water,	8	5
Safety-valves overloaded,	45	12
Safety-valves defective in construction,	38	11
Pressure-gauges defective,	340	35
Boilers without pressure-gauges,	6	3
Unclassified defects,	115	1
Total,	8,332	700

Boiler Explosions.

JUNE, 1889.

LARD REFINERY (71). — A distressing accident occurred on June 6th, at the N. K. Fairbanks & Co's lard refinery, Hutchinson, Kan., by which three men were severely injured. The works were preparing to draw off the first lard refined at this place, and while General Manager J. L. Woods, together with George D. Lewis, superintendent of the St. Louis works, and John Garvin, a steam-fitter, were testing the heat of a steam lard vat, a terrible explosion occurred. The three men were standing directly over the vat, and were thrown to the ceiling above. Mr. Woods was slightly cut, and was scalded from head to feet and is in a very dangerous condition. Superintendent Lewis fared the worst of the three, for in addition to being scalded in a most horrible manner he sustained a compound fracture of the ankle, and received two severe scalp wounds. Garvin was also terribly scalded. Physicians are doing everything to relieve the sufferers, but as yet are in doubt as to the recovery of Mr. Lewis. The others will get well.

IRON-WORKS (72). — At Youngstown, Ohio, on June 10th, the mud drum in a boiler at the sheet mill of the Mahoning Valley Iron Company, which is located between the nail plate mill and the blast furnace, gave way, causing the boiler to explode and badly wrecking four other boilers in the battery. Joseph Robinson, the fireman, was instantly killed. He was thrown about 15 feet, and two large boilers were lodged across his body. The remains were badly mutilated. Robinson had gone on duty ten minutes before the accident occurred. He leaves a wife and one child. William Edwards, the engineer, was injured by inhaling the escaping steam from the boilers. John McPherson was badly scalded on the back by hot water, but both will recover. After the explosion the coal bin took fire and the fire department was called and extinguished the flames, preventing what might have been a serious conflagration. After the fire had been extinguished the blast furnace, which was about ready to run off its molten iron, broke out at the bottom, and after much difficulty the fire department and mill employés succeeded in stopping the flow, and putting the fire out. The works will be idle for some time.

SAW-MILL (73). — The boiler of a saw-mill situated on Loss Creek, five miles west of Middletown, Mo., exploded on June 11th, completely demolishing the building and machinery. There were three men at work at the mill at the time, and all received injuries. Ben. Ogden, the proprietor, received a bad gash in the face, and another back of his ear. Joe Scotlander, a workman, had one leg broken and his back and head scalded. Another workman by the name of Moran was badly scalded on the hands and face, and was deeply gashed in the leg. The force of the explosion threw the engine some 60 yards away, over a wagon and team standing near. The engine and entire machinery are a total wreck.

EXPERIMENTAL BOILER (74). — Harry and William Jesser, 15 and 17 years old respectively, were killed in Philadelphia on June 22d, by the explosion of an old range boiler, with which they were experimenting. They had connected it by lead pipe with a small engine, and were preparing to turn the crank of the family ice-cream freezer by steam power, when the boiler blew up with a tremendous report. Harry was thrown with great force against a fence and instantly killed. His legs and arms were broken and one side of his head was horribly crushed. William was thrown under a shed, and a flying brick evidently struck him in the head, fracturing the skull. Both his legs were frightfully crushed. He was taken to the Pennsylvania Hospital, where he died in about an hour. Little Henry Kniese, who was watching the experiment from a shed, was cut under the eye, and Mrs. Flora Kniese was badly scalded about the back.

BREWERY (75). — At midnight on June 24th, a large horizontal tubular boiler exploded in the brewery of George Renner, Jr.. Youngstown, Ohio, tearing the greater part of the plant to pieces, and shattering the windows in all the surrounding buildings. Charles Richter, the engineer, aged 50, was instantly killed, his face being mashed into a pulp, and his body frightfully mutilated. Carl Stalter, Michael Kelly, and Thomas Reynolds, who were in the building at the time, were injured and taken to the hospital. It is reported that two other men are in the debris, and the bodies have not been recovered. The wreck took fire from the explosion. The loss is estimated at $50,000. A son of Mr. Renner left the building five minutes before the explosion, and thus escaped.

The Prevention of Consumption.

Drs. Prudden, Biggs, and Loomis having now presented their report on tuberculosis to the Board of Health of New York City, it remains to be seen what action will be taken on it. This report was prepared at the express request of the Board, and it is to be hoped that some action may be taken that will ultimately lessen the ravages of this terrible disease. There is no other disease to which mankind is heir that is so widespread or that claims so many victims. "Cholera, yellow-fever, and small-pox — diseases that paralyze with fright entire countries — are exceedingly limited in their results," says *Science*, "in comparison with the slaughter of consumption. Last year Florida was panic stricken from the havoc of yellow-fever; but during the same year consumption destroyed more than twice as many lives in the little State of New Hampshire, and not a tremor ran through the body corporate. The average annual death-rate in this country, from cholera, yellow-fever, small-pox, typhoid-fever, diphtheria, and scarlet-fever, all combined, does not reach the enormous total of deaths from consumption. It is time that some determined and systematic effort be made to lessen this disease, which is now regarded by so many as preventable. Among the general sources of infection there is one, at least, that should be removed, or, if not wholly removed, greatly lessened by legal action, and that is the sale of tuberculous food-products. Such foods, chiefly in the form of tuberculous meat and milk, particularly the latter, are undoubtedly extensively sold to unsuspecting consumers; and that the results are not infrequently lamentable, no sanitarian doubts."

We are well aware that it is quite the fashion in these days to annoy the public with stories of germs and bacilli, and we realize that if any one were to heed the innumerable injunctions that are published every few days concerning what he should eat and drink, how his food should be cooked, and the manner in which he should live in order to escape inoculation by the germs of dreadful diseases, this world would be a very uncomfortable place. We have no desire to add to this kind of literature; but, seriously, is it not proper, now that we know something about the worst disease to which we are liable, that we should take some elementary precautions against it? Listen to what the eminent doctors say in their report: "The disease known as tuberculosis, and, when affecting the lungs, as pulmonary tuberculosis (consumption), is very common in the human being, and in certain of the domestic animals, especially cattle. About one-fourth of all deaths occurring in the human being during adult life are caused by it, and nearly one-half of the entire population at some time in life acquires it. The disease is of the same nature in animals and in man, and has the same cause. It has been proved beyond a doubt that a living germ, called the 'tubercle bacillus,' is the cause, and the only cause, of tuberculosis. It does not seem necessary to state the facts upon which this assertion is based, for the observation first made by Robert Koch in 1882 has been confirmed so often and so completely that it now constitutes one of the most absolutely demonstrated facts in medicine. Tuberculosis may affect any organ of the body, but most frequently it first involves the lungs. When the living germs find their way into the body they multiply there, if favorable conditions for their growth exist, and produce small new growths or tubercles. The discharges from the tubercles, containing the living germs, are thrown off from the body. In consumption these discharges constitute part of the expectoration. The germs thus thrown off do not grow outside the living human or animal body, except under artificial conditions, though they may retain their vitality and virulence for long periods of time, even when thoroughly dried. As tuberculosis can only result from the action of these germs, it follows, from what has just been said, that when the disease is acquired it must result from receiving into the body the living germs that have come from some other human being, or from some animal affected with the disease. It has been abundantly established that the disease may be transmitted by meat or milk from the tubercular animal. Boiling the milk, or thoroughly cooking the meat, destroys the germs.

"Although the meat and milk from the tubercular animals constitute actual and important sources of danger, the disease is acquired, as a rule, through its communication from man to man. Consumption is commonly produced by breathing air in which the living germs are suspended as dust. The material which is coughed up by persons suffering from consumption contains these germs, often in enormous numbers. It lodges frequently on the streets, floors, carpets, clothing, handkerchiefs, etc., and after drying it is very apt to become pulverized and float in the air as dust. It is plain, therefore, and it has been proven by direct experiments, that where there are cases of consumption, under ordinary conditions the dust surrounding them often contain the 'tubercle bacilli,' and persons inhaling the air in which this dust is suspended may be taking in the living germs. It should, however, be distinctly understood that the breath of tubercular patients, and the moist sputum, received in proper cups, are not elements of danger, but only the dried and pulverized sputum. The breath and moist sputum are free from danger, because the germs are not dislodged from moist surfaces by drafts of air. If all discharges were destroyed at the time of exit from the body, the greatest danger of communication from man to man would be removed.

"The question of preventing consumption, therefore, resolves itself principally into the avoidance of tubercular meat and milk and the destruction of the discharges, especially of the sputum. As to the first means of communication, those measures of prevention alone answer the requirements which embrace the governmental inspection of dairy cows and of animals slaughtered for food, and the rigid exclusion and destruction of all those found to be tuberculous. For the removal of the second means of communication, *i. e.*, the sputum of consumptive persons, the problem is simple when the patients are confined to their rooms or houses. Then wooden or pasteboard cups, with covers, should always be at hand for the reception of the sputum. At least once a day, and oftener if necessary, these cups should be thrown with their contents into the fire. A cheap and efficient cup for this purpose is now on the market, and is supplied by the druggists. The disposition of the expectoration of persons who are not confined to their rooms or homes is a far more difficult problem. The expectoration certainly should not be discharged on the street, and the only practicable means for its collection seems to be in handkerchiefs, which, when soiled, should at the earliest possible moment be soaked in a five per cent. solution of carbolic acid, and then boiled and washed. Handkerchiefs thus soiled are exceedingly dangerous factors in distributing the bacilli; for, when the sputum becomes dry, it is easily separated in flakes from the cloth, and then soon becomes pulverized and suspended as dust.

"It becomes evident from what has been said that the means which will most certainly prevent the spread of this disease from one individual to another are those of scrupulous cleanliness regarding the sputum. These means lie largely within the power of the affected individual. It is further to be remembered that consumption is not always, as was formerly supposed, a fatal disease, but that it is in very many cases a distinctly curable affection: and an individual who is well on the road to recovery may, if he does not with the greatest care destroy his sputum, *greatly diminish his chances of recovery by self-inoculation.*"

It must be admitted that matter of this kind does not afford very agreeable reading, but we have given a very full abstract of the report because the subject, even if not pleasant, is of the highest possible importance. When once the principles advocated in this report are fully understood by the public, it ought not to be very difficult to rid ourselves to a great extent of this most terrible disease: for the preventives that the learned doctors have suggested are simple enough for any of us to put into operation, if we have friends or relatives so unfortunate as to be stricken.

If we could only make a beginning in this matter, in a few years the number of afflicted ones would be so much lessened that the subsequent control of the disease would be comparatively easy. We can hardly hope to exterminate it entirely, as we have exterminated small-pox, but we can certainly take a long step in that direction if we will all take hold together.

Bracing Boiler Heads.

The accompanying tables will greatly facilitate the calculation of the number of braces required in a boiler that is to run under any given pressure. They contain the results of our experience on the subject, and can be relied upon to give perfectly satisfactory results.

It has been shown by direct experiment that the tubes possess sufficient holding power to amply stay the part of the head to which they are attached, and we may safely consider that they will also possess sufficient staying power to take care of the head for say two inches above their upper surfaces. The flanges of the heads being securely united to the shell, and being also curved or dished, it may likewise be safely assumed that no braces need be provided for that part of the head which lies within three inches of the shell. The part to be braced, therefore, consists of a segment of a circle whose circumference lies three inches within the circle of the shell, and whose base is two inches above the upper row of tubes.

Thus in a 66-inch boiler, whose upper row of tubes is 26 inches below the top of the shell, the part of the head that requires bracing consists in a segment of a circle the diameter of which is 60 inches, and the height of which is 21 inches: 21 inches being the measured heighth (26 in.) minus the 3 inches that lies between the shell and the segment to be braced, and minus the two inches that lies between this segment and the top of the tubes. The area of such a segment is easily found by means of the table given in the LOCOMOTIVE for December, 1886, on p. 184. Thus 21÷60=.350 and opposite .350 in the table we find 0.24498. Then 60×60×0.24498=882 square inches, the area in question.

TABLE I. AREAS TO BE BRACED (SQUARE INCHES).

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

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

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

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

Height from Tubes to Shell.	Diameter of Boiler in Inches.							Height from Tubes to Shell.
	36″	42″	48″	54″	60″	66″	72″	
15″	3.5							15″
16	4 0							16
17	4.5	5.0						17
18		5.6	6.2	6.7				18
19		6.2	6.9	7.5				19
20		6.8	7.5	8.2	8.9			20
21			8 2	9.0	9.6			21
22			8.9	9.8	10.5			22
23				10.5	11.3	12.1		23
24				11.3	12.2	13.1		24
25				12.1	13.1	14.0		25
26				12.9	14.0	15.0	15.9	26
27				13.7	14.9	16 0	16.9	27
28					15.8	16.9	18.0	28
29					16.7	17.9	19.1	29
30					17.6	18.9	20.2	30
31						19.9	21.3	31
32						21.0	22.4	32
33							23 5	33
34							24.6	34

Table II will be found of more practical use than Table I, for it gives directly the number of braces required in any given boiler, instead of the area to be braced. It was calculated from Table I. The iron used in braces will safely stand a continuous pull of 7,500 lbs. to the square inch, which is the figure used in designing braces in this office. A round brace an inch in diameter has a sectional area of .7854 of an inch, and the strain that it will safely withstand is found by multiplying .7854 by 7,500, which gives 5,890 lbs. as the safe working strain on a brace of one-inch round iron.

In a 60-inch boiler, whose upper tubes are 28 inches below the shell, the area to be braced is, according to Table I, 930 square inches. If the pressure at which it is to be run is 100 lbs. to the square inch, the entire pressure on the area to be braced will be 93,000 lbs., and this is the strain that must be withstood by the braces. As one brace of inch round iron will safely stand 5,890 lbs., the boiler will need as many braces as 5,890 is contained in 93,000, which is 15.8. That is, 16 braces will be required. The table is made out on the basis of 100 lbs. pressure to the square inch, because that is a very convenient number to calculate from. If the actual pressure in the foregoing example was only 60 pounds instead of 100, only six-tenths as many braces would be required: six-tenths of 15.8 is 9.48, which we will call 10 in order to be on the safe side. In this way Table II was calculated: *i. e.*, by multiplying each number in Table I by 100 and dividing by 5,890.

As an example in the use of Table II let us take the following: How many braces of inch round iron are required to stay the head of a 72-inch boiler, the distance from the top of the shell down to the tubes being 29½ inches, and the allowable pressure being 75 lbs? *Ans.* Under 72 and opposite 29 we find 19.1; under 72 and opposite 30 we find 20.2. The difference between these is 1.1, half of which is .6, which being added to 19.1 gives 19.7, which is the number of braces that would be required if 100 lbs. were the allowable pressure. For a boiler on which only 75 lbs. are allowed, $\frac{75}{100}$ of this number of braces will be sufficient,— that is, $\frac{75}{100}$ (or three-quarters) of 19.7, which is 14 8. Hence 15 braces will be sufficient on a boiler of this size and design, running at a pressure not exceeding 75 lbs. to the square inch.

The Sahara.

Across the Atlantic, on the African Continent begins a series of deserts which extend with little interruption to the boundaries of China. The first of these is the greatest desert in the world, known under the name of Sahara or Zahara. The Arabian geographers were the first to apply the name. These writers also called it Sahara-belama, or the "waterless waste," or Sahara-ul-aski, the "complete waste." Beginning at the Atlantic Ocean, this desert extends eastward for a distance of 3,100 miles, broken only by the oases formed by the Nile, and reaching to the Red Sea. The average width is six hundred miles, so that it is equal in area to two-thirds of Europe. It has but one season, that of summer, burning and merciless. While the mean altitude is estimated at two thousand feet, there is one part near the northern boundary one hundred and sixty-five feet below the level of the Mediterranean, and other places on the south and east where the ground rises into plateaux and mountains of sandstone and granite, reaching an elevation of six thousand feet and more. In the center stands the mountain Djebel-Hoggar, the top of which is covered with snow three months of the year, while from December to March its sides are furrowed by streams which flow some distance and are lost in the sand. This group of mountains forms the dividing line between the eastern desert, or Sahara proper, and the western portion, known as the Sahel. "The Sahel," says Reclus, "is very sandy. Throughout the greater part of its extent the soil is composed of gravel and large-grained sand, which does not give way even under the foot of the camel." Sometimes it forms hills heavy enough to resist the action of the wind, but in other cases it is so fine and small that the constantly blowing trade winds carry it in clouds to the southwest, encroaching upon the channels of the Niger and Senegal, and driving them from their courses. At the west it also encroaches upon the ocean, forming such extensive banks that the Arabs who go to collect the waifs and strays from wrecked vessels can safely venture out several miles from shore. It is also stated that at times the sand so fills the air several miles out at sea that the weather seems hazy. Parts of the desert on the east are sandy also, but the main portion is occupied by plateaux of rock or clay, or groups of mountains.

Scattered in long lines over the desert are numbers of oases, little tracts of land watered by springs of water which gush out of the ground or descend from some groups of mountains. Here date palms, apricots, peaches, and other fruits ripen, and caravans stop for rest and refreshment. Every speck of space is utilized, the huts being built on the most unproductive spots. Date palms supply the greater part of the food of men, camels, horses, and dogs.

Immense tracts exist where these oases are not found. Here the path taken by the caravan follows a straight line to its destination. Sometimes the faint foot marks are covered with sand, and then the compass, an occasional hill, a bush, and often a heap of bones indicates the way. Vegetation is rare. Those plants that exist at all are spiny or aromatic. Wormwood, thistles, and the thorny mimosa are the principal kinds. Ants, scorpions, lizards, and vipers constitute the animal life. Flies accompany the caravan for a few days, but are soon killed by the heat, and even the flea finds it impossible to exist. Radiation from the white or red sand dazzles the eye, and all nature looks somber. The mirage displays cities, palaces, groves of palms, lakes and streams of water with a vividness scarcely to be credited. When the wind blows, the face and body are beaten by grains of sand which prick like needles. The wells scattered over the desert are sometimes good, sometimes bad, generally the latter. Sometimes the wells fail or are missed by the guides, and then each drop of water is guarded as a jewel of untold price.

Although terrible stories are told of whole caravans and whole armies being overwhelmed by the sand, and though the bleaching bones of men and camels often line the track of caravans for miles, generally speaking companies led by experienced guides, and protected by treaties from the depredations of tribes through whose country they pass, arrive safely at their journey's end. They experience little suffering except that caused by the bad water, the excessive heat of the day, and the cold of night. The air being so entirely destitute of aqueous vapor causes excessive radiation from the soil as soon as night sets in, so that burning days are followed by cold nights. Not a year passes without ice forming on the ground, and white frosts are frequent. A difference of 129° Fah. has been observed between the lowest (24° Fah.) and the highest (153° Fah.) temperature, and the real difference between extremes of heat and cold is estimated at 144° Fah.

The eastern portion of the desert, known to the Arabs as the Atmoor, is the ideal desert. "This," says General Colston, "consists mainly of hard gravel plains, diversified by zones of deep sand, rocky ridges, sometimes of considerable altitude, and rugged defiles. It is absolutely destitute of all vegetation, and consequently of animal life. Only the ostrich and hyena cross it swiftly by night, and the vulture hovers over the caravans by day. Not a tree, not a bush, not a blade of grass, relieves the glare of the sunlight upon the yellow sand." "Within the limits of Egypt and the Soudan these desolate atmoors extend over three-quarters of a million of square miles, never trodden by the foot of man. Only a few caravan trails cross them in their narrowest part, with scanty wells at long intervals, and the necessities of trade can alone account for their being penetrated at all. They are like oceans, where caravans pass each other in haste, like vessels at sea. The marches are perfectly terrible, and yet it is worse to halt during the day than to keep in motion, for the heat makes sleep or rest impossible even under canvas. . . . The air that blows feels as if it had just passed through a furnace or a brick kiln. Over the plain it quivers visibly in the sun, as if rising from a red-hot stove, while the mirage mocks your senses with the most life-like images of lakes, ponds, and rippling waters."

The Nile valley may be considered as nothing else than a long oasis in the midst of the desert. The life of this oasis is the Nile, which after centuries of speculation and exploration has had its secret wrested from it. For a distance of seventeen hundred miles above the delta, the river receives no tributaries. At this point two streams, the White and the Blue Nile, join to form the main stream. The latter of the two has many branches having their sources in the mountain regions of Abyssinia. The heavy summer rainfall causes torrents to rush down the sides of hills and mountains, carrying great quantities of soil with them. The White Nile, on the other hand, has its source in the great Victoria Nyanza, lying under the equator. The arable land of Egypt covers an area of about ten thousand square miles, which is made to support seven or eight million people. Where the irrigating waters cease the desert begins, and its limit is as sharply marked as a gravel walk across a greensward. From the eastern side of the Nile the desert extends without interruption to the shores of the Red Sea, and across this begins the great Arabian Desert, a tract not well defined, and but little known.—*Joseph F. James, in Scientific American Supplement.*

The Locomotive.

HARTFORD, AUGUST 15, 1889.

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

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WHEN the Hartford Steam Boiler Inspection and Insurance Company was organized, twenty odd years ago, the business of insuring steam boilers was new to this country. At first the public was inclined to treat it as a sort of innocent joke, but gradually they began to appreciate the benefits to be derived from it, and now it is universally acknowledged that boilers need to be insured fully as much as houses and factories. Not only have the people of the United States come to realize this fact, but even in Canada the people have arrived at the same conclusion, and a native Canadian company, with its headquarters in Toronto, has been in business for several years. There are numerous companies and associations in Europe, organized for the same purpose, and in the next issue of the LOCOMOTIVE we hope to review some of them and indicate the differences between the methods of conducting the business in Europe and in this country.

AT St. John, N. B., a carnival was recently held to commemorate the union of what were formerly the two cities of St. John and Portland, N. B. The particularly interesting thing about the festivities was the exhibition of electrical devices, most of which were furnished by American companies. New Brunswick covers a large area, yet it is so little known among our people that although it forms the eastern boundary of Maine, and would naturally attract attention from that fact, few hear it spoken of without thinking at once of the city by that name in New Jersey. Yet the people of New Brunswick are alive and awake, Mr. Charles Dudley Warner notwithstanding; and now that all parts of the province are so easily accessible our merchants and manufacturers should keep an eye open in that direction. New Brunswick now has more miles of railroad, in proportion to her population, than any of our States, and more, it is said, than any other country in the world. Her people know us and respect our abilities, and we fancy that if a little more attention were paid to them the market that she offers us would be more profitable.

FOR some time past we have noticed in the papers a discussion of somebody's discovery of a way to keep a fire going without using up coal. Now we do not see how any one, in these days, can cling to such a delusion as that, or even give it sober consideration. Experience has pretty solidly established the fact that you can't get something from nothing, no matter whether the something that you want is heat, light, electricity, money, or potatoes. Perpetual motion men have been of some service to us by piling up experimental evidence of this fact, and it is about time that we accepted it and made it one of our guiding principles.

We will not describe the new "discovery" in detail, partly because it is not worth it, and partly because most of our readers have already read all about it. But we want to say that it might be possible to "burn" our atmosphere if we could only persuade the oxygen and nitrogen in it to combine. These two elements do combine with one another under suitable conditions, and several oxides of nitrogen are familiar to the chemist; but, fortunately for us that have to breathe the air in its present state, nitrogen is a very inert substance, and has but little affinity for oxygen or for anything else. It is to the ease with which nitrogen compounds decompose that we owe the explosive properties of gunpowder, nitro-glycerine, gun-cotton, and that most explosive of all substances, chloride of nitrogen. In fact, it appears to be necessary, in order to make nitrogen combine directly with oxygen, to pass through the mixed gases a stream of electric sparks; and it will, we conceive, be several years before the saw-mills of our land are supplied with induction coils, condensers, and other suitable laboratory apparatus, to enable them to burn the air.

A Boiler of To-day.

A few days ago we saw a boiler that is worth more than passing mention. It belongs, now, to a saw-mill; but as it is placed outside the mill and blocked up in position by logs and bits of wood, the appearances indicate that the proprietor has some misgivings as to the length of time that his boiler is going to stay with him.

Running from the dome to the mill is a steam pipe, jacketed only by the accumulated rust of several winters. The pipe not being long enough for one length to reach from the boiler to the mill, there is a joint in it; and that joint is a study. One of the lengths of pipe is a little larger than the other, so that a sort of telescope joint is formed, the packing for which is composed of chips driven in tightly all around. Of course the leakage of steam at this joint is almost as great as the flow through the pipe itself.

There was neither safety-valve nor pressure-gauge attached to this wonderful boiler; and we looked for a glass water-gauge in vain, though we did find two try-cocks in a somewhat dilapidated condition. Some day or other — probably not very far away in the future — this boiler will rebel, and another "mysterious explosion" will go on record.

The Reversibility of Nerves.

When any portion of a person's body comes in contact with anything, the nerves that run to that portion of the body are thrown into a state of disturbance, the intensity of which depends on the violence with which the contact was made. This disturbance (the exact nature of which we do not know) passes up along the nerve until it reaches the brain, when we become conscious of it. About all we know about this wave of disturbance is that it travels with a velocity of only about 90 feet a second, so that if a weight should fall on the foot of a man 6 feet tall it would be 1-15th of a second before he would know he was hurt.

The impulses that are sent out by the brain to the muscles travel by different paths, known as motor nerves; and these are distinguishable in appearance from the sensory nerves. It will be seen, therefore, that each nerve has one particular direction in which it transmits the wave of nervous disturbance, and it occurred to a Frenchman, M. Bert, to discover whether nerves would be capable of transmitting impulses in the opposite direction if they could be turned end for end. To test the question he secured a rat, and after removing the skin from the tip of its tail and from a small spot on its back, he sewed the two together. After it had taken root in its new position he cut it off close to its original point of insertion. The rat now wore a tail reversed in position, the former tip being the root. After some time he found that the new tail was sensitive, which showed that the nerves of sensation can carry impulses in either direction.

Dr. Koch recently performed the same experiment on forty rats. In thirty cases the tails united satisfactorily with the body, but never, even eight months later, was any sensation present in the new appendage. However, if M. Bert is a reliable observer — and we have not the slightest reason to doubt that he is — the failure of Dr. Koch does not affect the conclusion. One positive experiment of this kind is worth thousands whose results are merely negative.

The Efficiency of Heat Engines.

A few months ago we called attention to the fact that the formula for efficiency, so often quoted and called Carnot's, in reality is not Carnot's at all, it having been first stated by Clausius. We refer to the expresion $\frac{T_1 - T_2}{T_1 + 461^\circ}$. The great discovery that M. Sadi Carnot *did* make is that the efficiency of a perfect heat engine does not depend upon the particular substance whose expansion does the work. He announced, that provided the engine is perfect in every way, its efficiency depends solely upon the two temperatures, T_1 and T_2, between which it works; but in what manner it depends on them he did not know.

It is natural to ask why he did not discover the formula itself, when he came near enough to it to see that one could be found, and that when it was found its value would depend in some way on the two temperatures between which the engine is to work. The answer is, that the calculation was much more difficult for him, with his conceptions of matter, than it is for us with our conceptions. A perfect gas — that is, one that exactly obeys the laws of Mariotte and Gay Lussac, and whose two specific heats are constant — was not a possible thing, according to the principles that Carnot held. In fact, he had demonstrated, as he thought, that the specific heat of a gas, instead of being constant as we now know it to be, must increase in proportion to the volume that the gas occupies. The principles that Carnot believed in, and those that are accepted by physicists to day, are in direct opposition to one another. When a gas passes through a cycle, Carnot believed that it takes up as much heat in the second part of the cycle as it gives up in the first part. We no longer believe this; we believe that the difference is very appreciable, and that it is proportional to the work performed during the cycle.

M. Bertrand has recently undertaken the task of imagining himself in Carnot's position, and then deducing the formula that Carnot would have found had he pushed his investigations further. It will not be necessary for us to give the argument by which he demonstrated his result to the French Academy of Sciences, though it is in itself highly interesting, being as ingenious a piece of mathematical work as we ever remember having seen. It will suffice to say that he finds that the efficiency of a perfect heat engine is proportional to the logarithm of $\frac{T_1 + 461^\circ}{T_2 + 461^\circ}$. This formula, rigorously deduced from the principles that Carnot held to be true, is very different from that which we now hold to be correct.

Carnot's great stumbling block was his belief that heat is a substance, and when that belief was done away with, it was so simple a matter to deduce the formula now known as Carnot's, that Prof. Clausius was too modest to attach his own name to it.

Great Discoveries and Innovations of the Past Sixty Years.

II. EVOLUTION.

We do not wish to approach the subject of evolution in the attitude either of an opponent or an advocate. The truth or untruth of a great principle like this can only be determined by long study of the facts, and all that we hope to do in this article is to present the subject in such a manner that those of our readers who have not already looked it up can form a clear conception of what the believers in evolution really claim for it.

It will be well to bear in mind that there are great and honest differences of opinion among naturalists and others on this subject. No one, for instance, will question the vast knowledge of Prof. Huxley, concerning animals and plants, nor will any be disposed to doubt the accuracy or the extent of Louis Agassiz's information in the same field; yet Huxley is one of the foremost disciples of Charles Darwin, and Agassiz was one of his warmest opponents.

The doctrine of evolution, as taught by Darwin, may be said to rest upon four main facts, which are ascertained to be true by direct observation of Nature. The first of these facts is that among animals and plants there is a tendency for each species to propagate itself in a sort of geometrical progression. For example, let us suppose that a single pair of rabbits, introduced into a new region by man, breeds eight others, all of which live and grow to maturity. After the death of the original pair there will be four pairs remaining; and we will assume that each of these breeds eight rabbits in the same manner. When the second generation has died there will be *sixteen* pairs still living. In the fourth generation there will be *sixty-four* pairs; in the fifth generation *two hundred and fifty-six* pairs; in the sixth generation *one thousand and twenty-four* pairs; in the tenth generation *two hundred and sixty-two thousand one hundred and forty-four.* It will be easily seen from this that if this multiplication continued after a comparatively few generations the country would be entirely overrun with rabbits; and this is what has actually taken place in Australia. In our own country, too, we observe the same rapid multiplication in the case of the English sparrows. These were introduced only a few years ago, and now they number millions. The potato bug is another well-known example. Among plants the tendency is not so noticeable, but yet abundant examples might be given of it. For instance, the writer has observed that a certain variety of clover that was new to us here only a short time ago, and was then highly prized by the botanist as a rare plant, has now become so common that specimens of it are to be found by almost every road-side.

The second general fact that the theory rests upon, is that the food supply for the animals and plants about us cannot increase with the same rapidity. At first thought this statement does not appear to be true; for as animals usually feed upon things lower in the scale of creation than themselves, and as the fertility of lower organisms is observed to be greater than that of higher ones, it would seem that the food supply for any particular animal must increase faster than the animal itself. This principle, however, is not a sound one. Animals cannot live solely by eating one another any more than a community of men can get rich by simply trading with one another. Some animals will have to eat plants, and the plants that they eat must grow out of the earth; and as the earth can support only a limited amount of verdure, it follows that the food-supply of herbaceous animals is limited, so that the herbaceous animals cannot go on multiplying beyond a certain point without suffering from want of food. Therefore, the next higher animals, whose food these lower ones are, cannot go on multiplying indefinitely; and so on up the scale.

This doctrine was once preached by Dr. Malthus, who taught that man himself is not an exception to it. It would seem, however, that man *is* an exception, for the reason that he does not live simply on the products of unassisted nature. He directs nature's operations in such a manner as to make her yield him a supply of food adequate to his needs; and as the numbers of the race increase, the food-producing power of the race increases also, and in the same proportion.

From the fact that animals and plants both tend to increase faster than their food supply, it follows that when a species reaches the point at which the supply of food is just equal to the demand, a "struggle for existence" begins. In the next generation there will be more individuals than can be properly nourished by the food that is available. Now, it is a matter of observation that in such a case some individuals get more than their proportional share of nourishment, and accordingly thrive better than their less fortunate neighbors. Being better nourished they will naturally be stronger and more healthy; and if any of the species die of starvation it will not be they. The better fed animals, too, will be better able to elude their enemies; while the weaker ones will be captured and devoured. One writer facetiously but accurately says, "the swiftest men caught the most animals, and the swiftest animals got away from the most men." As a general rule the "struggle for existence" is not only among individuals of the same species, but between different species that live in the same locality. For example, there are many plants that may be successfully cultivated in countries to which they are not indigenous, provided the plants that are indigenous are not allowed to come into competition with them. Weeds in a garden are a great source of annoyance to the gardener, because they grow with such rapidity that they speedily overtop the plants that he is trying to raise, and cut off from them the warmth and light without which they cannot grow.

The term "struggle for existence," as used by evolutionists, is often misunderstood by the public at large; for the phrase naturally suggests a visible and desperate combat between creatures endowed with motion. It is, however, applied to the quiet rivalry between plants, as well as to that between animals; and it is hoped that what has been said will show, after a little reflection, that the "struggle for existence" may be fierce and decisive, and yet not violent. One species may be mercilessly exterminating another without the fact being apparent to any but the experienced eye.

The next point to be observed is that in the struggle for existence the individuals that succeed do so because they are in some way fitted for success. If five plants start to grow in a space that can support only four, the one that dies will die because it cannot keep pace with its neighbors in extending its roots, in growing up into the sunlight, or in some other way. It dies because it is not so well adapted to the environment — not so well fitted to survive. From this illustration the meaning of the phrase "survival of the fittest" may be inferred. "The fittest" does not mean the most desirable or the most useful; the "fittest" individuals are those that are most nearly adapted to survive in the environment in which they subsist. Weeds exterminate potatoes, not because they are more useful to man, but because they are more vigorous and more adapted to take care of themselves. The usefulness of the animal or plant has nothing to do with the case.

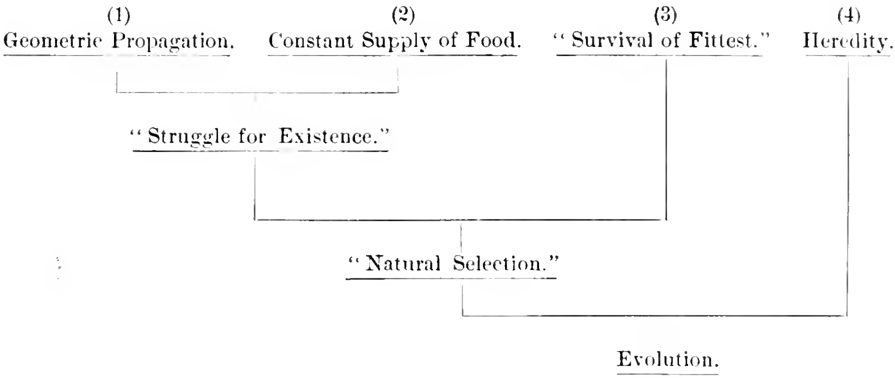
We have seen that the tendency of animals and plants is to multiply faster than the means of subsistence, and that this results in a "struggle for existence," in which the "fittest" will survive. It is evident that the survival of the fittest may arise from other causes than inadequacy in the food supply, for a hard winter, or a long season of dryness, or any other unusual happening in nature will necessarily single out the animals and plants that are least adapted to survive.

The gradual elimination of the weakest organisms and the survival of the fittest, whatever be the cause of the process, is called "natural selection"; since it is a selection performed by natural causes.

It will be seen that the process of "natural selection" ensures the existence of the strongest and healthiest individuals of each species; and it is plain that the "fitness," of whatever kind it is, that ensures the survival of any given individual, consists in some physical superiority of that individual over its fellows. Now it is a known fact that peculiarities of all kinds tend to be inherited from the parent to offspring, and hence it is that the fourth and last point for us to consider in the chain of evolution is *heredity*. Instances might easily be given of the most minute peculiarities being transmitted from one generation to another in this way, and no doubt many such instances will occur to the reader; and he should remember that the transmitted peculiarities that he has noticed are external only, and that there are also peculiarities in the internal organs and hence in the microscopic and the chemical constitution of each individual, and that these peculiarities may also be transmitted by heredity from parent to offspring. The offspring of the "fittest" of one generation may therefore be supposed to inherit in some degree the peculiarities that enabled their parents to survive; and it may also be supposed that they will themselves possess qualities of "fitness" that will aid them in their struggle for existence. The peculiarities in structure thus exercised and inherited will in time become more and more marked, and will finally become distinct features of the species.

It should be remembered, in considering this process, that those that possess the advantageous peculiarities in the greatest degree will be best fitted to survive; and that when these individuals come into competition with others possessing the same peculiarities but in a different degree, the survivors will always be those that possess the advantageous peculiarities in the most marked degree. There will therefore, under all circumstances, be a constant tendency toward the development of these peculiarities, until, as has been said, they become distinct features of the species.

The whole argument, as represented in this article, may be included in the following diagram :



The process here outlined is evolution in the true sense. It applies equally well to plants and to animals. It is, of course, impossible to review or even to mention the evidence that has been gathered together to show that this process of evolution is in reality taking place around us now. The horticulturist, the dog-fancier, the stock raiser, and all who have to do with the modification and improvement of animals and plants, testify that the process we have described certainly takes place when the variations in individuals are properly watched for and suitable selections are made. Whether natural selection is adequate to produce the same or greater effects must be a matter of study and individual opinion.

It will be seen from the foregoing that evolution tends, in general, to improve each species, and to raise it in the scale of development. It tends to preserve every peculiarity that is favorable to the species, and to blot out every one that is unfavorable.

The great bones of contention among naturalists who discuss this subject, are the *permanence* and the *magnitude* of the improvements resulting from natural selection, and over these a vast deal of thought has been spent. Some admit that small changes are produced by natural selection, but deny that great and permanent changes can be; others boldly claim that the considerations herein set forth, together with other analagous ones that we have not the space to consider, are adequate to explain the entire range in development that exists between the smallest anamalculum and man himself. Still others believe that all plant life, and all creatures *except man*, were developed in this way from some primitive and very simple form of life.

It is proper to say in closing, that there are three stages in the process of producing man (admitting that he was produced in this way) that are unthinkable, even to so strong a believer in evolution as Mr. Alfred Russell Wallace. In the first place, it is impossible to conceive of any process by which an animate cell, however simple, could be produced from inanimate matter; and it is fair to say that Darwin appreciated this difficulty, and admitted that he could not explain how the *first* organism was produced. Secondly, it is impossible to conceive how consciousness could have been evolved from non-conscious matter. Lastly, it is difficult to conceive how the tastes for mathematics, for chess, for music, and for other such things that we take pleasure in, but which cannot be supposed to directly promote our welfare, could have originated through natural selection.

The late Mr. Miguel de Cervantes-Saavedra said, in *Don Quixote*, that honesty is the best policy. It is plain, therefore, that he was unfamiliar with the policies issued by the Hartford Steam Boiler Inspection and Insurance Company ; for they have all the virtues that honesty has, and some others in addition.

The Locomotive.

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NEW SERIES—VOL. X. HARTFORD, CONN., SEPTEMBER, 1889. No. 9.

On Pumps for Boiler Feeding.

Our illustrations, this month, show two arrangements of pumps that were designed for boiler feeding by this company, and have now been in successful operation for a considerable time by the Boston Duck Company, Bondsville, Mass., and the Otis Company, Ware, Mass., respectively. The particular difficulties that these systems were designed to overcome were as follows: In each case a large amount of water is used, and in order to run economically it was desired to return the drip from the various mills to the boiler room. This was attended with considerable difficulty, as the boilers are higher than the points where the traps must be placed. A survey of the yards showed that certain points could be selected, though at considerable distances from the boiler houses, to which

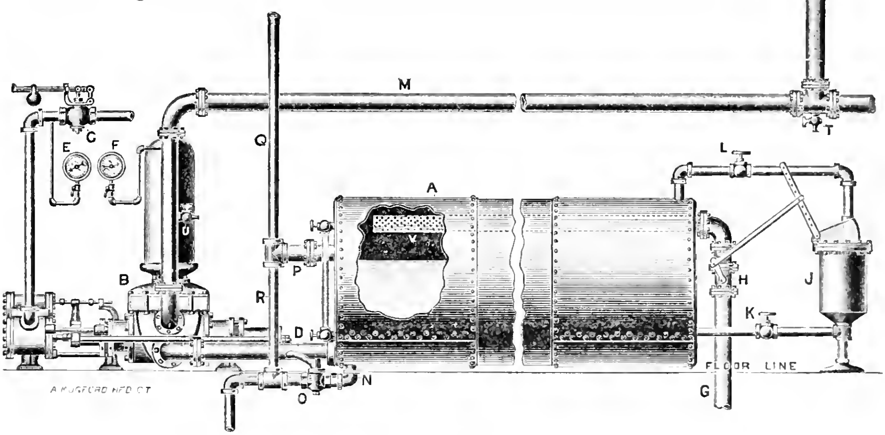

FIG. 1.

the drips could easily be returned; and it was resolved to place the receiving tanks at these points. In order that the pumps might be flooded it was necessary to place them in the same pits with the tank, several hundred feet from the boilers; and after some consideration it was decided to do this, and to arrange the pumps so that they might govern themselves automatically, and not need the personal attention of the firemen.

Fig. 1 shows how this was accomplished at Bondsville. Into the tank, A, all the drips from the mills are discharged, by means of traps of our own design. The exhaust from the pump also discharges into the same tank. The water in tank A is maintained at a constant level by means of a governor, J, which controls a valve, H, in the feed pipe G, in the usual way. This governor communicates with the tank by means of the pipes shown, which are provided with cocks, L, and K, so that the governor may be shut off from the tank when desired. Within the tank the feed pipe is perforated as shown at V so that the incoming water may condense any steam it may come in contact with, and be itself heated thereby. A blow-off is provided at N, and a three-inch overflow pipe at P, which discharges surplus water into the blow off through R, and allows any uncondensed steam to escape through Q.

The pump, B, draws its supply from the tank through pipe D, and discharges through M, which passes to the boiler room. Steam to operate the pump enters through the pipe C, which is provided with a reducing valve, as shown, which serves to maintain the pressure on the steam end of the pump constantly at 35 pounds, which is indicated by the gauge E. The water pressure in pipe M is indicated at F.

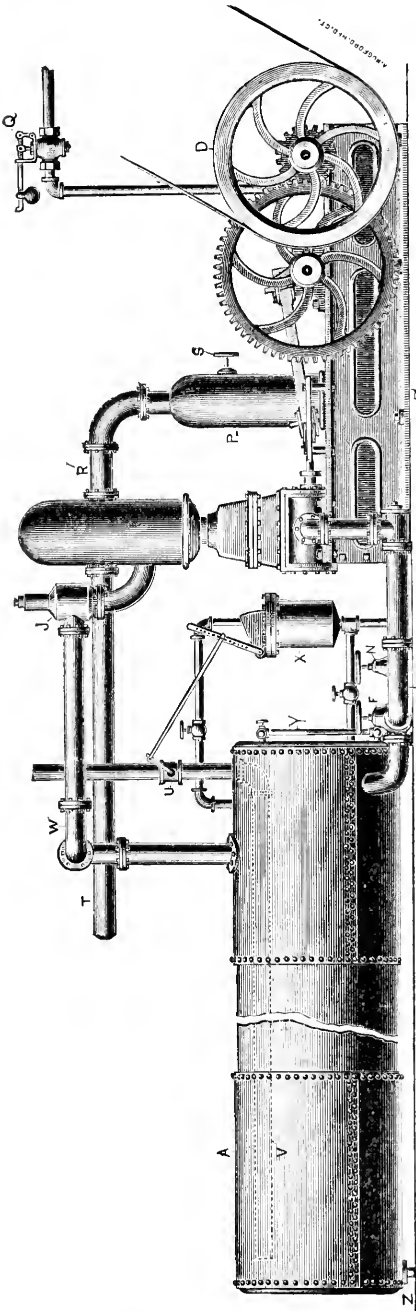

FIG. 2.

The operation of this system is very simple. If the attendant in the boiler-room shuts off all his valves, the pressure in the water pipe M immediately runs up to from 100 to 105 lbs., the steam and water cylinders of the pump being so proportioned that when this pressure is attained the water in M just balances the reduced steam pressure in C, and the pump can no longer run. It therefore remains motionless until a valve is opened somewhere on the pipe M. Then, the pressure in M being relieved, the pump is no longer balanced ; the steam pressure preponderates and the pump starts. This adjustment is so fine that if the attendant opens his valve a single spoke the pump responds immediately, and moves so slowly that its motion can hardly be seen ; while if he opens all his valves wide the pump instantly starts at full speed.

To prevent unpleasant rattling and pounding in the boiler-room a standpipe, S, is provided near the boilers, which acts as an air chamber and causes the whole to work smoothly and noiselessly. It happens occasionally, as for instance when the temperature of the boiler-feed is changed, that some of the air in S is absorbed or dissolved by the water, so that in time (say once in two or three months) pipe S becomes filled with water and ceases to act as an air chamber. In this case it is only necessary to stop the pump for a few moments and open the small cocks T and U. Water then runs out at U and air bubbles up through T into the chamber overhead. When sufficient air has entered the small cocks are closed and the system is ready for operation once more.

The plant at the Otis Company's mills is similar in principle, but somewhat more complicated in its details owing to the fact that a power pump is there used, in addition to a steam pump. The operation of this plant will be understood from Figs. 2 and 3, which are respectively an elevation and plan of the whole system. In these figures A is the tank for receiving the drips, X is the governor and U the valve that regulates the flow of water from the river into the tank through the perforated pipe V. The power pump, B, has two fly-wheels, C and D, on one of which runs the driving belt. It draws water from the tank through pipe E, and delivers through GKL to the boilers. The steam pump, P, is provided with a reducing valve, Q, as in the plant previously described; it draws its water from the tank through M and delivers it to the boilers through RR[1]L. At T a pipe is shown which runs through the mills and supplies water in case of fire or other emergencies. Valves are provided at S and N that allow the steam pump to be shut off entirely if desired, and similar valves, H and F, are provided for the power pump.

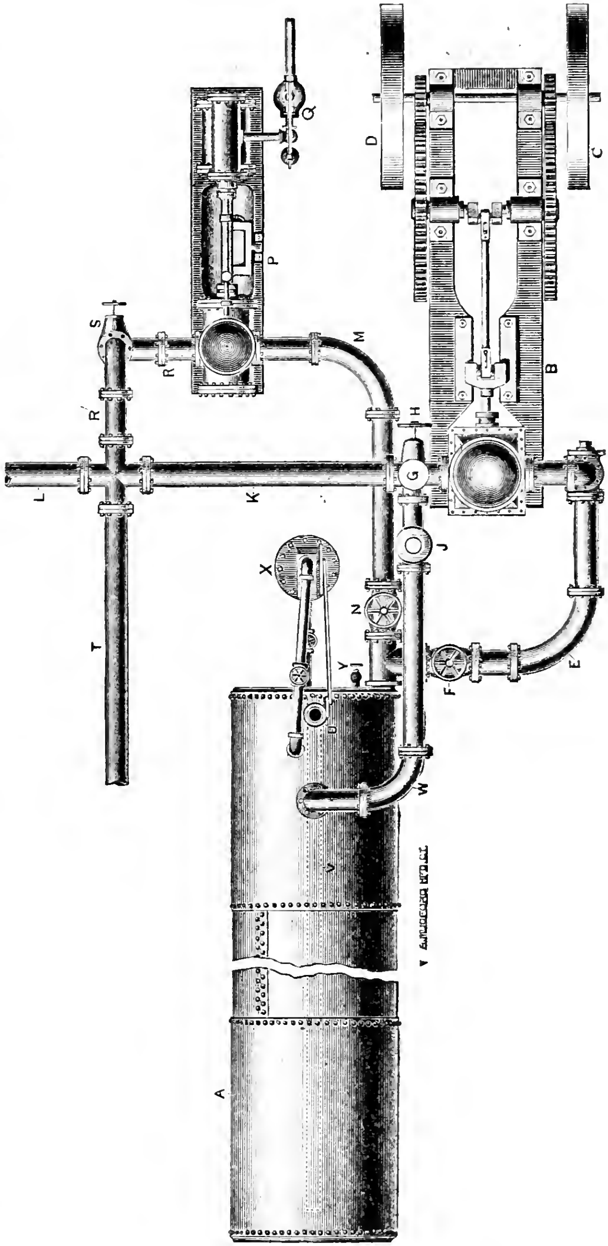

FIG. 3.

The action of these combined pumps is as follows: The power pump, B, runs continuously, while the machinery is in motion, and it is ample in size to supply all the ordinary wants of the boilers. In case the demand for water is less than the supply that this pump affords (which is frequently the case), the surplus passes back to the tank A through a relief valve, J, which is set to open at 115 pounds water pressure. Under these circumstances the steam pump, P, remains motionless; for the steam pressure in it is kept constantly at from twenty-four to twenty-five pounds by means of Q, which corresponds to a pressure in the water end of 105 pounds, so that it is impossible for this pump to start unless the pressure in KL falls to 105 pounds or less — that is, it is impossible for it to start while the demand for water does not exceed the capacity of the power pump.

To follow the action of the pumps, let us first suppose that all the valves in the boiler-room are closed. Then the pressure in the main, KL, rises at once. As soon as it reaches 115 pounds the relief valve, J, opens, and after that the entire delivery of the power pump passes through J and W and back into the tank A. Now let us suppose that the belt on the power pump breaks. Immediately the delivery of this pump ceases, and the valve J closes. The pressure in the main, KL, is now 115 lbs., and both pumps are motionless. Now suppose an attendant in the boiler-room opens a feed valve there, the pressure in the boiler being only 80 lbs., water begins to flow from the main into the boiler; but this reduces the pressure in the main, KL, which pressure, at the time of opening the valve in the boiler-room, was 115 lbs. The moment that this pressure falls below 105 lbs., however, the steam pump, P, ceases to be balanced: the steam pressure preponderates over the water pressure, and the pump starts with a velocity proportional to the demand for water, the working of this pump, from this moment on, being exactly the same as the working of the pump shown in Fig. 1.

Now let us go back to the beginning once more, and suppose that the belt on the power pump does not break, but that the demand for water, owing to a fire breaking out or to any other cause, suddenly increases, so that pump B can no longer supply it. The pressure in KL then decreases as before, the relief valve, J, closes, the steam pump, P, starts up the moment the pressure in KL falls to 105 lbs., and both pumps run together, the power pump at a uniform speed and the steam pump at a variable speed, depending on the amount of water that is wanted.

When night comes on the power pump of course stops at six o'clock, and the steam pump at once starts automatically and takes its place; and at seven o'clock in the morning the power pump starts once more and the steam pump stops.

In both of these plants pressure gauges are attached to the steam and water pipes, so that an occasional visit to the pump-room shows at once whether everything is working properly or not. Both systems also have an air-chamber in the boiler-room, as shown at S in Fig. 1; and it seems proper to say that in each case the pumps have worked smoothly from the outset, and to the entire satisfaction of everyone.

In order that the advantage in economy that comes from returning the drips from the various pipes may be appreciated, we would call attention to the following figures: The water in the tanks of these systems has a temperature of between 160° and 190° Fah. Now, one of the companies referred to in the beginning of this article uses five boilers constantly, and for these boilers and the dye-houses between 15,000 and 20,000 pounds of water are required per hour. To raise this amount of water from say 70° to 170°, as many heat units must be expended as would evaporate say 2,000 pounds of water per hour; that is to say, it would be necessary for this company to run six boilers instead of five, if the drips were thrown away.

Inspectors' Reports.

JULY, 1889.

During this month our inspectors made 4,479 inspection trips, visited 9,680 boilers, inspected 4,732 both internally and externally, and subjected 622 to hydrostatic pressure. The whole number of defects reported reached 9,841, of which 887 were considered dangerous; 38 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	585	51
Cases of incrustation and scale,	1,062	73
Cases of internal grooving,	57	14
Cases of internal corrosion,	352	24
Cases of external corrosion,	739	59
Broken and loose braces and stays,	90	31
Settings defective,	243	21

Nature of Defects.	Whole Number.	Dangerous.
Furnaces out of shape,	298	16
Fractured plates,	195	56
Burned plates,	156	36
Blistered plates,	351	18
Cases of defective riveting,	2,424	47
Defective heads,	72	15
Serious leakage around tube ends,	1,966	202
Serious leakage at seams,	394	31
Defective water-gauges,	243	63
Defective blow-offs,	82	35
Cases of deficiency of water,	16	8
Safety-valves overloaded,	56	16
Safety-valves defective in construction,	57	16
Pressure-gauges defective,	315	44
Boilers without pressure-gauges,	7	7
Unclassified defects,	81	4
Total,	9,841	887

Boiler Explosions.

JULY, 1889.

PAPER MILL (76). On July 2d, an immense upright steam bleaching vat in the Lyons Paper Mill, Lyons, Iowa, exploded, totally wrecking the building and killing two workmen—Thomas McBride and Alexander Hart. James Callahan, another workman, was fatally scalded. The damages to property are estimated at $15,000.

LOCOMOTIVE (77). A wash-out took place on the Norfolk & Western Railroad, thirty-one miles above Lynchburg, Va., on July 2d, and a passenger train plunged into it while running at forty miles an hour. As the locomotive struck the bottom of the cut the boiler exploded. Debris was thrown in every direction, and firebrands were lodged among the coaches. Flames broke out and spread rapidly, and many were burned to death. Altogether eleven are known to have been killed, and it is said that eighty were injured.

THRESHING ENGINE (78). On Saturday, July 6th, the boiler of a threshing engine exploded at the ranch of J. M. Lewis, near Phœnix, Arizona. David Holman and Frank Opershaw were dangerously hurt. The separator was ruined and 80,000 pounds of grain were burned.

THRESHING ENGINE (79). On the morning of July 8th the boiler of a threshing engine owned by Simpson & Rubel and working at J. Parks' ranch, ten miles north of Marysville, Cal., blew up. Engineer Rubel and fireman Rogers narrowly escaped with their lives. Rubel was badly scalded, and his injury may prove fatal.

SAW-MILL (80). James Raisen, colored, fireman in John H. Thawley's saw-mill, near Denton, Md., was instantly killed by a boiler explosion on July 9th. Raisen was found by Mr. Thawley after the disaster with his head jammed between two slabs. The engine was blown from its bed and fell thirty feet from its former position. The building in which the boiler was situated is almost a total wreck. Mr. Thawley and a colored man narrowly escaped with their lives.

LOCOMOTIVE (81). An explosion occurred July 16th, on the Union Pacific Railway, three miles west of Topeka, Kan. A switch engine employed in the yards here was hauling a train of cars to a point where the track was being repaired. Just as it was slowing up the boiler of the engine exploded with terrible force. Fireman James Dutton was fatally injured, and Engineer R. T. Seacord received injuries which will probably prove fatal. Trainmen on the cars also received serious injuries. The track was torn up for a distance of 150 feet and the cars were scattered promiscuously about.

Saw-Mill (82). Three men were killed in Chicago on July 18th by the explosion of a boiler in the yards of the R. B. Stone Lumber Company, and four others were badly injured. A piece of the boiler weighing three hundred pounds tore out the brick supports for the roof in the main room of the mill and lodged on top of a rip-saw fifty feet from where it started. Another piece knocked out the west wall of the engine-room, tore a hole in the side of a freight car and tipped it off its trucks. One end of the boiler knocked off the roof of the engine-room and tore down some of the supports of the shed. The bricks in the furnace and iron pieces composing the engine were scattered in all directions. King, the engineer, was instantly killed, and his body was buried under a great pile of sawdust, pieces of iron, and broken beams.

Tannery (83). An explosion occurred, July 19th, in the Eagle Valley tannery at Ridgeway, Pa. A young man named Striker was cremated, and six other employes were badly burned, some of them fatally.

Saw-Mill (84). At Days Station, Wash., on the line of the Seattle, Lake Shore & Eastern Railroad, July 19th, a boiler exploded, and set fire to Day Bros.' mill. The fire completely destroyed the mill, which was valued at $25,000.

Portable Saw-Mill (85). A boiler explosion occurred at Washington Courthouse, Ohio, on July 19th, in a portable saw-mill, which was at the time in use for pumping out water from wells for the new water works in process of construction at that place. Fred Worrell (the engineer) and Nathaniel Taylor were instantly killed. Eight others were seriously injured, some probably fatally.

Chemical Works (86). A still exploded in Dodge & Olcott's chemical works, Jersey City, July 20th, and a three-story brick building 100x25 feet was destroyed. The loss was estimated at $300,000.

Pleasure Yacht (87). The boiler of the steam yacht *Lotus Seeker*, owned by E. R. Holden, Vice-President of the Delaware & Lackawanna Railroad, exploded July 21st, while lying at the private dock of the owner in Thousand Island Park, N. Y. Only one end of the boiler blew out, and, although several persons were in the boat, no one was injured. The loss was about $1,000.

Stone Quarry (88). A boiler in the stone quarry of Louis Canterbury, at One Hundred and Seventy-eighth Street and La Fontaine Avenue, New York, exploded July 22d, and set fire to a lot of hay. One of the pieces struck the stoop of the house at 4,273 Third Avenue, occupied by George Neuffer, damaging it slightly.

Brewery (89). A horizontal tubular boiler exploded at the Eagle Brewery, Altoona, Pa., on July 30th. Fortunately no one was injured. The boiler-house and the brick-stack were demolished.

Mill (90). On July 30th the boiler in the mill of Andrew and John Flanagan, Manayunk, Pa., exploded, killing two boys and injuring two men. The upper half of the shell was thrown 150 yards, the boiler-house was wrecked, and the loss to the proprietors will be about $10,000.

Saw-Mill (91). A saw-mill boiler exploded at Golden Gate, about seven miles from Fairfield, Ill., on July 30th, instantly killing Frank Peters, a son of the proprietor, and injuring Joe Wallace and William Fox so badly that they cannot recover.

Tug-Boat (92). The boiler of the tug-boat *Jersey Boy*, owned by Richard Parrot, exploded July 31st, at the mouth of Five Mile River harbor, Conn. She was engaged on a government contract in digging mud. The boat was blown to atoms, only small fragments being found. The crew had just left her.

Heating and Ventilation.

By Thomas Elkinton.

Fifty years ago buildings were heated by stoves, and had no provision for change of air, beyond the leakage of the doors and windows. It will be remarked in passing that the air in a room heated by stoves will remain for a short time surprisingly pure, because of the rapid transfer of the lower strata to the upper, by the currents induced by the hot surfaces of the stoves; but when it becomes uniformly bad, as it quickly does, its conditio' cannot be described in terms of refinement.

No public buildings are now constructed without some recognition of the importance of ventilation; but, as a rule, the recognition is scarcely more than in appearance, for although outlets are provided for the foul air, there is scarcely any means for the inflow of air that is pure. The fact seems to be constantly overlooked, that while provisions for the passage of foul air are well enough in themselves, they are of little account without equal provision for the inflow of fresh air. It is true that windows and doors afford inlets for air, but as the choice between pneumonias and neuralgias and the evils of foul air are not worth discussing, all such sources of air supply should be dismissed from consideration.

There is much difference of opinion concerning the temperature that the air of rooms should have, in order to be most conducive to the health and comfort of the occupants, and the ideas of different nations present curious phases. Curtis tells us that the Chilians, with a climate similar to that of Washington, think that fires in a house are unhealthful, and that they wear their wraps indoors as well as out, and although coal is cheap and wood abundant, sit in their houses with noses blue and teeth chattering, and at fashionable gatherings women appear in evening dress with the thermometer between 40° and 50°. He also states that the mortality from throat and lung complaints is immense. The Englishman, too, sits in his large parlor with a small grate and considers himself comfortable with the thermometer in the fifties. The proper temperature for each individual is probably that at which he feels most comfortable; and this will be found to be about as follows: In audience chambers, where the occupants sit with their wraps on, 65° is suitable; in schools, 69° to 70° will be necessary; and 70° to 72° will be better for parlors in private houses, especially if there are elderly persons in the family.

Authorities differ concerning the quantity of air that is necessary for good ventilation. The lowest estimate is ten cubic feet a minute, for each person, this being based on the supposition that each person receives perfectly pure air at each inhalation, and that the air he exhales is removed from the room at once. This state of things is realized out of doors in a stiff breeze, but within doors it is not practicable. Sixty cubic feet a minute, for each person, is none too much for health and comfort in school-rooms and other places of public gathering, and a much greater supply should be provided in the sick room and the hospital; and forty feet for each person, each minute, should certainly be provided. This means 1,200 cubic feet a minute in a class-room of thirty; 2,000 cubic feet for a parlor containing fifty; 4,000 for a school-room of 100; 20,000 for a lecture-room or court-room of 500; 40,000 for an audience of 1,000; and, lastly, 100,000 cubic feet a minute for a larger audience of 2,500. This amount certainly ought to be provided to secure conditions fairly healthy and comfortable; yet how many buildings of the day are supplied with air in quantity like this, or anywhere approximating it?

If these figures appear startling to one who has not thought of them before, let him consider his own head encased for a minute in an air-tight box three feet and six inches square (forty feet in capacity); after he had taken about a dozen full breaths, would he not deem it proper to have a fresh box at the end of that minute,—especially if, instead of having his box all alone he should be sharing his exhalations with his neighbors, and breathing back theirs in return?—*Adapted from the Journal of the Franklin Institute.*

The Locomotive.

HARTFORD, SEPTEMBER 15, 1889.

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.

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

THE Toronto meeting of the American Association for the Advancement of Science was held from August 27th to September 7th. Papers were read by Prof. J. D. Dana, Dr. E. O. Hovey, Prof. Gilbert, Prof. Newberry, Prof. J. Le Conte, Prof. A. Winchell, Mr. C. D. Walcott, and others, and the occasion was one of special interest.

JAPAN is rapidly growing in civilization, and we should not be greatly surprised if it turns into a republic some day in the not very distant future. Among other encouraging things, we learn than the Imperial University of Tokio has now no less than 138 instructors and 788 students. That would be a very respectable college in any country. "New buildings for technical education, and a new chemical laboratory, have been erected at a cost of nearly $300,000, and more money is promised by the government for further extensions."

The Mikado's palace, it will be remembered, is lighted by electricity, the dynamos for which are run by a Sweet straight-line engine.

AS WE go to press word comes that the peerless *City of Paris* has broken her own record again — this time by nearly four hours! She has crossed the Atlantic, from Queenstown to Sandy Hook, in five days nineteen hours and eighteen minutes. The distances covered in the respective days were as follows: On Aug. 23, 432 miles; on Aug. 24, 493 miles; on Aug. 25, 502 miles; on Aug. 26, 506 miles; on Aug. 27, 509 miles; and on Aug. 28, 346 miles. She brought over 527 first cabin passengers, 192 second or intermediate, and 422 steerage; in all, 1,141. And everyone on board was inexpressibly happy.

WE understand that the trustees of the estate of the late Sir Joseph Whitworth have just presented to Owens College, Manchester, Eng., an engineering laboratory containing, among other things, a vertical testing machine with a capacity of 224,000 pounds, and a triple expansion engine made by Messrs. Mather & Platt. This engine was designed especially for experimental work, and interesting results may be expected of it, though it is not large enough, of course, to be strictly comparable with modern marine engines of the same type. The cylinders are respectively 5"×12", 8"×12", 12"×15", and the volumes swept through in a single stroke are to one another in the proportion of 1, 2.56, and 7.2. The cranks can all be coupled so as to run as if on a continuous shaft, in which case the angles at which they are set can be modified at will, or all three of the cranks can be run at different speeds. Steam jackets are provided on each cylinder, and the water condensed here and in the condenser can be accurately measured. Each cylinder is provided with thermometers and with a pair of Crosby indicators.

A GOOD deal is being said in the papers about the liability of electricity to a tariff duty, when brought into the United States from a foreign country. The immediate cause of this newspaper uneasiness is the fact that a company whose plant is to be on the Canadian side at Niagara Falls, proposes to run wires across the river and furnish light to one or two towns on the American side. This company, it seems, has applied to the Treasury for a decision, being unwilling to put up its wires and machinery until it knows whether it will be taxed or not. Of course we don't know what the present Secretary will decide, but we remember that when a similar question was put to Secretary Fairchild by some one down near Calais, Me., he took the very sensible and reasonable ground that "electricity, being an imponderable fluid or force, and not a material article of manufacture," cannot well be counted among the things that Congress had in mind in passing our present tariff laws.

The electric lighting company is getting a little free advertising by raising this question again, but we imagine that that will be all it will come to.

A CURIOUS illustration of the necessity of eternal vigilance in the boiler room came to our notice a few days ago. The particular engineer that we have in mind is in the habit of shutting off the water-column when leaving his boiler for the night. One morning he opened the cocks as usual, as he supposed, and proceeded to get up steam. After a time it occurred to him to consult his gauge glass, when he noticed that it was either full or empty — he couldn't tell positively which, but from the appearance of it he judged it to be full, and the subsequent events proved his judgment to be correct. Proceeding therefore to his blow-off valve he opened it and allowed a considerable amount of water to escape. About this time it struck him that it would not be a bad idea to examine his try-cocks. Finding nothing but steam he became greatly alarmed and hauled his fire with great expedition, and sent for one of our inspectors, to whom he explained that he could not make steam. The inspector, viewing the fire on the floor, said he did not wonder much at that ; and immediately suspecting the cause of the trouble he stepped up to the water column and examined the cocks. The lower one was broken, so that the wheel turned freely on the stem, while the valve remained pressed against its seat. Upon opening the broken valve the water in the glass immediately ran out and the trouble was at an end. Water was then pumped in, the fires were re-started, and all went on as usual.

WE take pleasure in acknowledging the receipt of the report of Mr. Henry Hiller, Chief Engineer, to the National Boiler Insurance Company of Manchester, England. This report is full of interesting and instructive matter concerning the defects that have been observed by the company during the past year, and concerning the explosions that have come to their notice. Both the defects and the explosions are exhaustively discussed. We quote the summary of explosions: "During 1888, 33 actual explosions of steam boilers in the United Kingdom were reported, causing the deaths of 18 persons and injury to 44 others. In 1887 there were reported 33 explosions, causing 21 deaths and injury to 39 persons. In 1886, 32 explosions, 30 deaths, and 57 injured . . . Eleven of the 33 exploded boilers were vertical, with internal fire-box. Many of them were not under proper supervision and had not been inspected by competent persons." On page 17 is a list made up from 12,000 to 13,000 boilers, and intended to show what percentage of the whole are Cornish, what percentage are Lancashire, what cylindrical, etc. We select the more numerous ones: Lancashire, 31.3 per cent; Cornish, 24.0 per cent.; vertical (with internal fire-box), 12.4 per cent.; plain cylindrical, 9.3 per cent.; portable, 5.7 per cent.; Galloway, 4.3 per cent.; multubular and multiflued, 2.27 per cent. Of the remaining types no one forms as large a proportion as two per cent. From the fact that these proportions are based on such a large number of measurements, they may be considered as representing the average practice in England.

The Bruce Telescope.

Miss C. W. Bruce of New York, has recently presented to the astronomical observatory of Harvard College the sum of $50,000, to be devoted "to the construction of a photographic telescope having an objective of about twenty-four inches aperture with a focal length of about eleven feet, and of the character described by the director of the observatory in circular of November last: also to secure its use under favorable climatic conditions in such a way as in his judgment will best advance astronomical science." A telescope eight inches in diameter, but otherwise similar to the one proposed, has been in use in the observatory for several years, and has done very satisfactory work; in fact, stars have been photographed by this eight-inch glass that cannot be seen through the excellent 15-inch at the observatory. The Bruce telescope will be designed to take photographs thirteen inches square, and on such a scale that the moon will be an inch and a half in diameter.

As this instrument will be somewhat of a new departure it may be well to explain that telescopes designed for photography alone differ from other telescopes in two important respects. The object-glass is designed with especial reference to the chemically active rays of light, rather than the rays by which our eyes are affected: and, furthermore, the focal length of the object-glass is much less in proportion than in ordinary telescopes. Since so much good work has been done already with the eight-inch glass at Cambridge, it is confidently hoped and expected that the new glass having three times the diameter, and therefore nine times the light-gathering power, will be of the greatest service in unraveling the mysteries of the stars.

The Elixir of Life.

It seems proper that we should make some mention of the "elixir of life" that Dr. Brown-Sequard affirms that he has discovered. The details of his process of preparing the elixir may be found in the *Scientific American Supplement* for August 10th and more fully in the *Comptes Rendus* of the Paris Societé de Biologie for June 21st, *et seq.* Suffice it to say that the learned doctor has spent twenty years of thought on this subject, and that he began experimenting upon it as long ago as 1875. The fluid that he prepared he injected under the skin of his arm and legs with a morphine needle on ten different occasions. The results in his own words were as follows: "I am seventy-two years old. My general strength, which has been considerable, has notably and gradually diminished during the last ten or twelve years. Before May 15th last (the date of the first injection), I was so weak that I was always compelled to sit down after half an hour's work in the laboratory. For many years, on returning home in a carriage by six o'clock, after several hours passed in the laboratory, I was so extremely tired that I invariably had to go to bed, after having hastily taken a very small amount of food." He then relates that he was greatly improved after the first injection, and goes on to say that "on one day, the 23d of May (after the sixth injection), after three hours and a quarter of hard experimental labor in the standing attitude, I went home so little tired that after dinner I was able to work and to write for an hour and a half a part of a paper on a difficult subject. For more than twenty years I had not been able to do as much. For a great many years I had lost all power of doing any serious mental work after dinner. Since my first subcutaneous injections I have very frequently been able to do such work for two, three, and one evening for nearly four hours." He then tells of experiments of the same kind made by Dr. Variot on patients who did not know what to expect, and who knew nothing of Dr. Brown-Sequard's experiments. Three of these patients were treated with the "elixir," and two with clear water: for it was desired to distinguish between mind-cures and actual material benefits. The three that were treated with the elixir grew stronger and more active, as did the distinguished discoverer of the elixir himself. The other two obtained no effect whatever.

We regret to say that experiments similar to these have been lately carried on in this country in rather an indiscriminate manner. Dr. Brown-Sequard was Charles Sumner's physician, it will be remembered, after he was assaulted in the Senate; and there is no doubt but that he is an able man, and one whose words should be listened to with consideration and respect. It is proper that our truly eminent physicians should turn their attention to the "elixir" and give it such trial as they think wise; but reports are coming in from all over the country, that this, that, and the other doctor is experimenting with it to try its virtues. Now, apart from the danger of inoculating the patient with the germs of tuberculosis or some other affection, there is a serious likelihood of blood-poisoning in its most serious forms, and no ordinary physician has any right to experiment with the elixir until properly qualified and properly equipped pathologists have examined it and discovered a way to administer it without danger.

We are led to make these remarks by the fact that several cases have come to our knowledge in which patients were made seriously ill by the "elixir" presumably administered by some one who did not understand it. We have even heard rumors of a suit for five thousand dollars damages, growing out of such a case. The best thing for our doctors to do with this elixir, for the present, is to not do anything. It may be an excellent thing; but let us wait till we find out for sure.

The Latest Ocean Wonder.

The following description of the magnificent new steamship *Teutonic*, that broke the maiden record in her recent race across the Atlantic with the *City of New York*, is taken from the London *Times*, and will be of interest to all who are watching the development of ocean navigation: The vessel has been built by Messrs. Harland & Wolff for Messrs. Ismay, Imrie & Co., and may be regarded as absolutely the safest ship afloat. She is fitted with twin screws, and the whole of the machinery, engines, boilers, and coal for working either screw is shut off completely from its neighbor by a fore and aft bulkhead, which extends from the after end of the engine room to the forward end of the foremost coal bunker, and in fact intersects the six largest of the twelve water-tight compartments made by the eleven ordinary transverse bulkheads. This fore and aft bulkhead is pierced by only one locked door, the key of which is held by the chief engineer. The doors between the engine rooms and the stokeholes are in every instance duplicated, and the duplicate door in every case under the control of the Captain on deck. When liberated they close by their own weight, but by an ingenious contrivance their descent is freed from violence. Ascending from the door is a rod surmounted by a piston, which works in a cylinder 4½ inches in diameter filled with glycerine. When the door is allowed to descend the whole of the glycerine has to pass through a half-inch hole in the piston, and the sluggish liquid thus prevents a rapid and dangerous descent of the massive door.

There is, however, another and more interesting novelty about these doors. In the event of water flowing into the ship the doors will close automatically. As the water rises in the bilge it will buoy up a hollow ball attached to a rod. This rod, on being pushed up about a foot, removes the catch that holds the door, and it might chance that the first information of danger in the engine room would be the automatic closing of these protective doors. The principle is common enough. It is merely an adaptation of the domestic ball cock; and, assuming the buoyancy sufficient for the work to be done, nothing could be more certain in its action. The introduction of the fore and aft bulkhead dividing the separate engines of a twin-screw ship has been objected to by high authorities, on the ground that if one side were filled with water the list would be so great that the vessel would inevitably overturn, and that what was conceived as a means of safety would become a source of certain danger. It has, however, been experimentally demonstrated in this case that if the two largest compartments on one side of the fore and aft bulkhead were filled the list would be only 12 degrees, and facilities are at command to correct this by pumping in water on the other side.

These engines are triple expansion, with three cylinders 43 inches, 68 inches, and 110 inches in diameter, and they have been constructed to develop 17,000 horse power. The pistons have a 5-foot stroke, and the machinery, in accordance with Admiralty requirements, has all been placed below the water line. The boilers are twelve in number. Some are 12 feet and some 12 feet 6 inches in diameter, and 17 feet long, with six furnaces in each, and a grate area of 1,163 feet.

The propellers, which are 21 feet 6 inches in diameter, with a pitch of 28 feet 6 inches and a superficial area of 128 feet, are of special interest in this ship on account of the unusual manner in which they are placed. They overlap each other to the extent of 5 feet 6 inches, or, in other words, they each extend over the center line 2 feet 9 inches. The centres of their axles are 16 feet apart, and the port side propeller is 6 feet forward of the starboard, measuring from boss to boss. The port propeller is a left-handed screw and the starboard a right-handed; thus both work away from the ship, and the port propeller working in the loose water of the after screw makes two revolutions a minute more than its twin. The propeller shafts are 199 feet and 205 feet long respectively, and are entirely encased to the boss of the screw. The hull is very much cut away under the stern, and a large space has been cut in the frames to admit of the massive casting that carries the screw shafts. The stern post is connected with the rudder post by a bar on a line of the keel in the ordinary way, the scheme of allowing the rudder to be suspended without support below having been abandoned as dangerous.

The vessel herself is 582 feet long — the longest ship afloat; 57 feet 6 inches broad, 39 feet 4 inches deep, and has a gross tonnage of 9,685 tons. She has a cutter stem, and, relying wholly on her two sets of engines, the masts are little more than three bare poles without yards. Thirty feet up the foremast is a sort of crow's nest for the lookout.

Accommodation is provided for 300 first-class, 150 second, and 750 steerage passengers. She has a promenade deck 245 feet long, with a clear way of 18 feet on each side of the deck houses. Some portion of this promenade is covered by an awning deck, which is used for stowing the boats.

For the fittings and decorations throughout the boat, it must suffice to say that they are unusually lavish, even in these days of sumptuous ocean traveling.

Great Discoveries and Innovations of the Past Sixty Years.

III. PHOTOGRAPHY.

Although the beginnings of photography reach back farther than sixty years, yet the progress that has been made during the sixty years has been so vast and has so immeasurably exceeded what was known at the beginning of that period that we may fairly include it among our serial articles.

The fact that an image may be produced on a screen by means of a lens had been known for many years, and legions of experimenters had seen this image and had commented on its beauty. A beautiful picture of any scene, in all the colors of nature, could be thrown on a screen by a single lens, men and horses could be seen moving about, trees and fields of grain could be seen rustling in the wind; yet all this was transitory, for no means of fixing the image was known. Some substance sensitive to sunlight was necessary — something that could be spread over the screen, and that would turn dark in the dark places of the picture, and remain light in the light places. It was known, of course, that the human skin is sensitive to light in a certain degree, so that the sun on a warm day will turn it brown; but human skin was not a very promising thing to print pictures on, nor was there any way of fixing such pictures after they were printed. At length it was proposed to use compounds of silver, as it was noticed that sunlight has the power of blackening them. A Swedish chemist, Scheele, was the first, we believe, to examine this blackening action of sunlight on silver compounds. About 1780 he found that when moist chloride of silver is exposed to the sun it is split up into chlorine and metallic silver, the latter being in such a fine state of division that it appears black. Jean Senebier, a Swiss clergyman, repeated his experiments and found that this action is due almost entirely to the violet rays. Many still doubted if the decomposition of the silver chloride was really effected by *light*, and in 1798 Count Rumford contributed an article to the Royal Society which he called "An Inquiry concerning the Chemical Properties that have been attributed to Light," in which he endeavored to show that it is heat and not light that produces the observed change. Four years later Harrup proved that certain compounds of mercury are reduced by light and not by heat.

It will be seen that these early discoveries and investigations had only a remote bearing on what we now know as photography, yet they are most interesting, as showing from what small beginnings the modern art started.

In 1801 Ritter showed that there are rays in the sun's light that are invisible to our eyes, but which have a most important influence in blackening the compounds of silver. This discovery attracted great attention, and during the next seven years Seebeck and Bérard carried on investigations that had valuable results. But the event of greatest interest in those early times was the publication of Wedgwood's paper, in June, 1802, on his "Method of Copying Paintings upon Glass, and of making Profiles by the Agency of Light." His process, as he explains, is based upon the fact that white paper moistened with nitrate of silver undergoes no change in the dark, but quickly becomes first brown and then black, when exposed to daylight. His method of procedure was to let the shadow of his object fall on the sensitive paper. The part of the paper in the sun rapidly blackened, and the profile of the object was therefore reproduced. Wedgwood explains that he found it impossible to make these prints permanent, for wash it as much as he would he could not remove the silver from the unexposed portions so that they would not in the course of time turn black like the rest. Sir Humphrey Davy (though he was not at that time a "Sir") then tried to make use of this paper in the camera obscura, but failed, as he explains, on account of the faintness of the image. Even at the time that Davy and Wedgwood were experimenting a substance was known that would fix the prints in the manner desired; for hyposulphite of soda was discovered by Chaussier in 1799, three years before Wedgwood's paper was published; but it was left for Herschel to discover the usefulness of this substance, which he announced in February, 1840.

Passing on a few years in the history of the art we come to a Frenchman, Nicéphore de Niepce, who began his researches in 1814 and continued them with rather discouraging results until 1827, when his labors were crowned with success. In a word, to Niepce belongs the honor of first discovering a process for taking pictures that were afterwards unaffected by light. He coated plates of metal with a solution of asphaltum in oil of lavender, and then, after drying them, he exposed them for a prodigious length of time in a camera. A very faint image was the result. His developer consisted of one part of oil of lavender and ten parts of white petroleum, which must be allowed to stand three days before using. When the plate is immersed in this developer the parts unaffected by light gradually dissolve away, leaving a picture formed of asphaltum modified by light. Later on Daguerre associated himself with Niepce, and the two formed a partnership for prosecuting their researches together. After working with the old process for a time they modified it somewhat, and after they had made some improvements in it Daguerre says that "the time required to procure a photographic copy of a landscape is from seven to eight hours, but single monuments, when strongly lighted by the sun, or which are themselves very bright, can be taken in about three hours." Yet in these days we think nothing of photographing a moving cannon ball, or a flash of lightning! In 1827 Niepce sent to Dr. Bauer of Kew, then secretary of the Royal Society of London, a paper narrating the results he had attained, and accompanied by specimens illustrating the quality of his work. The process, however, remained a secret; and for this reason his paper was not printed in the "Proceedings" of the society.

We regret to say that there are strong grounds for thinking that Daguerre took unfair advantage of the partnership into which he and Niepce had entered, and that he published processes as his own when in reality they belonged equally to his fellow-worker. Indeed it is believed that Daguerre bodily appropriated, without any credit whatever, some of

Niepce's most important discoveries. This belief is supported by a considerable amount of evidence, a considerable portion of which still exists in letters written by Daguerre himself, and by others.

The process, now known by Daguerre's name, consisted in coating a silvered plate with iodine, and then exposing it in the camera for from three minutes to half an hour. It was then exposed to the vapor of quicksilver, which condensed most on those places where the light had acted most. The image was then fixed by immersion in hyposulphite of soda. Afterward it became customary to "tone" the picture by adding to the hyposulphite bath a small quantity of chloride of gold. Other modifications and improvements have since been made, but it would be useless for us to follow them since the whole subject of daguerreotyping has only a historic interest to us now. The process of Niepce and Daguerre was first published on the 6th of February, 1839.

In 1841 Mr. Fox Talbot patented a process that has considerable interest. He brushed sheets of paper over with silver nitrate, and then dipped it in iodide of potash until iodide of silver had formed on the paper. It was then brushed over with a sensitizing solution composed of 100 grains of silver nitrate, 2 ounces of water, and a third of an ounce of acetic acid, to which, immediately before applying it, an equal volume of saturated gallic acid was added. After exposure in the camera the picture develops itself in the dark, and it is fixed by washing in water, dipping in potassium bromide, washing again, and drying with blotting paper.

In 1848 Niepce de St. Victor (who was a nephew of Nicéphore de Niepce) substituted glass for the paper and metal that had hitherto been used as the sensitive films, coating the glass with a thin layer of iodized albumen. His process, as afterward perfected by Le Gray, was substantially like that of Talbot, except that he used glass instead of paper, and was thus able to print as many positives as he pleased from the one plate — which previous experimenters had not been able to do.

In 1850 a great step was taken; for in that year the collodion film was introduced, and from that time on the success of photography was assured. With the introduction of this new substance photography passed into the hands of great numbers who had been deterred from taking it up before on account of the difficulties that had to be contended with; and in consequence of this sudden increase in the number of its votaries the art grew with surprising rapidity and processes multiplied so that we shall no longer attempt to follow them in detail.

In 1854 M. Gaudin in France and Mr. Muirhead in England, announced that it is not necessary that the sensitive plate in the camera should be kept wet, but that if certain precautions were taken dry plates would work equally well; and a little later Dr. Taupenot published an excellent method of preparing plates for dry work. The "alkaline developer" followed soon after, and with it came the first important contribution to the art that the United States had furnished.

Although the introduction of the collodion process had brought about a revolution in photography, a still greater revolution was instituted in 1864 when Sayce and Bolton proposed the use of collodion emulsion. The new method, briefly stated, "was to dissolve a soluble bromide in plain collodion, and add to it, drop by drop, an alcoholic solution of silver nitrate." This was poured over the plate in the usual manner and allowed to set. The special advantages of plates so prepared was that they could be used dry, and that the tiresome sensitizing bath of nitrate of silver did not have to be used. This process attracted a great deal of attention, and gave a new turn to experimental work, and it was not long before gelatine was tried, among other things, as a substitute for the collodion. In 1871 Dr. Maddox had produced excellent negatives with gelatine in the place of collodion, and from that time on until 1878 numerous improvements in the process were made. In this year (1878) it was shown that by keeping the gelatine solution for a number of days in a liquid condition by warming it slightly, the silver salt becomes extraordinarily sensitive; and in 1879 Col. Wortley announced that the same result could be obtained by stewing the emulsion at 150° Fah. in a few hours instead of days. Improvements then followed one another in rapid succession until the art reached its present high state of perfection.

The applications of photography are very numerous and interesting, and its field of usefulness is widening every day. Instead of having to expose our plates for from three to six hours, as in the early days, we now require only a small fraction of a second. We are thus able to photograph animals and other objects even though they are moving at a high rate of speed; and Mr. Eadweard Muybridge, who has given special attention to this branch of the art, has given us a large amount of information concerning the attitudes that animals take while they are in motion. In fact, artists have found his work of great value, and the fruits of it are easily seen by comparing pictures of moving animals, drawn some years ago, with those drawn in more recent days.

In astronomy the uses of photography are numerous and increasing. Maps of the heavens, indefinitely surpassing in fullness and accuracy the best of the hand-made maps, can now be made in the hundredth part of the time and with the hundredth part of the labor formerly required. Accurate records can also be made with ease, of the appearance of the heavenly bodies at critical times, as, for instance, during the eclipse of the sun or a transit of Venus; and measurements of parallax have likewise been executed in the same manner. Beautiful discoveries have been made, by exposing the plate for a great length of time, of objects, such as nebulæ, too faint to be seen by the human eye.

In the arts photography has also found a wide field of usefulness. Engraving is now largely done by means of it, and entire books have been duplicated by photo-engraving each page in the same manner as a drawing would be photo-engraved. (The writer has in his possession a complete set of the Encyclopædia Britannica, reproduced in this way.) Valuable manuscripts are reproduced in *fac simile* for the benefit of scholars all over the world, and many other like applications will doubtless suggest themselves to the reader. Even surveying is making use of the new art, and photo-surveys promise to be familiar things to us in the near future.

Composite photography claims our attention as one of the peculiar possibilities of the art, and though the pictures produced by it are rarely very elegant in appearance, they are often of great interest. Not long ago some very good likenesses of Washington were obtained by means of it, the similar features of the different paintings used being preserved in the final picture, while the differences were eliminated; so that in all probability the result was a better likeness of the Father of his Country than we have heretofore had.

Photography in the true colors of nature — when shall we have that? Attempts that have been made in this direction have already met with some degree of success, but it has been very slight, and the main problem may be considered to be practically untouched.

Back in 1884, when the Mexican Central Railroad was yet a curiosity to the simple people along its line, and the locomotive was not as familiar an object to them as it now is, an Irish employé of the company named Mike McCue set his wits at work to devise a method whereby he could transfer his cooking stove to his new home on the south side of the Rio Grande without having to pay the duty of 9 cents a pound exacted by the Mexican Government. Fortunately for him, he was one day directed to move a lot of freight belonging to the company from El Paso to Paso del Norte. Taking advantage of the opportunity thus offered him, McCue strapped his stove on the front of the locomotive, placed a few joints of stovepipe on it, built a fire in it, and passed the customs officers without the slightest difficulty. They supposed it to be a necessary adjunct to the locomotive.— *Railway Age.*

A citizen of Elmira, Cal., has finished working up a fir tree which grew on his place. He received $12 for the bark, built a frame house 14×30 feet, 8 feet high, with a kitchen 8 feet wide and 20 feet long; built a woodshed 14×30 feet; made 330 fence rails 10 feet long; made 334 railroad ties, 500 boards 6 inches wide and 12 feet long, and 15 cords of wood. All this from one tree, and part of the tree is left.— ***Machinist.***

The Locomotive.

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On Firing With Soft Coal.

It is too generally assumed, in firing steam boilers, that the fuel is burned under conditions over which the fireman or engineer has little or no control; and that any man who can keep up a proper supply of steam is equally good with any other man. That such an opinion is very erroneous is fully shown by many almost daily observations; and one case in point will be enough to illustrate the fact. In a certain plant of three or four hundred horse-power the water for the boilers was passed through a meter, the coal was carefully weighed, and the fire-room log was kept by a competent man. In this way it was easily shown that Mr. A evaporated less than eight pounds of water per pound of fuel, while Mr. B, apparently just the same kind of a man, evaporated over nine

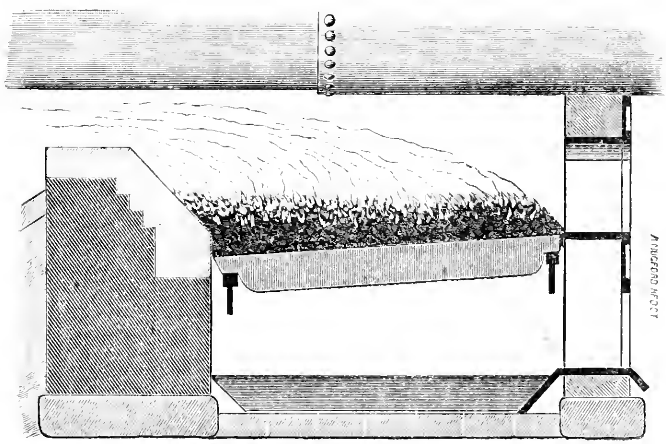

Fig. 1. A Good Fire.

pounds, the difference between the two results being exactly two pounds of water per pound of coal in favor of Mr. B.

It is also a fact that much of the waste generally attributed to the steam engine is in reality due to lack of knowledge and skill in the boiler-room. That a certain quantity of air is necessary in order to secure perfect combustion, is well known; that too much air detracts from the economy and injures the boiler, is also well known; and the skilled and experienced engineer needs no anemometer to tell him when he has reached the delicate point where the air supply is just right. A glance at his fires, a knowledge of his chimney draft, a look at his dampers, and an understanding of the work his boilers are doing, are sufficient to guide him. But there are boilers and boilers, not all of which are cared for or fired in this manner; and it is to those that are not that our illustrations apply.

In Fig. 1 a bituminous coal fire is shown, from six to nine inches thick. It is kept thicker at the back end and along the furnace walls and in the corners, because the heat radiated from the side walls and the bridge causes the coal in these places to burn faster than that on the rest of the grate. It is kept solid and in form by quickly sprinkling a thin uniform layer of coal on alternate sides of the furnace at frequent intervals, and by filling in such parts as may burn hollow. If the fire is neglected for a short time it is morally certain to burn hollow, and holes will develop, through which the cool air in the ash-pit will pour up freely, chilling the hot gases of combustion and materially lessening the efficiency of the boiler.

Fig. 2 illustrates what is called coke firing. The grate is covered with incandescent fuel as in Fig. 1, except near the doors, where a windrow eighteen inches wide, and built of fresh coal, extends entirely across the front of the furnace. The heat to which this windrow is exposed causes it to coke as it would in a retort in a gas works, and to give off the inflammable gases that it contains, which are burned as they pass back over the incandescent bed of fuel. When fresh fuel is required this mass of coke is broken up and distributed evenly over the grate, bearing in mind the necessity of keeping a good

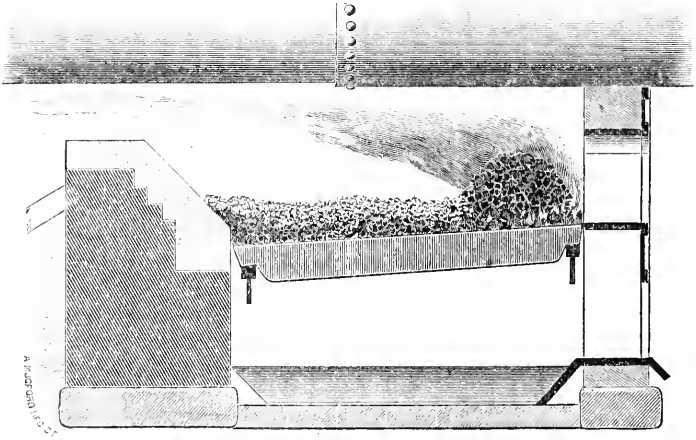

FIG. 2. COKE FIRING WITH SOFT COAL.

supply on those portions of the fire which tend to burn the fastest. When the fire has again become incandescent, fresh coal is put to coke, and so the firing continues. In this method of running a fire it is still all-important to prevent holes from burning through, and admitting undue quantities of air into the furnace.

Other methods of firing are often seen. One is, to fire only at considerable intervals, throwing on coal so heavily as to almost shut off the draft for a time. Fires run in this way and then left to themselves burn hollow, and air rushes though the holes, burning the fuel away around the edges of them, and thus constantly enlarging them until after a time a strong current of cool air passes unchecked up through the grates, along the side walls and the bridge, and the hot gases coming from the coal are so chilled by it that it is almost impossible to make steam. The same result follows when the coal is heaped upon the center of the grate like a haycock, as shown in Figs. 3 and 4; and in both cases the invariable result is a hard-worked fireman, laboring manfully to keep up steam, and a bitter complaint from the office at the cost of the fuel consumed. The cold air that passes up through the empty places on the grate, and which must be heated and passed out at the chimney, puts a constant drain upon the coal piles and a constant effort upon the muscles of the fireman, who punches and works away, fretting at the poor steaming qualities of the boilers and at his inability to keep up steam.

To burn bituminous coal without smoke has long been the hope of inventors and engineers, for it is generally admitted that an enormous waste occurs when any considerable amount of smoke issues from the chimney. It is true that smoke is a sure indication of imperfect combustion, but the vapor ordinarily seen coming from the chimney is not all smoke. The dense black smoke sometimes seen consists almost entirely of unconsumed carbon, but the composition of the lighter smoke is very different. Most

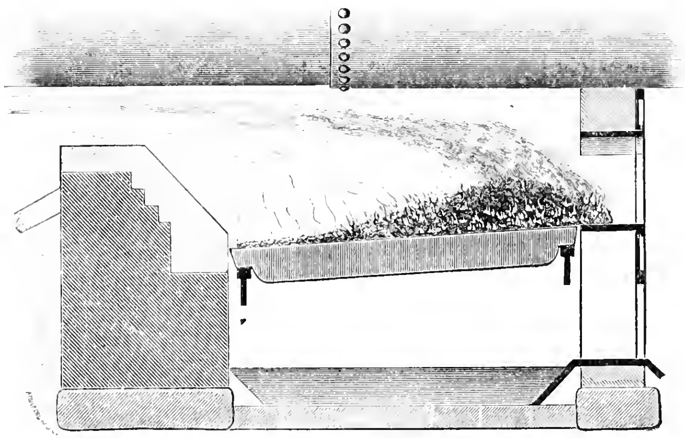

Fig. 3. Bad Firing. — Side View of Furnace.

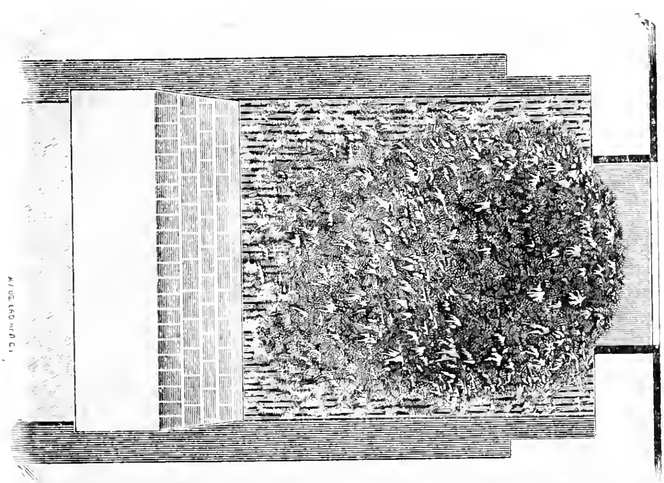

Fig. 4. Bad Firing. — Plan View of Furnace.

coal contains a considerable quantity of moisture, especially bituminous coal; and this moisture is, of course, evaporated by the heat of the fire, and driven off as steam, in company with other products of combustion, giving the light vapor usually seen issuing from the chimneys. Even the densest smoke contains but a small quantity of unconsumed carbon, though of course it is likely to contain a considerable quantity of invisible gases that would have been burned and utilized had the combustion been more perfect. The black smoke is usually given off when long flames of a yellowish or reddish hue lap along the whole length of the boiler and perhaps pass into the flues. When the damper is right, and the draft good, and the fires well laid, so that all parts of the grate are evenly covered, the lazy smoky flame is changed to a short flame of intense brightness.

Too much air is as capable of producing smoke as too little; for by its chilling action, previously explained, it makes perfect combustion impossible, and causes the same dense cloud to appear at the stack.

In charging fresh coal it is a good plan to leave the furnace door ajar slightly until the fire has burned up a little, so as to admit an extra supply of air, that which passes up through the grate being checked for a few moments by the fresh fuel. If the door is kept *wide open* the boiler will be cooled down and may be severely strained, and a big column of cold air will pass right over the fire in a body, and up the chimney; but if the door is kept half or three-quarters of an inch ajar the air that is admitted will distribute itself through the furnace pretty uniformly, and will consume the gases given off by the fresh coal. As soon as these gases burn off the door should again be tightly shut.

Inspectors' Reports.

AUGUST, 1889.

During this month our inspectors made 4,416 inspection trips, visited 7,964 boilers, inspected 3,371 both internally and externally, and subjected 726 to hydrostatic pressure. The whole number of defects reported reached 8,470, of which 650 were considered dangerous; 25 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	415	37
Cases of incrustation and scale,	708	43
Cases of internal grooving,	39	11
Cases of internal corrosion,	309	34
Cases of external corrosion,	678	33
Broken and loose braces and stays,	90	31
Settings defective,	189	15
Furnaces out of shape,	287	9
Fractured plates,	139	52
Burned plates,	122	27
Blistered plates,	249	8
Cases of defective riveting,	2,446	139
Defective heads,	69	16
Serious leakage around tube ends,	1,602	58
Serious leakage at seams,	345	25
Defective water-gauges,	223	25
Defective blow-offs,	71	17
Cases of deficiency of water,	11	6
Safety-valves overloaded,	43	12
Safety-valves defective in construction,	38	13
Pressure gauges defective,	269	27
Boilers without pressure gauges,	1	1
Miscellaneous defects,	127	11
Total,	8,470	650

Boiler Explosions.

AUGUST, 1889.

COAL WORKS (93). The explosion of a boiler at Gumbert & Huey's coal works near McKeesport, Penn., on August 3d, completely wrecked the boiler and engine-house, and instantly killed the engineer, Louis Erb. Three others, John and Philip Harvey, and an unknown young man, were badly scalded, and may not recover. Portions of the boiler were carried a quarter of a mile, and Erb's body was terribly mangled.

PLEASURE BOAT (94). The boiler of the pleasure yacht *Cedar Ridge*, owned by L. B. Crocker, superintendent of the New York Central stock yards, blew up on August 7th, in the boat house at the foot of Ferry street, Buffalo, N. Y., killing three of Crocker's children and a workman, and severely burning three other persons. The boat, a naphtha launch, was completely wrecked, and was burned, together with the boat house.

SAW-MILL (95). On Friday, August 9th, the boiler of "Squire Grounds's" steam mill exploded with terrific force, tearing the engine room into splinters, demolishing the machinery, and wounding or scalding a number of persons, and causing the death of Mr. J. M. Crooks. A stranger named William Lee, a colored man living near Fulton, was in the yard, and received a wound in the back, which it is feared will prove fatal. The loss is not heavy, perhaps $1,000. No insurance. The wounded are James Jackson, colored, badly scalded; William Lee, colored, badly injured internally; J. W. Grady, white, slightly wounded on the head; Robert Chamberlain, slightly burned; Frank Matthews, hit on the head, slightly, and some others whose names could not be ascertained.

PLANING MILL (96). On Saturday, August 10th, a flue burst in the boiler of Burnham, Stanford & Co., at First and Washington streets, Oakland, Cal. No one was injured, but the mill will be closed some time for repairs.

THRESHING ENGINE (97). The boiler of a threshing engine exploded on Monday, August 12th, near Haines Canyon, San Luis Obispo Co., Cal. No one was injured.

STAVE FACTORY (98). A portable boiler, used at Thomas Anderson & Co's stave factory, at Dawson, Ky., to furnish extra power when the factory was specially busy, exploded August 12th, killing James Jackson, Laton Menser, and Dennis L. Purdy, and wounding four others.

THRESHING ENGINE (99). A threshing-machine boiler exploded in New Hope township, D. T., on August 14th, instantly killing Frank Arnswell, William Fowler, and an unknown man who was acting as fireman, and seriously injuring a Russian and a man named Lamaka. Two of the killed were blown a distance of twelve and seven rods respectively.

THRESHING ENGINE (100). Jefferson Mooney was blown twenty feet and his body fearfully torn and his head crushed, John Kennedy's skull was fractured, and several other people were seriously injured, by the explosion of the boiler of a threshing machine at Nortonsville, Va., on August 15th.

BREWERY (101). On August 20th, the boiler in the Gangwisch Brewing Company's establishment, on the corner of Juniata and Magnolia streets, Allegany City, exploded with terrible force. A young man named Schneider, who was acting as engineer in the absence of the regular man, was hurled fifty feet and instantly killed. A Swede named Johnson had both his arms and legs broken and is probably fatally injured. Miss Lizzie Blasco, a domestic standing in an adjoining yard, had her back broken and was otherwise terribly bruised by the flying debris. The brewery building is almost a total wreck. Several employees were more or less severely hurt.

ROLLING MILLS (102). On August 21st a boiler exploded in the rolling mill of Scruggs & Whaley, Gainesville, Texas, blowing out the east end of the building. The top of the boiler was blown over the tops of houses 300 feet away, half burying itself in the ground where it fell. Mr. Bosley, the engineer, was blown over the debris and landed against a pile of wood twenty feet away. He was badly burned about the head, and had both legs scalded. No bones were broken. The air was filled with flying timbers and pieces of iron, some which fell hundreds of feet away. The fire department was called to the scene and quickly subdued the flames. The loss is estimated at from $5,000 to $8,000, with no insurance.

THRESHING ENGINE (103). A boiler attached to a threshing-machine belonging to Charles Swift exploded at Buena Vista, near Ione, Cal., on August 22d, blowing the fireman, George McGivens, eighty-five feet, breaking several ribs and badly scalding him. He is not expected to live.

SAW-MILL (104). A boiler in the saw and planing mill at Port Angles, W. T., exploded on or about August 24th, seriously injuring three men. Two of these, Meagher and Campbell, had their ankles crushed. A piece of steel penetrated the left cheek and under the ear of Meagher, that it required a weight of ninety pounds to remove.

SAW-MILL (105). A flue collapsed on August 27th in the middle boiler of Mr. C. B. Paul's saw-mill, located at the foot of Shelby street, Louisville, Ky. Three men were badly scalded and bruised, and considerable damage was done.

NAIL FACTORY (106). On August 27th, a boiler in the nail factory of Godcharles & Co., at South Towanda, Pa., exploded. Five men were instantly killed, two others will die, and four were terribly injured. The killed are: Richard Ackley, Sanford Smith, John Bostwick, Isaac Bantford, and Guy Heenan. J. Rider and George Seebeck will probably die. Charles MacVeagh, Ray Thomas, and two Swedes, names unknown, are badly hurt. The building was wrecked, and the ruins took fire, but the flames were soon extinguished. The boiler was hurled 70 feet, striking on the railroad track, which it tore up for some distance. The damage to the building and machinery is from $15,000 to $20,000.

SAW-MILL (107). A terrible boiler explosion occurred at the saw-mill of W. H. Weller, five miles southwest of Murphysboro, Ill., on August 29th, which resulted in the death of two men and the terrible mangling of another. Every vestige of the mill was literally blown away, and parts of the boiler were found nearly a quarter of a mile distant.

LOCOMOTIVE (108). A tube failed recently on a locomotive belonging to the Rapid Transit Railroad, Staten Island. The engineer and two friends were badly scalded, one of them being also thrown out upon the track. No one was killed.

Machinery Riots.

The most serious outbreak of machinery rioters occurred in the early part of the present century. This was the period when some of the chief labor-saving machines were being introduced in the factories of this country [England], and the working population were seized with the sudden impulse of destruction. The long and costly war which England had waged, and was still waging, with Napoleon, had reduced the people to the verge of starvation. Heavy taxation, dearness of provisions, and scarcity of employment had crushed the hope out of the hearts of the laboring classes, and they were ready to wreak their resentment upon almost any object that presented itself. They watched with strong discontent the increasing power of machinery, which seemed to threaten them with extinction, and at last, unable to bear the prospect any longer, they began to plot and conspire to prevent any further encroachment upon their imagined rights.

It was in Nottingham that the first manifestation of violence was displayed, the stocking-weavers of the ancient town rising in determined opposition to the new loom, which was then being largely introduced. Riots were organized, under the leadership of a mysterious but not altogether mythical personage called General Lud, and attacks were made upon the various factories in which the obnoxious frames had been adopted. Over a thousand looms were destroyed in Nottingham. So desperate were the rioters that they quickly spread themselves over the whole of the manufacturing districts of the north, and wherever they went carried destruction with them.

Nowhere did the agitation bear more bitter fruit than in the West Riding of Yorkshire, where it spread with relentless force. The rioters used to assemble by night on the moors and commons, and there determine their plans of attack. They administered a fearful oath to all who joined them, each member being sworn never to reveal "to any person or persons under the canopy of heaven" the names of those who composed the secret committee, "their proceedings, meetings, places of abode, dress, features, connections, or anything else that might lead to a discovery of the same, either by word, or deed, or sign, under the penalty of being sent out of the world by the first brother," who should meet him, and having his name and character "blotted out of existence, and never to be remembered but with contempt and abhorrence."

The movement almost swelled to the proportions of a rebellion. As time wore on the boldness of the rioters increased; no mill was safe from attack, no mill-owner but felt his life in peril, for they not only pronounced the doom of the machinery, but of all who used it. Thousands of pounds' worth of property was destroyed in the cloth-weaving districts around Leeds, Dewsbury, and Huddersfield. Vigorous measures were adopted by the local authorities to put down the rioters, but for a long time their efforts were of little avail. Mr. Joseph Radcliffe, of Milne Bridge, was one of the most active of the Yorkshire magistracy in organizing a system for the surprise and detection of the ringleaders, and he was bravely aided by the Rev. Hammond Robertson, of Hartshead (the Mr. Helstone of Charlotte Brontë's "Shirley"). For his services in this cause Mr. Radcliffe had a baronetcy conferred upon him. The assistance of the military had to be sought in many instances, and conflict between the soldiers and the rioters was frequent. Deeds of murder, atrocity, and outrage were committed on all sides, and the government were compelled to pass a special act of parliament with a view to checking these crimes. Arrests were made daily, and the prisoners became so numerous that special commissions for their trial were opened in the various assize towns of the north. Rewards were offered and king's pardons to accomplices; but, though many offenders were brought to justice, the agitation did not abate. A crisis was precipitated, however, in the month of April, 1812, by the perpetration of two crimes of startling violence.

On the night of Saturday, the 11th of April, according to a preconcerted plan, a body of Ludites, some hundred and fifty strong, made an attack upon the mill of Mr. William Cartwright, at Rawfolds, near Liversedge. For more than six weeks previous to this night, Mr. Cartwright, four workmen, and five soldiers, had slept in the factory. The mill-owner knew that the Ludites were bent upon destroying his machinery, and he had determined, if possible, to prevent them. Shortly after midnight this gallant little band of defenders retired to rest, Mr. Cartwright having first assured himself that the pickets outside were at their posts. For a while all was as still as death; the first hour of the Sabbath had been entered upon with a calm peacefulness that was in harmony with the associations of the day. But the stillness was not to be of long duration. At twenty-five minutes to one, the dog in the yard began to bark furiously, and Mr. Cartwright immediately jumped out of bed. As he opened the door of the room where he had been lying down, he was startled by a crash of breaking windows and a discharge of fire-arms. He also heard a loud hammering at the mill doors, and the sound of many voices. He rushed to the spot where he and his companions had piled their arms before going to bed; the workmen and the soldiers were running to the same place; and all, like himself, were without clothing, except their shirts. There was no time to be lost. Each man seized his gun. Two of the workmen ran to the top of the mill and rang the bell. Then the bell rope broke, and they rushed down again. All this time the mob without were discharging their guns and pistols at the windows, and the hammering at the door was kept up unceasingly. George Mellor, the General Lud of the district, was leading the attack, the rioters having advanced in regular military order, the musket-men first, then the pistol-men, then the hatchet-men, club-men, and staff-men, those without weapons bringing up the rear. "Bang away, my lads!" "In with you!" "Kill them every one!" were the shouts that proceeded from the mob, as volley after volley was fired. But the half score besieged men were not to be so easily overcome. The conflict was kept up for about twenty minutes, and then, unable to effect an entrance, and having spent all their ammunition, the Ludites, repulsed and furious, retreated in the direction of Huddersfield, leaving behind them two wounded companions, who afterwards died.

This was the incident which Charlotte Brontë worked up with dramatic effect in "Shirley," only, for the sake of picturesqueness, she described the little mill in the hollow near Haworth instead of the one at Rawfolds. Mrs. Gaskell, in a note upon this circumstance, mentions the fact that some of the rioters had threatened that if they did not succeed in forcing their way into the mill, they would break into the house, which was near, and murder Mr. Cartwright's wife and children. "This was a terrible threat," she wrote, "for he had been obliged to leave his family with only one or two soldiers to defend them. Mrs. Cartwright knew what they had threatened; and on that dreadful night, hearing, as she thought, steps approaching, she snatched up her two infant children and put them in a basket up the great chimney common in old-fashioned Yorkshire houses." Within a week of the attack on the mill, Mr. Cartwright was twice shot at on the high road. The ringleaders were subsequently arrested and tried at York. Mr. Cartwright was presented with a sum of £3,000, subscribed by neighboring mill-owners, as a tribute of admiration of his courageous conduct.

A few days after the attack on Rawfolds mill, Mr. William Horsfall, a manufacturer at Marsden, while riding home from the Huddersfield market, was fired at from behind a wall and killed. Four Ludites — George Mellor, William Thorpe, Thomas Smith, and Benjamin Walker — were concerned in the commission of this crime. Walker afterwards turned king's evidence, and the other three were hanged. At the special commission opened at York in January, 1813, sixty-four persons were put upon their trial for offenses connected with Ludism, and fifteen of them were executed on the same scaffold on the morning of the 16th of January. This severe example had the effect of repressing the agitation.— *Romance of Invention.*

THAT is a story worth preserving — the one that comes from Chicago, narrating how the workingmen helped one of their fellows to a home. A Bohemian laborer, Mr. Seveck, by years of self-denial had saved money enough to build himself a home; not a mansion, but a sufficient shelter for himself and family. But in a furious gale his house was blown down and utterly demolished. The saving of years were gone in a moment, and old age was coming on. Then it was that the workingmen — men scarcely better off than himself — carpenters and masons — gave the work of three Sundays to building him a new house. They finished it completely, ready for him to move into, and the women of the neighborhood provided a dinner, and the children brought flowers. True the work was done on Sundays, but it was a good deed, for the doing of which there is high authority. The *Chicago Tribune*, which notices the matter at considerable length, says: "The Sevecks are obscure people. The new house is a little one. The people who built it are not famous, but no more beautiful or charitable deed ever illuminated this world." When conspicuous examples of charity and good will are wanted, the place to look for them is amongst those who have little to give. There is a great deal besides lumber and nails and stone and brick in this house that Chicago workingmen built for the Sevecks. — *American Machinist.*

Near-Sightedness.

We learn from *Science* that Dr. Boucheron, a Paris physician, has made some observations on near-sightedness that are highly interesting, if true. "The children of myopes are not born myopes; they become so, but at an age more and more young, according as generations succeed. Thus, a grandfather who became myopic at twenty years, having a son myopic at fifteen years, would be able to read in old age without spectacles, and the son would also; but the grandchildren will become myopic at twelve years. The great-grandson will be a myope at eight years, will arrive at six dioptrics of myopia at fifteen years, at eight dioptrics at thirty years, will lose an eye at thirty-five years, and will have great difficulty in preserving his second eye to the end of his days. It is therefore necessary that this state of things should be more vigorously attended to. Dr. Boucheron remarked that in children somewhat the same thing happens with the muscles of the eye as what occurs in writer's cramp. The child strains, contracts himself, and there is produced cramp of the accommodation of the eye, and this abnormal accommodation tends to become permanent in myopic pupils. Dr. Boucheron examined one hundred pupils in one institution, and took the measure of their myopia. He instilled atropine into their eyes, and their myopia was modified. Hence, beyond the principles of hygiene, so easy to institute, he recommends the employment of feeble doses of atropine, or simply cocaine."

It may be that Dr. Boucheron's conclusions are correct in the long run of cases, but they certainly are not borne out by observations in this country. The facts are as follows, according to the practice of our best American oculists: A tendency to near-sightedness is observable, among the children of near-sighted persons, and this tendency appears to be more pronounced when both parents are myopic than when only one of them is so; and this is precisely what we might expect from general considerations. Moreover, it is by no means certain that children are not born myopic, for it must be evident that it is exceedingly difficult to find out whether the sight of a baby is normal or not. It is true that the ophthalmoscope enables us to measure the curvature of the different refracting surfaces of the eye, and then to learn, by calculation, whether the images of objects are formed on the retina or not; but the eye of a child only a few days old is so excessively sensitive and delicate that the strong light ordinarily used in such examinations would ruin it forever. Measurements have been made, however, with very faint light, on the eyes of children less than a week old, and some have been shown to be near-sighted by the process of calculation above referred to. In several respects, therefore, Dr. Boucheron's results look questionable.

The Locomotive.

HARTFORD, OCTOBER 15, 1889.

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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MAYOR Grant, of New York, has done himself credit in selecting the men who are to get the World's Fair of 1892 under weigh. The indications are, now, that the fair will be held, and that it will be successful.

ON Tuesday, October 15th, the American Boiler Manufacturers' Association meets at Pittsburgh. It was organized in that city six months ago, the first meeting being held at Hotel Anderson on April 16th. The next regular meeting is to be held in New York on the first Tuesday in February, 1890, the present meeting being called for the purpose of hearing certain committee reports, and for discussing certain matters relating to the organization.

THE reports of the twelfth and thirteenth meetings of the chief engineers of the steam boiler owners' associations of France (*Comptes Rendus des Séances des* 12ᵉ *et* 13ᵐᵉ *Congrès des Ingénieurs en Chef des Associations de Propriétaires d' Appareils á Vapeur*), which we have just received, are full of useful information and discussion concerning the strength of materials, the evaporative power of boilers, the efficiency of engines, and many other important things. We were specially interested in the very full and detailed accounts of explosions that are given.

MR. HENRY C. ADAMS, statistician to the Interstate Commerce Commission, has recently submitted a first annual report of the statistics of railways in the United States, for the year ending June 30, 1889, a copy of which we have received. It consists, briefly, of five tables, treating respectively of the classification of railways and mileage, of the amount of railway capital on June 30, 1888, of the earnings and income for the year, of the general expenditures, and of payments on railway capital. To the main body of the work an appendix is added, treating the subject of railway statistics in general; and to the whole two very complete indexes are attached. The entire work forms a volume of 390 pages.

"BOILER Explosions in 1888" is the title of an interesting little pamphlet published by E. & F. N. Spon, from the pen of E. B. Marten, who is chief engineer to the Midland Steam Boiler Inspection and Insurance Company, of England. This is the 27th report of the kind that has been issued by Mr. Marten, and it includes all the explosions in England during the year. In all there were 47 true boiler explosions during 1888, resulting in the death of 18 persons, and in injury to 49 others. There were 15 other explosions of apparatus similar to boilers, but which could not properly be classified with them. These additional explosions resulted in the death of 3, and in injury to 16. The casualties are illustrated, almost without exception, and the manner of failure is indicated in each case, making the pamphlet both interesting and instructive.

We acknowledge with much pleasure the report of the board of commissioners appointed by Massachusetts to set to rights the boundary line between Massachusetts and New Hampshire. The line from Lowell to the ocean is very crooked, and is supposed to follow the course of the river, three miles distant therefrom, on the northerly side. The questions to be decided were, whether the boundary monuments as they now stand represent the present line of jurisdiction between the two States; when, by whom, and under what circumstances these boundary monuments were erected; and whether the present line or any other line had ever been established by competent authority. In discussing these matters the report reproduces many interesting old documents bearing on the question, and several *fac simile* maps. As the outcome of much discussion it has been decided to let the line stand as it is, and to make no changes except such as may be necessary in replacing monuments that have been moved, or that were not originally placed in the positions they were intended to be in.

Experiments on Iron and Steel.

We have received from Mr. James E. Howard a most interesting paper on the "Physical Properties of Iron and Steel at Higher Temperatures," giving the results of experiments made at Watertown Arsenal, Watertown, Mass. A large number of bars were tested, the co-efficient of expansion of each being carefully measured, and the temperature of the bars during the subsequent tests determined by observing the elongation, by heat, of measured lengths of them. It appears that "the tensile strength of steel bars diminishes as the temperature increases from zero, Fah., until a minimum is reached between 200° and 300° Fah.; the milder steels appearing to reach the place of minimum strength at lower temperatures than the higher carbon bars. From the temperature of this first minimum strength the bars display greater tenacity with increase of temperature until the maximum is reached between 400° to 650° Fah." The greatest loss of strength, in passing from 70° to the temperature of first minimum strength, was 6.5 per cent., at 295° Fah. The greatest gain over the strength of the metal at 70° was 25.8 per cent., the maximum point being reached at 460° Fah. "The elastic limit appears to diminish with increase of temperature. Owing to a period of rapid yielding without increase of stress, or even under reduced stress, the elastic limit is well defined at moderate temperatures with most of the steels. Mild steel shows this yielding point up to the vicinity of 500° in hard steels, if present, it appears at lower temperatures. . . . It appears that the contraction of area of the mild and medium hard steels is somewhat less at 400° to 600° than at atmospheric temperatures, and within this range there is a tendency to fracture obliquely across the bar. The hard steels showed substantially the same contraction up to 500° Fah. Above 500° or 600° the contraction increases with the temperature of the metal. . . . One specimen of steel, fractured at the temperature of 1,572°, contracted 98.9 per cent."

Experiments were also made with riveted joints and steel boiler plates, at temperatures ranging from 70° to 700° Fah. "Joints at 200° showed less strength than when cold; at 250° and higher temperatures the strength exceeded that of cold joints; and when overstrained at 400° and 500° an increase of strength was found upon completing the test cold. . . . Rivets that sheared cold at 40,000 to 41,000 lbs. per square inch, sheared at 46,000 lbs. per square inch at 300°; and at 600°, the highest temperature at which the joints failed in this manner, the shearing strength was 42.130 lbs." The paper from which we quote contains six valuable plates in addition to the many tables, and throws a good deal of light upon some vexed questions.

Great Discoveries and Innovations of the Past Sixty Years.

IV. The Conservation of Energy.

The discovery of the conservation of energy is probably the greatest achievement of man. It may be explained in simple language, and one soon comes to look upon it almost as a self-evident truth ; yet its importance can hardly be overestimated. It is, in fact, the foundation of everything. Our everyday work would be impossible without it; the simplest calculations that we make are based upon it; and even our philosophies (though the fact is not always easy to see) accept it as their ultimate basis.

In beginning our examination of this subject, let us consider a few examples of the fact that "action and reaction are equal and opposite." Let us suppose that a glass globe containing a number of goldfish is so delicately mounted upon wheels or rollers that the slightest conceivable touch is sufficient to make it move. Now, however the goldfish move about in that globe — with whatever violence or in whatever direction — we may rest assured that the globe itself will not move in any direction. If a fish presses upon the water with his tail, so also does the water press back upon the fish to an equal extent and in an opposite direction. (In fact, any pressure whatever, when produced between two objects, must of necessity act equally upon both of them.) The result is, that whatever the forces are that are set in action by the fishes in the globe, an equal number of precisely equal forces exist in the opposite direction; so that no motion can possibly be communicated by the fishes to the globe as a whole.

Let us now consider the case of a rifle and ball. When we fire the rifle the most noticeable result is that the ball rushes forward with great velocity, and goes perhaps a mile before it comes to rest again. It seems to us that here is surely a case in which action is not equal to reaction. It appears that the ball has been sent forward without any equal effect being produced in the opposite direction. As a matter of fact, however, an equal effect has been produced; for if the ball weighs say one ounce, and the rifle 100 ounces, and if the velocity given to the ball is 1,000 feet per second in a forward direction, a velocity of 10 feet per second in a backward direction will be given to the rifle itself, causing it to "kick," as the sportsmen say. The force that acts forward on the ball is precisely equal to the force that acts backward on the rifle; but the velocity that this force communicates to the rifle is only one one-hundredth of that which it communicates to the ball, because in the rifle there is 100 times as much matter to be moved. Thus we see that although at first here seemed to be a case in which action and reaction were exceedingly unequal, we find upon examination that the equality does in reality exist.

There are many other apparent exceptions to the law of equality of action and reaction, but every one of them, when properly examined, will be found to confirm the law instead of opposing it. For instance, when we let a stone fall to the earth we do not see a reaction, but we may be sure that one exists. In fact, the case is very much like the one just cited, except that here the bodies are coming together instead of going apart. The earth corresponds to the rifle, and the stone to the ball; and though the motion of the earth toward the stone is exceedingly small, it is nevertheless capable of being calculated, and we may be certain that it really takes place, and that we could per ceive it if we had instruments sufficiently delicate.

Returning to the consideration of the rifle and ball, we have to own that although the momentum of the rifle is equal to the momentum of the ball (the greater mass of the rifle exactly compensating for its lesser velocity), there is, nevertheless, a tremendous difference between being in front of the rifle and being behind it. Now in what does this difference consist? Clearly it is that the ball has the power of penetrating wood, water, flesh, etc., and that the rifle has not; that is, the ball has the power of *overcoming resistance*, and the rifle has not. This something that the ball possesses that the rifle does not is called *energy;* and energy may therefore be defined as "the power of overcoming resistance, or of doing work."

A little consideration will show that this energy will be proportional to the weight or mass of the ball; for, as Balfour Stewart says, "a ball of two ounces moving with the velocity of one thousand feet per second will be the same as two balls of one ounce moving with this velocity, but the energy of two similarly moving ounce balls will manifestly be double that of one, so that the energy is proportional to the weight, if we imagine that meanwhile the velocity remains the same." But though the energy that a moving body possesses is thus proportional to the weight of that body, it is not proportional to the velocity with which the body moves. It increases much faster than that velocity; for if this were not the case the energy of the rifle and the ball would be the same, the greater weight of the rifle exactly compensating for its lesser velocity, as already explained. It must be, therefore, that when the velocity of a body is doubled, its energy is much more than doubled. Experiment shows that a cannon ball has its penetrating power, or power of overcoming resistance, increased fourfold by doubling its velocity; that is, a ball that has a certain velocity can penetrate a certain number of inches of plank; and a similar ball with double the velocity can penetrate four times as many inches of plank. This fact is expressed by saying that the energy of a body is proportional to the square of the body's velocity.

At this point it will be necessary to explain the exact meaning of the word *work*. Every one knows in a general way what work is, but for the purposes of this article we want a more precise definition. Work is the overcoming of resistance; and, for scientific purposes, at least, it is measured in foot-pounds. A foot-pound is the amount of work that must be done in order to lift a one-pound weight through a vertical height of one foot. To raise ten pounds one foot, ten foot-pounds of work must be done; to raise one pound thirty feet, thirty foot-pounds of work must be done; to raise 10 pounds 30 feet, 300 foot-pounds of work must be done. That is, the work done in raising a weight is found by multiplying the weight (in pounds) by the distance (in feet) through which it is lifted. In the same manner, the work done in overcoming any other resistance is found by multiplying this resistance (estimated in pounds) by the distance (in feet) through which it is overcome; and the work done by any force is found by multiplying that force (estimated, as before, in pounds) by the distance, in feet, through which it acts.

We are now prepared to understand the following statement: It has been found by experiment that a body weighing w pounds, and moving with a velocity v, possesses an amount of energy equal to $w \times v^2 \div 64$. As an example, let us return to the bullet, which weighed one ounce, and was moving with a velocity of 1,000 feet per second. Its weight is 1-16th of a pound, so that $w \times v^2 = \frac{1}{16} \times 1{,}000{,}000$, or 62,500. Dividing this by 64, in accordance with the formula, we find that the energy of the ball is 976 foot-pounds. This means that if it were possible to attach one end of a string to the moving bullet, and the other end to a train of perfectly frictionless gearwheels (to reduce the velocity), the bullet would raise a weight of 976 pounds through a height of one foot before it came to rest. Again, if the bullet should strike against a target made of wood of such a quality that a pressure of 400 lbs. would have to be exerted against a similar bullet in order to press it into the wood, our imaginary bullet with a velocity of 1,000 feet a second would penetrate this target 2.44 feet before it came to rest. ($976 \div 400 = 2.44$.) For in order to penetrate at all the bullet must keep up a continuous pressure against the wood in front of it of 400 lbs.; and in moving through the wood a distance of 2.44 feet it does 2.44×400 (=976) foot-pounds of work, which is exactly all the work it was capable of doing, and therefore at the end of 2.44 feet it stops.

We may now perceive, perhaps, a part of the meaning of the expression "conservation of energy." The bullet, in penetrating the wood, can do no more (and no less) work than the equivalent of the energy it had, in virtue of its velocity.

A stone or a weight, weighing one pound, and raised sixteen feet above the ground, can do sixteen foot-pounds of work in falling. If it is connected to a train of wheels and made to run a clock, or some other piece of mechanism, it does that work, and comes down slowly to the ground. If it is allowed to fall freely, it does no work, but comes quickly to the ground, and strikes it with considerable velocity. Surely here is a case in which energy is not "conserved"; surely here is a case in which the energy that the stone possessed, in virtue of its elevated position, does nothing, and is lost. But no; when the stone starts it has no velocity, and when it strikes the ground it has a considerable velocity. The energy that it had in virtue of its elevated position has disappeared, it is true, but in disappearing it has given rise to the velocity that the stone has when it strikes the ground; and that velocity may be shown, by experiment, to be 32 feet per second. The pound weight, moving with a velocity of 32 feet per second, as it is when it strikes the earth, is capable of doing precisely as much work as it would have done if allowed to fall slowly, while connected with the clock. For, as we have said, when it operates the clock it does 16 foot-pounds of work; and when it is moving with a speed of 32 feet per second it possesses $1 \times 32^2 \div 64$ (=1,024÷64=16) foot-pounds of energy — the same as before. During its fall, therefore, it has lost none of its power of doing work — that is, it has lost none of its *energy*. When it does strike the earth its energy is at once removed from it, it is true, but still it is not lost. It is converted into heat, as we shall see later on.

As a matter of fact, no instance has ever yet been found in which energy is either created or lost; and scientists are now fully persuaded that there is no such instance in the whole universe. The planets and their satelites afford us beautiful examples of the transformation of one kind of energy into another — of the energy of position into the energy of motion, and *vice versa* — but it appears from a mathematical analysis of their motions that none of their energy passes out of existence into nothing, or comes into existence from nothing.

Our readers are all very well aware that heat was at one time regarded as a substance; but that this theory was exploded early in the present century, and that we now know heat to be a kind of motion — a motion of the molecules of substances. It has been found that heat and mechanical energy can be converted, the one into the other. Accordingly, we are now pretty familiar with the fact that the heat given off by a pound of water in cooling one degree Fah., would, if it could all be converted into mechanical energy, raise a one-pound weight through a vertical height of 772 feet (780 feet according to later measures). We are also growing more familiar with the fact that electricity, chemical affinity, and all other forces can be converted into heat, and that each has its own invariable heat equivalent. The dynamo converts mechanical energy into electricity, and the electric motor reconverts electricity into visible mechanical energy. The thermopile converts heat into electricity, and any electrical resistance will convert electricity back into heat. Plants convert the energy of sunlight into the energy of chemical separation, giving us coal, oil, and natural gas. These again, in our ordinary stoves and lamps, have their energy of chemical separation transformed once more into light and heat. The steam engine transforms heat into mechanical energy; and any unlubricated bearing or hot box illustrates the conversion of mechanical energy into heat. In fact, every form of energy is transformable into every other form; and when an amount of energy of one form disappears, a precisely equivalent amount of some other form of energy appears. When the rifle ball penetrated the wooden target, thereby doing 976 foot-pounds of work, the visible energy of motion that it possessed became at once transformed into invisible heat. When the ball had come to rest, in the place of 976 foot-pounds of mechanical energy we had 1.26 units of heat (976÷772=1.26) given off, which heat was absorbed by the target. (We may show, experimentally, that heat is produced in this manner, by hammering a piece of lead on an anvil. Under repeated blows the lead grows quite hot.) When the stone weighing one pound fell a distance of 16 feet, the energy that it possessed became converted into heat immediately upon its striking the ground; but since it takes 772 foot-pounds of mechanical energy to produce enough heat to raise the temperature of a pound of water one degree, the heat given out by a stone falling through a small distance is so slight that it cannot be detected without special instruments. When the stone falls a great distance, however, (as is the case with meteors), the heat given out is at once apparent; it may even be so great, in the case of meteors, as to vaporize part of the stone.

So all the phenomena that we see, from the grand falls of Niagara to the truck-horse drawing a wagon, are merely instances in which some form of energy is being transformed into some other form — without the loss or creation of a single foot-pound. In fact, it is firmly believed that the sum total of all the energies of the universe is precisely the same now as it was when the universe was created — that there is not one single foot-pound more or less of it than there was then, or than there will be when it all comes to an end.

This, then, is what is meant by the "conservation of energy." The honor of its discovery does not belong to any one man. Grove, Mayer, Séguin, Joule, Helmholtz, Rankine, Clausius, Tait, Andrews, Maxwell, and William and James Thomson — all contributed to it, and to them all belongs the glory.

There is one consideration that must not be omitted. It is easy enough to transform all of a given quantity of mechanical energy into heat; but the heat so produced cannot all be transformed back again into mechanical energy; some of it, when once changed into heat, must evermore remain as heat. This arises from the fact that no heat engine can be perfect, even in theory, for reasons that were pointed out by Carnot. There is no energy lost, be it understood. The point is, that it is easier to make the transformation in one direction than to make it in the other; and the result is that there must be a gradual and continuous transformation of mechanical energy into diffused heat, which will come to an end only when all the mechanical energy of the universe is transformed into heat, and that heat has become uniformly diffused throughout space. "Although, therefore, in a strictly mechanical sense," says Balfour Stewart, "there is a conservation of energy, yet, as regards usefulness or fitness for living beings, the energy of the universe is in process of deterioration. Universally diffused heat forms what we may call the great waste heap of the universe, and this is growing larger year by year. . . . It has been well pointed out by Thomson that, looked at in this light, the universe is a system that had a beginning and must have an end; for a process of degradation cannot be eternal. If we could view the universe as a candle not lit, then it is perhaps conceivable to regard it as having been always in existence; but if regard it rather as a candle that has been lit, we become absolutely certain that it cannot have been burning from eternity, and that a time will come when it will cease to burn. We are led to look to a beginning in which the particles of matter were in a diffused chaotic state, but endowed with the power of gravitation, and we are led to look to an end in which the whole universe will be one equally heated inert mass, and from which everything like life or motion or beauty will have utterly gone away."

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The Locomotive.

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Explosion of an Oil Still.

The engravings illustrate an instructive explosion that took place some little time ago in Pennsylvania. The still was used only for the purpose of removing the lighter hydrocarbons, and it did not reduce the oil to more than sixty degrees specific gravity. There was therefore no liability to accident from burning, from deposit or from fouling of pipes and connections, as only a low degree of temperature was required. The generator which exploded was 21 feet in diameter and $8\frac{1}{2}$ feet high from the bottom to the

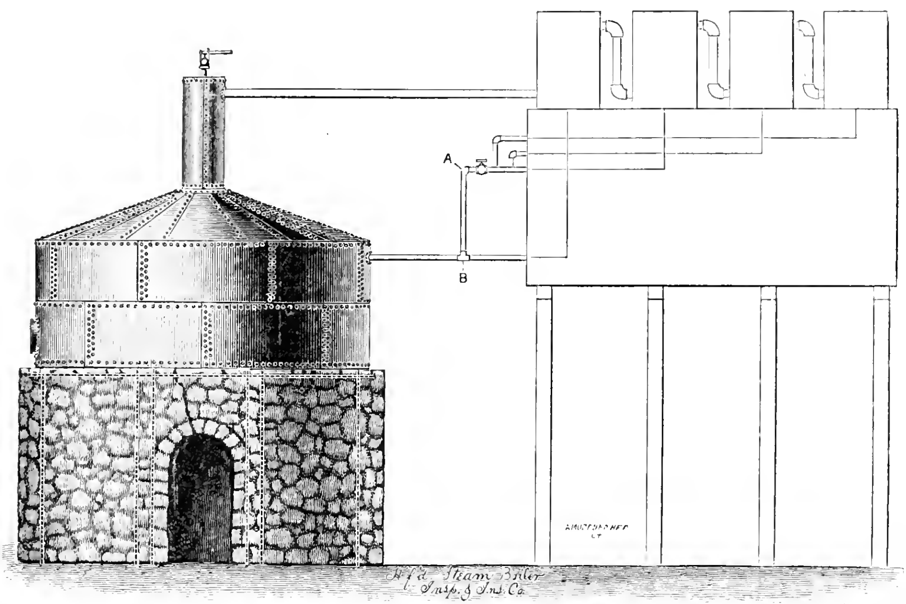

FIG. 1.—THE STILL BEFORE THE EXPLOSION.

root of the roof flange, and was heated internally by 300 lineal feet of three-inch steam pipe. The upper head, or roof, was about 3 feet 3 inches high, and to it a dome was fitted that was 7 feet high and 30 inches in diameter. The bottom of the still was flat, and was secured to the shell with $3'' \times 3'' \times \frac{1}{2}''$ angle iron. The bottom and shell plates were each $\frac{5}{16}$ inch thick, and the dome and roof $\frac{1}{4}''$. The vertical seams of the shell were double riveted.

The generator was supported upon a stone foundation consisting of 18-inch walls with strong buttresses, and two division walls for central support; and crossing underneath it, and firmly and evenly bedded in all the walls, were bars of railroad track iron, to give an even and uniform support. All the work was new, and the accident took place during the third run, just at night. It was proposed ultimately to run the still under 10 to 15 lbs. of internal pressure, but at the time of the accident the ball had not yet been placed on the safety-valve, and as the weight of the lever was all that held the valve down, the pressure in the tank at the time of rupture could not have been greater than 1½ lbs. to the square inch. A heavy shower of rain was falling at the time, and a stiff wind was blowing, the initial rupture taking place upon the exposed side. The fracture was along the row of rivets in the bottom of the shell, and in the angle iron, the action being to tear the shell from the bottom through either the line of rivets or the root of the angle in the flange.

After the explosion the generator was found in the yard in the position indicated in Fig. 2. The dome was driven inward through the roof, as shown, part of it also projecting downward into the ground. From the position of the wreck we infer that the generator must have been buckled in construction, so that it did not rest evenly and equally upon its seating: it may have been unsupported, therefore, for many feet in its circumference and for some distance inward, throwing a severe strain upon the angle iron and its connection to the shell. This view of the case was borne out by an examination of a duplicate still at the same works, which was found to rest upon the central

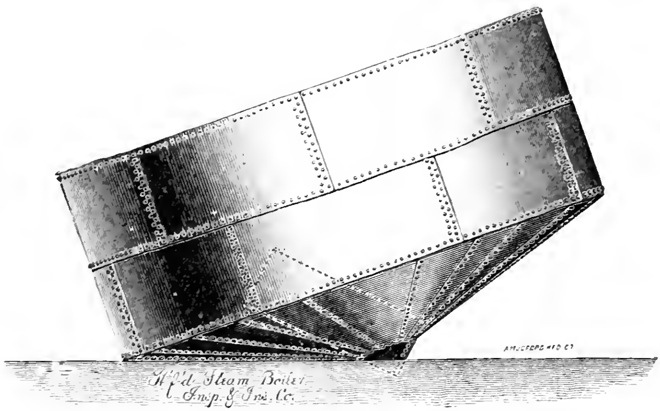

FIG. 2.—POSITION OF THE STILL AFTER THE EXPLOSION.

portion of the bottom, this part being held rigid by the weight of the pipe coils, while the outer edge of the still touched the seating at two or three points only. It was also borne out by the fact that at the time of the first filling or run, the drip-pipe connection was broken at A and B, which would indicate that the generator had settled. The foundations showed no sign of having settled, save for a crack through the arch over each door. We understand, however, that these cracks were not visible before the explosion, so that they probably occurred at the moment when the explosion took place.

The primary cause of the accident, therefore, seems to have been the settling and consequent alteration of form, each time the still was used, throwing a severe strain upon the point ruptured. The plates were not of a quality suitable to withstand much strain or buckling, and no doubt the fracture was large and perhaps nearly complete some time before the accident, the final giving out of the structure being hastened by the contraction caused by the rain. The shell was not thrown to any distance, but merely tipped over into the position shown in Fig. 2, which would require but slight internal pressure, assisted by the wind and the steam escaping after the coil connections were broken inside.

Stills of such a size as this one should be constructed with great care, and should contain only the best of material. In forming the angle iron that joins the shell to the bottom plates everything should be made true and uniform, so that the shell can be attached without the use of drift-pins to draw the parts together. In order to effect this, drilled instead of punched holes would be necessary on this part of the work. Any distortion or buckling in so large a surface is greatly augmented when the generator is filled with oil. The bottom and sides are made rigid by the timbers and scaffolding placed within for the support of the coils, and hence, if there is a depression on one side, owing to a want of contact with the foundation, the strain would very naturally locate itself at the joint connecting the cylinder with the bottom. That a tendency to such deflection and strain would exist may be seen by the following figures: the weight of the contents of the generator, including the timbers and coils, and assuming the oil to weigh 55 pounds per cubic foot, would be not far from 80 tons. The unsupported part of the bottom would be subjected to a strain due to a considerable part of this weight, and in our judgment it is quite possible that this strain might be so distributed as to rupture the plates receiving it. After the crack or rupture had occurred there was nothing to hold the cylinder to the bottom, through the ruptured section, and as the area of the bottom of the tank was about 50,000 square inches, one pound of internal pressure per square inch would give a total pressure of 50,000 pounds, tending to separate the top of the generator from the bottom. Now, the weight of the cylinder and the top was only about 12,000 pounds, so that it is plain that with one pound of internal pressure per square inch, the lifting force exerted on the upper part of the generator and tending to lift it from the lower part would be over four times the generator's weight. The conditions were similar to those in a balloon. The generator would naturally begin to lift at the fractured portion and turn over in the opposite direction, the unfractured portion preventing its being lifted off the bottom bodily. The sudden gust of wind striking it on the west side, and the dash of rain suddenly cooling it off were efficient aids to the accident, no doubt, and the reaction of the steam as it escaped from the broken coil connection may have helped also.

In building and setting up stills of this size and description, the following precautions should be taken. The angle iron connecting the cylinder or shell to the bottom should be laid out with great care so that it shall lie on the bottom without rocking or buckling. The holes in the angle iron and the shell should then be drilled instead of punched, and care should be taken to have them coincide without being forced to make them do so by the use of drift-pins. In seating the tank upon its foundation, care should be taken to have complete contact at all points. It would be difficult to construct a still of such size as this with an absolutely flat bottom, and hence the necessity arises of paying careful attention to the seating in order that no part shall be left unsupported, so as to bring an undue strain on the more rigid portions. All places where there is not contact with the foundation walls should be grouted with good cement, and such places within the wall as do not rest firmly on the foundation should be "shimmed" up and made secure. A good quality of iron should be used in these large generators, and in our judgment the lower course of plates on such a one as this should be three-eigths of an inch thick. The angle iron, too, should be stouter — we should recommend $2\frac{1}{2}''$ by $4\frac{1}{2}''$, and $\frac{3}{4}''$ thickness. Lastly, it would be wise to brace such tanks from the bottom to the shell, with $\frac{3}{4}''$ iron braces, three feet or so in length, and about two feet apart.

The reports of the committees appointed by the American Boiler Manufacturers' Association will undoubtedly be printed later on, and when they are we shall be pleased to review them more fully than is possible at present.

Inspectors' Reports.

September, 1889.

During this month our inspectors made 5,024 inspection trips, visited 9,060 boilers, inspected 3,911 both internally and externally, and subjected 628 to hydrostatic pressure. The whole number of defects reported reached 8,285, of which 616 were considered dangerous; 34 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	495	35
Cases of incrustation and scale,	821	44
Cases of internal grooving,	61	6
Cases of internal corrosion,	305	18
Cases of external corrosion,	617	31
Broken and loose braces and stays,	87	10
Settings defective,	217	26
Furnaces out of shape,	197	13
Fractured plates,	136	35
Burned plates,	112	18
Blistered plates,	287	13
Cases of defective riveting,	2,266	58
Defective heads,	57	19
Serious leakage around tube ends,	1,464	50
Serious leakage at seams,	314	19
Defective water-gauges,	177	26
Defective blow-offs,	64	24
Cases of deficiency of water,	17	6
Safety-valves overloaded,	34	7
Safety-valves defective in construction,	51	18
Pressure gauges defective,	280	34
Boilers without pressure gauges,	3	3
Unclassified defects,	223	103
Total,	8,285	616

Boiler Explosions.

September, 1889.

Coal Mine (108). A boiler of the north mine, at the Portsmouth coal mines, Portsmouth, R. I., exploded with tremendous noise and force at half-past six, on the morning of Sept. 5th. Charles Morgan, a fireman, was so badly scalded that he died two hours later. The whole side of the building over the mouth of the mine is a mass of broken timbers and loose bricks. The work of the mine will be delayed four or five weeks.

Dry Dock (109). A boiler supplying steam to a stationary engine on McKeever's dry dock, south of the gap in Washington Street, Jersey City, blew up on Sept. 8th. Charles Nelson, the engineer, was struck by one of the iron plates, and both his legs were broken by the blow. The force with which he was thrown down broke his arms and sprained his back. The escaping steam scalded him. The part of the boiler that did not hit him flew high in the air and hit Thomas Murphy, a laborer, who was on his way home from work when it fell. He was injured about the head and back. Nelson cannot live. Murphy will probably recover. Besides the loss of the boiler, very little damage was done by the explosion.

THRESHING MACHINE (110). On Sept. 9th, a boiler used on the farm of John W. Snyder, half a mile east of Carbondale, Ill., exploded with disastrous results. Five men lost their lives, viz.: John W. Snyder, Thomas Lyget, Andrew Lyget, John Biggs, and Isaac Miller. The men were grouped about the boiler, which was leaking and giving trouble. Mr. Snyder gave the order to shut down, when, in an instant, the boiler exploded. William G. Spiller was blown some distance, and escaped with a broken leg.

SASH FACTORY (111). A boiler in the California sash, door, and blind factory at Oakland, Cal., exploded on Sept. 10th, killing four men outright and injuring several others, two probably fatally. Two others are supposed to be buried in the ruins. The explosion occurred in the engine-room, where there were three boilers. One was blown one hundred feet away, another half that distance, and the third — the one which exploded — was blown in two pieces. The engine-house was completely demolished, and the factory caught fire. At the time of the explosion, the engineer and two firemen were in the engine-room. Three packers and a plumber were at work on the boilers, and four or five others were in the yard near by. The fireman, a Portuguese, is expected to die. Edward J. White, one of the men in the yard, was badly injured internally. Emanuel Francis was found dead two hundred feet from the engine-room, terribly mutilated. Charles Baemer was badly burned and had his eyesight ruined. Frank Hodge had both arms and legs broken, and William Ball received a number of deep cuts. One body was found on a lumber-pile, headless and crushed. It has not yet been identified. Charles Anderson, a Contra Costa laundry employé, was crushed out of all resemblance to human shape. A man named Dailey, who was in the engine-room, is missing. (Later in the day his body was found.) John Dolan was blown out of the building, but was not injured.

LOCOMOTIVE (112). The fast eastward-bound express, on the Pennsylvania railroad, was about an hour behind time in passing Altoona, Pa., on Sept. 12th. It was delayed by an accident of rare occurrence on the Pennsylvania road. Ahead of it, and coming eastward, was a freight train, which was being helped up the western slope of the mountain by engine No. 1,106. When within a short distance of Lilly, the boiler of the helping engine exploded and blockaded the track. It was derailed, and its cab torn off, and was otherwise damaged. Neither engineer nor firemen were seriously hurt. The former had his back scalded, and the latter suffered similar injuries to his face. The fireman was blown out of the cab and across the north track.

STEAM YACHT (113). The boiler of the pleasure yacht *Lee* exploded near Cleveland, Ohio, on Sept. 16th, and nine men were drowned before assistance could be had.

SAW-MILL (114). The boiler at the saw-mill of Fritz Brothers, Berlin, Pa., exploded Sept. 24th. John Fritz, Edward Fritz, Oliver Ross, David Ross, and David Baker, all well-known young men of this vicinity, were instantly killed. Two brothers, named Brant, who were near the saw-mill, were badly injured, but may recover. The force of the explosion was terrific, and the mill was completely wrecked.

FERTILIZER WORKS (115). A tank used for refining oil in George Slimer's fertilizer works, in Deer Creek, near Cincinnati, exploded on Sept. 23d. The upper part of the tank went up like a rocket through the second floor of the building and through the roof. William Hulligan was seriously, but not fatally, hurt, and ten others had very narrow escapes.

SAW-MILL (116). The boiler of a saw-mill, near Hopkinsville, Ky., blew up on Sept. 24th, instantly killing Frank Herrington and Joseph Beckner, who were near the boiler at the time.

SAUSAGE FACTORY (117). On Sept. 27th, an explosion occurred in Henry Schofel's sausage factory, Louisville, Ky., by which Jacob Wagner was badly hurt. Wagner, who is something of an expert in the boiler line, had, the day before, placed in position a large second-hand boiler, and at the time of the explosion was trying its power. Schofel's factory has been completed but a short while, and the owner was anxious to begin operations by Monday. Wagner seemed rather confident of the capacity of the boiler, and a very heavy pressure had been reached, when suddenly there was a crash that startled the entire neighborhood. Luckily, no one chanced to be in the boiler-room at the time save Wagner; and when some laborers ran in they found him about twenty feet from where he had been standing at the time of the explosion, suffering the most excruciating pain from scalds which extended all over the lower half of his body.

STONE QUARRY (118). A portable boiler in Billmeyer & Baker's limestone quarry, Wrightsville, Pa., exploded Sept. 28th. Lemuel Barnes, the fireman, was eating his dinner a short distance from the engine, at half-past eleven o'clock this morning. His mother, Mrs. Joseph Barnes, and his wife, a young woman of twenty-five, who had brought him his dinner, were sitting near by when the explosion took place. The head of Barnes' wife was blown off, and he himself was so badly scalded and injured about the legs that he will probably die. His mother, aged fifty years, received serious, though probably not fatal, injuries about the head and body. A portion of the boiler-house was blown over into the quarry among a large quantity of dynamite, which exploded and completed the destruction. A number of workmen who were near by narrowly escaped death, but none of them were seriously injured. Fragments of the boiler were thrown a distance of 500 feet. Nothing but a hole in the ground marks the scene of destruction.

STEAM LAUNDRY (119). At 8.30 P. M., on Sept. 30th, a boiler exploded in the steam laundry of Wyoming, Pa. Some damage was done, and a number of people were badly scared, but no one was hurt.

ICE FACTORY (120). An explosion at the Wichita ice factory, Wichita, Kan., on Sept. 30th, wrecked one entire end of the building and much of the machinery. About ten o'clock, it was noticed that the heads of the heater were cracking, and the fires were hauled to allow of repairs. A few minutes later the boilers burst, and the huge heater, weighing eight tons, went flying through the walls, skipped over the Missouri Pacific tracks, struck the depot platform on the other side, splintering it into match wood, and finally buried itself some feet in the ground about 150 feet from where it started. The employés of the works all escaped injury. The factory will be rebuilt at once.

STEAM LAUNDRY (121). By the explosion of a mud-drum on September 30th, at the Memphis Steam Laundry, Memphis, Tenn., the engineer, Nelson McClure, and Philip Linz, and Ed. Hine, one of the proprietors of the laundry, were terribly scalded. McClure died from his injuries, but the others will recover.

SAW-MILL boilers do not explode quite as frequently as threshing engines at this time of year, but they are in use during a much greater portion of the year, and are thus able to make up for deficiencies. In most saw-mills the question of fuel economy is not considered at all. There are usually more slabs and cuttings lying around than can possibly be burned by the most wasteful plant, but, as it is desirable to get rid of as much of the refuse as possible, the only thing to do, apparently, is to make the steam plant as wasteful as possible. And where economy is so entirely disregarded, it is, of course, thought to be entirely superfluous to employ an engineer who knows anything of his business. No further explanation as to the causes of the numerous explosions of saw-mill boilers is required; for the intelligence by which a steam-plant is maintained in a condition to secure good economy usually secures also the conditions of safety. Of course there are some real engineers employed in saw-mills, but, for the reason we have mentioned, they are the exception, and the best preventive of explosions of boilers in saw-mills would be a discovery which would impart considerable value to slabs and other cuttings.—*American Machinist.*

To the Editor of The Locomotive — *Sir:* In the March number of The Locomotive I noticed something about the "danger of caulking steam pipes while the pressure is on," which reminded me of conversations I have had with boiler-makers about caulking flues, and also of a question that I wish to put to you. The question is this: Is it best to caulk flues when the boiler is cold and in a contracted state, or when it is warm but without pressure, or when it is under working pressure?

Respectfully,

Milwaukee, Wis. A. E. P.

[Caulking may be done either when the boiler is hot or when it is cold: but it should never be done while under pressure. When pressure is on, the entire boiler is in a state of strain, and nothing should be done to it that will increase the strain on any part. Distressful accidents have resulted from a neglect of this maxim.— Ed.]

The American Boiler Manufacturers' Association.

As announced in our issue of last month, the association met at Pittsburg on Oct. 15th. Most of the reports that were read were tentative, and were intended to draw out the opinions of the members and start up discussion, rather than to be final. In fact, the only final report submitted was the one by the Committee on Materials and Tests. As a preliminary to the preparation of this report, the committee had sent out about a thousand circulars to members of the association and others known to be interested, requesting answers to the following nine questions: "(1.) Is there any warrant for the use of wrought-iron in the place of homogeneous steel in the shells or heads of boilers; if so, what qualities do you find in the boiler-iron of commerce not possessed in the same or a higher degree by boiler steel? (2.) Should the use of cast-iron be permitted in boilers anywhere except in such minor parts as manheads, mudheads, handhole plates, etc.; *i. e.*, is it good practice to use cast metal for such parts as mud-drums, legs, necks, headers, and the like, subject to internal strains? (3.) What physical properties should cast-iron possess to make it safe for use in boilers? (4.) For testing the physical properties of boiler steel or boiler iron there are four types of test pieces in use, namely: *a.* the U. S. treasury standard employed by the government boiler inspectors, and being simply a coupon with suitably reduced test section made by cutting half-round holes near the center of the two opposite edges; *b.* a coupon reduced to uniform width for a length of two inches by planing or milling down the opposite edges for that distance; *c.* a coupon similarly reduced for a length of 8 inches or 10 inches; *d*, a coupon planed or milled down to uniform width for its entire length. Which of the four is best adapted to determine the requisite qualities of boiler steel (or iron)? Give reasons in detail for this preference. (5.) Should different grades or qualities of metal be used in boilers, for instance, one for shells, one for fire-box or furnace-plates, one for flanged heads, one for flues, etc., or is it the best practice to use but one grade throughout the boiler? (6.) What physical qualities, such as tensile strength, reduction of area, per cent. of elongation, degree of bending, etc., should good boiler steel (or iron) possess? (If you believe in using several grades, please specify for each.) (7.) How should bending tests be made? Please give particulars as to length of test piece as compared with thickness or width; bending by successive blows of a hand-hammer or power-hammer, around a horn or mandrel, in a die, or between the jaws of a testing machine, and the advantages or disadvantages of each method. (8.) Between what practical limits of greatest and least heat must all flanging be done? (9.) Which is the best material for rivets? Charcoal iron or mild steel? Please give reasons for your preference, based on experience in the shop."

From the answers to these questions the report was largely made up. It continues: "The unanimous opinion of all parties is that the use of cast-iron in mud-drums, legs, necks, headers, etc., and in any part of boilers where it will be subject to tensile strains, is dangerous and should not be permitted. For handhole-plates, crabs, yokes, etc., of manheads it may be used, but only a superior article, such as is generally known as 'gun metal,' should be thus employed; *i. e.* a metal of soft grey texture and of a high degree of ductility. For the strengthening rings of man-holes, homogeneous steel or wrought-iron, or soft and annealed steel castings should be used. In testing materials for boilers the grooved section known as the Marine section, because still in use for marine inspection purposes under the regulations of the treasury department, should be discarded and the eight-inch straight or reduced section exclusively used by the inspectors of the U. S. Navy should be substituted. It is immaterial whether the test piece be a straight, planed piece, or an 8-inch reduced section, planed or milled down. The latter has some practical advantages in the testing machine, but is somewhat more expensive to make, and has the further objection of consuming more time in preparation. The cross-sectional area of the test piece should be not less than one-half of one square inch; *i. e.*, if the piece is one-fourth of an inch thick its width should be two inches; if it be one-half inch thick its width should be one inch. But for heavier material the width shall in no case be less than the thickness of the plate. On this test piece the metal shall show the following physical qualities: The tensile strength shall be from 55,000 to 65,000 pounds; the elongation shall be 20 per cent. for plates $\frac{3}{8}$ inch thick or less, 22 per cent. for plates from $\frac{3}{8}$ inch thick to $\frac{3}{4}$ inch thick, and 25 per cent. for plates over $\frac{3}{4}$ inch. The reduction of area as a test is found to be entirely unreliable by all expert testing engineers. Not only is it impossible for two inspectors to get even approximately the same reduction of area in their measurements of the same piece, but no single inspector can get the same measurement twice in succession."

Concerning the bending tests the report says: "Good boiler steel up to one-half inch in thickness should be capable of being doubled over and hammered down on itself without showing any signs of fracture, and above that thickness it should be capable of being bent round a mandrel of a diameter equal to one and one-half times the thickness of the plate to an angle of 180 degrees without signs of distress. Such bending pieces should not be less in length than sixteen times the thickness of the plate. If the bent edge shows any roughness, which under the magnifying glass will appear as a series of incipient cracks, the specimen should be rejected. In preparing specimens for bending, the rough shear edges should be milled or filed off. The pieces for bending test should be cut both lengthwise and crosswise of the plate. We recommend that all tests be made at the steel mill. Three pulling tests and three bending tests shall be made from the plates of each heat. If one of these fails the manufacturer shall have the right to prepare and test a fourth piece, but if two fail the entire heat to be rejected.

"When a member of this association orders a lot of steel from a steel manufacturer he shall be entitled to receive a certified copy of the chemical and physical tests of the heat from which his plates are made, which must conform to the above requirements. It is, of course, understood that all boiler steel must be made by the open hearth or crucible processes. The flanging of steel should be done at not less than a good red heat, and not a single blow should be given after the plate is cooled down to less than cherry red by daylight. After flanging, all plates should be annealed simply by uniform cooling from an even dull red heat for the whole sheet, in the open air.

"Rivets should be made of good charcoal iron or a very soft mild steel running between 50,000 and 60,000 pounds tensile strength, and showing an elongation of not less than 30 per cent. in eight inches, and having the same chemical composition as specified for plates; *i. e.*, not more than .04 per cent. of phosphorus, nor more than .03 per cent. of sulphur."

Reports were read from the Committee on Bracing, Stays, and Proper Tube Spacing, and the Committee on Valves and Fittings, and from others also. Some of the committees asked for more time, and their full reports will not be heard until the New York meeting is held in February next.

On the 22d day of December next there will be a total eclipse of the sun. It will not be visible here, but can be seen anywhere along a certain strip of the earth's surface, 5,000 miles in length and 100 miles wide. This strip begins in the Caribbean Sea and extends from there across the Atlantic Ocean to Africa, which it strikes a few hundred miles south of the Congo river. There are many interesting things about the sun that we do not understand yet, and some of these cannot be studied at any other time than during total eclipses. When we remember how infrequent these eclipses are, and how short a time they last when they do come, it will be seen that it is highly important to take advantage of every one of them. An expedition from the Lick Observatory will observe the eclipse in French Guiana, which is the only point in South America from which it will be visible. Another expedition, fitted out by the United States Government, sailed for Africa on October 17th in the war ship *Pensacola*, and if the weather is clear we may hope that during the few brief moments of totality many photographs, measurements, and other observations may be taken. Mr. Carbutt will accompany the expedition to Africa, and will try his orthochromatic dry-plates.

"The boom in steel and iron rivals the memorable advance of 1884. Even when compared with that time, other things considered, the advance in products of steel and iron is more remarkable. Steel rails cannot to-day be bought for less than $32 per ton, and manufacturers are quite independent on these figures, for it is confidently believed the price will yet reach $35. In the last few days Bessemer pig has stiffened from $18.75 to $19.50, and a heavy consumer said to-day he doubts if he could buy one hundred or one thousand tons for less than $20. This in an advance in the past five weeks of between $5 and $6. At the office of Carnegie Bros. & Co., it was learned that the advance is caused by the increased cost in raw materials. Said the authority, 'If Bessemer pig advances to $20, rails and other products must cost just so much more. A $4 advance on pig means a $5 advance on the finished product, for the shrinkage is estimated at 25 per cent., and in addition to that is the sliding scale under which our men work.'"—*Indianapolis Journal for Oct. 4th.*

The Locomotive.

HARTFORD, NOVEMBER 15, 1889.

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.

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

THE *Corona*, a steamer plying the lower Mississippi, blew up her boiler at about noon of October 3d, and sank in a few minutes with the loss of thirty-six lives. The disaster occurred opposite False River Settlement, ten miles above Baton Rouge. The *Corona* had just been repaired at a cost of $12,000, and was supposed to be in complete order. This was her first trip since the repairs were made. Further particulars of the explosion will be given next month.

WE have received from the publishers, Messrs. John Wiley & Sons, a copy of Wilson's "Treatise on Steam Boilers," edited and enlarged from the fifth English edition, with Mr. Wilson's permission, by Prof. J. J. Flather of Lehigh University. The original work was highly esteemed in this office, and it gives us pleasure to say that Prof. Flather's additions have considerably increased its value. The appendix is of special interest, as it contains considerable matter relating to American practice that is not to be found in the original.

THE Eiffel Tower at Paris has been found useful for scientific purposes. M. Jannsen, a distinguished spectroscopist, has been carrying on observations for the purpose of discovering whether the oxygen lines in the spectrum of the sun are due to oxygen in the sun itself, or only to that which exists in our air. By observing the electric lights on the tower from a distance of five miles, he finds that the lines in question in the sun's spectrum are distinctly visible in the spectrum of the tower lights; and the conclusion is, that these are probably due to the earth's atmosphere, and cannot be considered to prove the existence of oxygen in the sun.

WE are pleased to learn that the Johns Hopkins University begins its work this fall with unimpaired efficiency. Some time ago sensational rumors were going the rounds in the papers, to the effect that the days of the University were numbered. The revenue of the institution had been largely derived in the past from Baltimore and Ohio stock that it owns, and it is no secret that this source of income is now unavailing. However, the savings of former years, the income from investments outside of the railroad, the income from tuition (which will be about $40,000), the gift of $108,000 received from generous persons interested in the institution, and the gift of $100,000 left them by John W. McCoy, will enable the trustees to continue the work of the University for the next three years with all the thoroughness for which it is noted.

Cæsar's Horse.—Apropos of the frequent discovery in the far West of fossils of horses with toes, has it ever been recalled that Julius Cæsar had such a horse? Suetonius, in his *Life of Cæsar*, sixty-first section, says, "Cæsar made use of a remarkable horse, with feet almost human, and hoofs divided in the manner of toes" (*Utebatur equo insigni, pedibus prope humanis et in modum digitorum ungulis fissis.*) The whole passage is interesting. The horse, it appears, was foaled in Cæsar's stud. The soothsayers at once proclaimed that it betokened for its master the dominion of the world, whereupon Cæsar had it reared with the utmost care, and was the first to mount it. Indeed, it would never suffer anybody else upon its back. Later he sat up an image of the horse in front of the Temple of Venus Genetrix. Was not this an instance of what evolutionists call "reversion?"—*Charles R. Williams in New York Evening Post.*

"Groombridge 1830."

Under this heading an article appeared in the August number of the Locomotive, 1883, giving some interesting particulars concerning this star, which is known among astronomers as one of the most remarkable of all. It is traveling through space with a velocity so prodigious that the combined attraction of all the known matter in the universe fails to account for it. Through the kindness of Prof. Asaph Hall, of the U. S. Naval Observatory, we are enabled to place the following additional facts before our readers.

The star "1830 Groombridge" is so called because it is No. 1830 in the catalogue observed by Groombridge. Stephen Groombridge was a London merchant who had a great fondness for astronomical studies, and after he had acquired a comfortable fortune he bought a good meridian circle, which he used with skill. His observations were reduced and published after his death by Airy. The star mentioned is very interesting, but nobody knows the cause of its enormous velocity. At first it was thought that this star must have a large parallax, and in fact Faye found a parallax of more than 1″; but this is a mistake, and the best determinations give nearly + 0.″1.

Dr. Wells and Nitrous Oxide Gas.

The minute history of the first practical application of nitrous oxide may be of interest to our readers. Mr. Colton was going about the country giving lectures and exhibiting the peculiar properties of the gas, which was popularly known as "laughing gas." When he came to Hartford, he spoke in Union Hall, which was at that time the only suitable place in the city. Dr. Wells lived near by, and for an evening's diversion he and his wife went over to see Colton's exhibition. Mr. Cooley was one of the subjects, and while he was under the influence of the gas he injured his shin in some way, but paid no attention to the injury until the effects of the gas had passed off, and apparently was not aware of it until then. Wells remarked this, and called his wife's attention to it. He afterwards asked Cooley about it and learned that his surmise was correct. He went home and passed a sleepless night, and next day, before Colton was up, he went to his room at the hotel and asked if he had any of the gas left. Colton replied that he had, and Wells then invited him to bring it down to his office so that he might take it while Riggs pulled a tooth. Colton laughed at the idea of using the gas in that way, but admitted that it might be done, and agreed to do what he could to help him out. The tooth was pulled, and as he returned to consciousness, Wells leaped from the chair and cried, "I didn't feel it! The greatest discovery of the age!"

Safety-Valves on Heating Boilers.

THE proportion of the area of a safety-valve to the area of the grate, according to the United States rule, should be such that there is half an inch of valve area to each square foot of grate surface, when lever or dead-weight valves are used, and one-third of an inch of valve area to each square foot of grate surface when spring or pop valves are used. It has been shown by actual trial that when these proportions are observed, the valve is of sufficient size to prevent any considerable rise of pressure beyond the point of blowing off — that is, if everything is in good order. This rule, therefore, is a very safe one to follow.

In heating boilers, the valve area should be increased rather than diminished, because the class of help employed to run these boilers usually lacks the experience and intelligence of the class employed to run high-pressure boilers, and the necessity of seeing to it that all pertaining to such boilers is properly designed becomes correspondingly more urgent. But it would seem, judging from our past experience, that altogether too many people consider anything in the form of a safety-valve to be good enough for a heating boiler, and we found one boiler with a grate area of seven square feet, which had a safety-valve area of only 44-100 of an inch (or somewhat less than half an inch), when according to the United States rule the area should have been three inches and a half. If the safety-valve on such a boiler should at any time have to be depended upon to relieve the boiler, a dangerous rise of pressure would take place, the steam being unable to escape as fast as it is formed.

Another trouble in the safety-valves of low pressure boilers is so frequently met with, that it seems almost to be the rule, even when the areas are properly proportioned. It is that the regular high-pressure valve and weight is used, so that even when the weight is pushed in as close to the valve as it will go, it takes a steam pressure of from twenty to forty pounds to raise it. In other words, the valve was made to use on a high-pressure boiler, and is so designed that it can be set to blow off at any pressure between forty and one hundred pounds, with the idea that this range would be all that would be required; and this being the case, forty pounds is the lowest pressure at which it can be set to blow off. The safety-valves and weights on all heating boilers should be adapted to the duty they have to perform, and the levers should be marked accordingly.

Let us consider any ordinary heating boiler. The maximum pressure carried is ten pounds, the pressure gauge registers up to twenty pounds, and the damper regulator is adjusted to ten pounds. Now let us suppose that through ignorance or neglect the draft doors are blocked open. The pressure rises, and the damper regulator cannot control it, when ten pounds are reached. The safety-valve should have been so constructed and set that it would blow at twelve or fifteen pounds, but with the ball pushed in, in too many cases it takes thirty-five pounds to lift the valve. The light diaphragms in the damper regulators are broken, and the pressure gauge is destroyed or strained.

The weight of the lever and valve, ordinarily, will balance about two pounds of internal pressure, and the weight placed on the lever should be such that when it is pushed in close to the valve, the boiler will blow off at five pounds or less. Then, if it is desired to set the valve to blow at ten pounds or fifteen pounds, it will be easy to do so by shifting the weight outward along the lever till the proper point is reached.

We have stated what can take place when valves are weighted as we frequently find them, and we will say, further, that just such accidents as these have come under our personal observation, and that frequently in our practice we are obliged to re-adjust valves by having light weights substituted for heavy ones. The only objection to this change is, that the point at which the valve blows off will no longer correspond with the marking on the lever. If those fitting up low-pressure boilers will call upon the valve manufacturer for valves weighted and graduated for low-pressure work, they can easily procure precisely what is needed.

Great Discoveries and Innovations of the Past Sixty Years.

V. Anæsthesia.

The greatest of all human benefactors is he who relieves his race from misery and suffering. Surely, then, the first man to employ anæsthetic substances for the annihilation of pain deserves the highest honor, and should command our most respectful consideration. Unfortunately there are rival claimants for this distinction, whose respective claims to it have been contended for with unusual earnestness, and the controversy, we are sorry to say, has been one of exceeding length and bitterness. We have been to some considerable trouble to learn the precise truth of the matter as nearly as may be, and the resulting story is given below:

The use of drugs for producing temporary insensibility is an ancient practice. Homer mentions the anæsthetic effects of nepenthe. Herodotus refers to a practice the Scythians had of inhaling the vapor of a certain variety of hemp, in order to bring on a condition of intoxication. Dioscorides and Pliny allude to the employment of mandragora in surgical operations. This name will doubtless call to the reader's mind several passages in Shakespeare, as, for instance:

> "Give me to drink mandragora."*

Also,

> "Not poppy, nor mandragora,
> Nor all the drowsy syrups of the world,
> Shall ever medicine thee to that sweet sleep
> Which thou owedst yesterday." †

According to Dr. Affleck, too, it seems that M. Julien, a French academician, has found an ancient Chinese manuscript showing that Hoa-tho, a physician who lived about two hundred years after Christ, gave his patients a preparation of hemp, and performed surgical operations upon them while they were unconscious. Again, in the thirteenth century mandragora was extensively used for the same purpose by Hugo de Lucca. In 1782 a treatise was published in German by Dr. Meissner, in which it is said that Augustus, King of Poland, had an amputation performed while he was under the influence of a narcotic.

In spite of these numerous evidences of the use of anæsthesia, surgeons generally regarded it with disfavor — probably because they considered the agents then used to be unsafe. However, the magnificent discoveries made shortly after the Revolution by Priestley and others gave a new impetus to chemistry, and led to the careful examination of the properties of gases and vapors, in the hope that some of them would be found to be of value in medicine. In the year 1800 Sir Humphrey Davy noticed the anæsthetic properties of nitrous oxide ("laughing gas"), and made the following suggestion, which we quote in his own words: "As nitrous oxide, in its extensive operation, seems capable of destroying physical pain, it may probably be used with advantage in surgical operations in which no great effusion of blood takes place." It is strange, indeed, that such a valuable suggestion, from so eminent a man, should have remained entirely unheeded for nearly half a century, but such appears to have been the fact.

Nitrous oxide was not the only gas or vapor whose peculiar properties were known in the early part of this century. Sulphuric ether had been administered by inhalation by Dr. Pearson of England, in 1785, as a remedy for asthma, and by Dr. Warren

* *Antony and Cleopatra*, Act I., Sc. 5. † *Othello*, Act III., Sc. 3.

of Boston in 1805; and in 1818 Faraday showed that by administering an increased quantity of this vapor anæsthetic effects could be produced that were similar in every way to those produced by nitrous oxide. Nevertheless, the surgeons did not make use of either. They continued to perform operations in the old, blood-freezing way, strapping the patient down to an operating table so that he could not writhe with the pain that their knives and saws produced.

Up to this point the facts are indubitable; and now begins a narrative whose every sentence, almost, has been questioned and contested. We believe, however, that it is substantially correct.

Horace Wells, who figures in the story to follow, was born in Hartford, Vermont, on the twenty-first of January, 1815. He received a general education in several academies in New England, and in 1834 he began the study of dentistry in Boston. Two years later he opened an office in Hartford, Connecticut. His business prospered, and he soon began to consider the possibility of performing dental operations without pain. He experimented with a number of narcotics, but found all of them to be unsatisfactory. In 1840 he expressed his belief that nitrous oxide possessed the properties he desired, but for some reason or other he does not appear to have tried it until four years later. On December 10, 1844, Dr. Gardiner Q. Colton gave a lecture on "Laughing Gas" in this city, and administered it before his audience to several persons, for the purpose of illustrating its peculiar properties. On the very next day Dr. Wells took a large quantity of the gas, administering it to himself in order that no responsibility might rest upon his associate in case of failure or unpleasant after effects, and while he was under the influence of it Dr. Riggs removed one of his teeth. As he felt no pain whatever, and no unpleasant symptoms followed the operation, Dr. Wells at once began to use it in his business, holding it out as a special inducement to his patrons that in his office operations were performed without pain; and later on other Hartford dentists adopted it.

Dr. William T. G. Morton had been a pupil of Wells in Hartford, and by the assistance of Wells, Morton had become connected with the Massachusetts General Hospital in Boston. When Wells had become satisfied, by continuous use of the gas, that it was a valuable thing, he became desirous of bringing it more prominently before the medical profession, and he went to Boston for this purpose in January, 1845. Naturally enough he sought Morton, and to him and Drs. Chas. T. Jackson and John C. Warren he explained his discovery. Dr. Warren extended to him an invitation to lecture at the Harvard medical school, which invitation he accepted. For some reason or other, probably on account of the strange surroundings and a fear lest he might, in his agitation, administer too much of the gas, the experiment that he had repeatedly performed with success in his own office, failed. That is, the anæthesia that he produced was only partial. The students hissed him, called him a charlatan, and pronounced his gas a humbug.

In 1846 Morton and Jackson applied for a patent, claiming the discovery of anæsthesia. Wells had used ether on one occasion in his own work. Morton announced that he had discovered a compound vastly superior to Wells's gas or ether; but this compound, it subsequently appeared, was nothing but ether itself, though he called it by the name "letheron." Wells immediately protested against the issue of a patent, gave the results of his own experiments, and for a substantiation of his statements he referred to the medical fraternity of Hartford. His efforts were fruitless, and in November, 1846, the patent was granted. Later on Drs. Morton and Jackson placed their claims before the Institute of France. Wells immediately took passage for Europe to contest them, but again he met with defeat, and the medal of the institute was awarded to Morton.

The consciousness that the fruits of his labor were passing into the hands of another weighed heavily upon Wells, and deranged his mind. In 1847 he removed to New York, where he hired a small room for a laboratory and continued his experiments, fruitlessly striving to establish his rightful claim to priority. He ultimately broke down entirely, and on the 24th of January, 1848, while he was yet only thirty-three years of age, he passed away.

Dr. H. P. Stearns, in a paper published in 1876, makes the following statements, which are supported, we believe, by affidavits: "Not only were Wells, Riggs, and others using nitrous oxide in Hartford during 1845, but Morton was thoroughly aware of the fact; and during that and the succeeding year he came to Hartford on at least two occasions, and is known to have had conferences with Wells on the subject, and from him and Riggs he learned the fact that ether as well as nitrous oxide had been used. This last interview was only a short time before Morton drew the tooth of Eben Frost, under the influence of ether, in Boston." Dr. Stearns sums up his paper under the following four heads: "1st. In December, 1844, Wells made the suggestion and applied the test in his own person by inhaling a large dose of nitrous oxide, and having a tooth extracted without pain. He and his friends in Hartford continued to perform painless operations with nitrous oxide (except once, when ether was used) until his death. 2d. In September, 1846, Morton, a former pupil of Wells, aware of his discovery and repeating his experiments, extracted a tooth without pain, while the patient was under the influence of sulphuric ether. He afterwards introduced the practice of anæsthesia by ether into the Massachusetts hospital, and from there it became known to the world. 3d. In 1847, Simpson first introduced the practice of anæsthesia in midwifery, thereby making known more widely its value. He also discovered the anæsthetic properties of chloroform, and by his writings and teachings very largely contributed to introducing the practice of anæsthesia to the world. 4th. Others have since discovered the anæsthetic properties of different vapors, which are more or less used in practice."

We are told that Dr. Crawford W. Long, of Athens, Ga., administered sulphuric ether to a patient on the thirtieth of March, 1842, and performed a surgical operation while the patient was unconscious. We know nothing of the details of this operation, and, in truth, the fact itself is new to us. We do not understand that Dr. Long has ever claimed the honor of being the first in modern times to apply anæsthesia in this way, and although our account goes on to say that "Dr. Long's expectations were fully realized, and thenceforward sulphuric ether was administered in his surgical operations," we do not understand his silence in the matter.

Chloroform, which has since assumed a very important role in medicine, is believed to have been discovered by Samuel Guthrie of Sackett's Harbor, N. Y., in 1830 or thereabouts. His announcement of the discovery, unfortunately, is not dated; but from certain circumstantial evidence it appears that the date was about July 1, 1831. Guthrie wrote a letter to Prof. Silliman on Feb. 15, 1832, describing a process for preparing it in a state of great purity, so that the original discovery must have been made some time previous to that. In the latter part of 1831, Souberein, in France, announced the discovery of the same substance, and Liebig, in Germany, published his discovery of it in February, 1832. There were thus three independent discoverers of chloroform, all at about the same time; but the indications are that Guthrie was first.

Although chloroform was discovered at this early day, it does not appear that it was used as an anæsthetic until after Wells and Morton had used nitrous oxide. It is true that Eli Ives administered it by inhalation as early as 1831, but he used it as a remedy for pulmonary disease, and not for the purpose of producing unconsciousness.

The Locomotive.

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Corrosion from Standing Water.

Our illustrations this month show some of the effects of standing water upon metal with which it is in contact. Figs. 1 and 2 show a familiar form of corrosion, one that we meet with every day, and which has doubtless been seen by all of our readers. In the chemistries both tin and iron are classed as metals that do not decompose water at ordinary temperature; that is, they do not abstract oxygen from pure water and appropriate it to themselves to form rust. It would seem, therefore, that the oxygen that forms the rust must come from something in the water. Now, the purest water often is the most active in corroding and pitting plates, and this makes it probable that the active substance, in some cases at least, is air. It is well known that water is capable of dissolving a considerable amount of air; in fact, it is this dissolved air that enables fish to breathe. It is not so widely known, however, that the oxygen of the air is

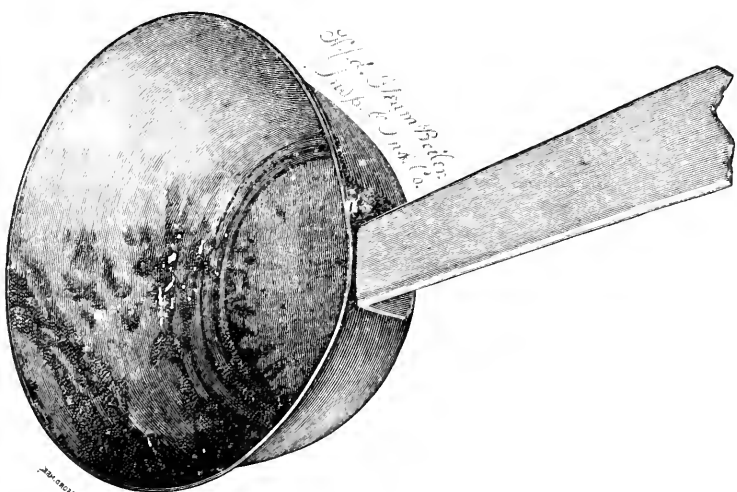

Fig. 1.—Corrosion from Standing Water.

more soluble than the nitrogen. If a small quantity of water be shaken up in a bottle it dissolves some of the enclosed air, and when this is afterwards driven off by boiling, and analyzed, it is found to consist of oxygen and nitrogen in the proportion of 1 to 1.87, instead of 1 to 4, as in the natural air. Thus the dissolved air, being more than twice as rich in oxygen as common air is, and being brought into more intimate contact with the metal by means of the water that holds it in solution, exerts a correspondingly more noticeable effect. It is probable, too, that water plays some other important action in connection with the oxidation of metals, for it has been found by recent experiments that pure oxygen will not combine with things that it has the greatest affinity for, *pro-*

vided it is perfectly dry. Even the metal sodium, which has an intense affinity for oxygen, may be heated in it to a very high temperature without combination, provided sufficient precautions are taken to exclude the slightest trace of moisture. It appears, therefore, that water plays a most important part in the oxidation of metals by air — a part, indeed, that we cannot explain, and that we really know but little about.

The dipper shown in Fig. 1 has hung for a considerable time in the boiler-room of a large paper-mill, where it has been in constant use every hour in the week except for a short time on Sunday. Its usual position is shown in Fig. 2. The fireman, after taking a drink, would throw the unused water to one side and return the dipper to its place on the wall. The film of water still clinging to it would run down on the inside and collect at the lowest point, A, in Fig. 2, standing there until the dipper was once more in use, when the same thing would happen again. The result is, that though the dipper is perfectly sound in all other places, in the particular spot where the water rested it resembles a sieve, as shown in Fig. 1.

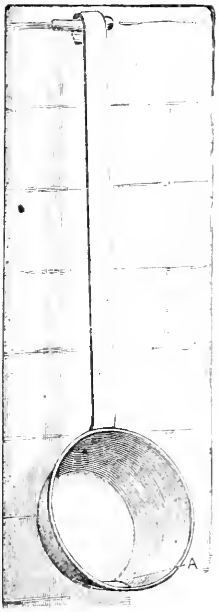

FIG. 2.

In Fig. 3 the effects of a related but different form of corrosion are seen. The cut represents a portion of a two-inch tube taken from a small boiler that was used at irregular intervals, water being left standing in it during the time it was not in operation. Perhaps it would be used for a few days, and then remain idle for a month or more. Most of the pits were quite deep, and two, near the left-hand end of the part shown, had perforated the tube entirely. The action shows itself first in the formation of a thin blister of rust, two good examples of which are shown on the upper side of the tube, and one near the right-hand end. In some cases these have fanciful and fantastic shapes, resembling fungus growths on the metal. These blisters or fungus-like growths may be easily removed, and the surface of the metal below will be found to be of a reddish black color. It may be that no change, other than this discoloration, will be visible when the blister is removed; but by pecking at this discoloration sharply with the point of a knife, it will be found that a considerable

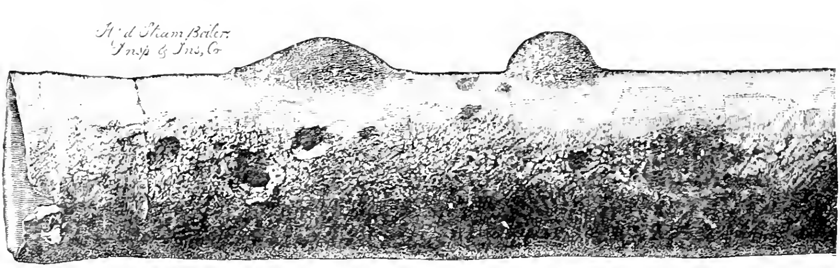

FIG. 3.—A TUBE PITTED BY STANDING WATER.

quantity of oxide may be removed before the bright metal is exposed, leaving pits of various sizes. Those shown in the cut were brought out in this way.

The pitting action shown in Fig. 3 is most liable to occur when the boiler is put out of use, and left with water standing in it; but it often occurs in boilers that are running constantly, provided the circulation is not good so that water stands in places. It often develops, for instance, in mud-drums, and in feed-pipes that are not in continual use. An interesting case of feed-pipe pitting is to be seen near here at the moment of writing.

Water is taken from the city mains and pumped through a heater to the boiler. From the city main to the heater the pipe is clean and free from pits; but from the heater to the boiler, where the water is warm and often not in motion, the pipe is pitting with great rapidity.

The fact that this action is often most severe where the water is purest seems to be explained by the formation of a thin projecting layer of scale in the boilers using water that is less pure, which acts as a sort of varnish, and prevents the water from coming into intimate contact with the metal.

In laying by heating boilers for the summer water should never be left standing in them, for, if the conditions are just right, the tubes may be entirely ruined, and the shell badly pitted, in a few summers. These boilers should be blown off while warm, and cleaned and washed out, and it is a wise thing, when it is possible to do so, to send a man inside to wipe everything out dry, and see that no water is left standing anywhere. Then a light fire of shavings may be started on the grate — just enough to warm the boiler through and dry it out well.

Inspectors' Reports.

OCTOBER, 1889.

During this month our inspectors made 4,995 inspection trips, visited 10,540 boilers, inspected 3,639 both internally and externally, and subjected 737 to hydrostatic pressure. The whole number of defects reported reached 10,108, of which 893 were considered dangerous; 67 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	586	52
Cases of incrustation and scale,	1,032	69
Cases of internal grooving,	63	13
Cases of internal corrosion,	343	28
Cases of external corrosion,	702	52
Broken and loose braces and stays,	147	52
Settings defective,	241	23
Furnaces out of shape,	263	14
Fractured plates,	197	92
Burned plates,	150	29
Blistered plates,	317	18
Cases of defective riveting,	2,442	63
Defective heads,	212	12
Serious leakage around tube ends,	1,916	200
Serious leakage at seams,	454	40
Defective water-gauges,	299	29
Defective blow-offs,	64	15
Cases of deficiency of water,	25	10
Safety-valves overloaded,	69	22
Safety-valves defective in construction,	88	20
Pressure gauges defective,	327	32
Boilers without pressure gauges,	2	2
Unclassified defects,	169	6
Total,	10,108	893

Boiler Explosions.

OCTOBER, 1889.

SAW-MILL (122). Robert Leach and his son Thomas, living in Jackson county, about six miles southeast of Hamden, O., and operating a saw-mill in the Kanawha Valley, were blown to pieces by the bursting of the boiler on October 3d. Leach was married and leaves a large family.

RIVER STEAMER (123). The steamer *Corona*, of the Ouachita Consolidated line, left New Orleans at 7.30 P.M., on October 2d, for the Ouachita river, with a full cargo of freight and a good list of passengers. She exploded her boilers at False river, nearly opposite Port Hudson, at 11.45 on the morning of October 3d, causing the loss of the steamer and thirty-six lives. The Anchor-line steamer *City of St. Louis*, Captain James O'Neil, was near by, and saved many lives. The surviving passengers and crew were taken on board by Captain O'Neil, and very kindly cared for by him and his crew. The *Corona* was on her first trip of the season and had but recently come out of the dry-dock, where she received repairs amounting to nearly $12,000. She was built at Wheeling, W. Va., by Sweeney Brothers of that city, about seven years ago, and had a carrying capacity of 2,700 bales of cotton. At the time of the accident she was valued at $20,000. Ten of the saved are wounded, but not dangerously. Five minutes after the explosion not a vestige of the *Corona* was to be seen, except the floating pieces of her upper works, and a portion of her lighter freight.

THRESHING MACHINE (124). The boiler of Hoeschen Bros.' steam thresher exploded October 7th in the town of Oak, Minn., injuring a number of men. John Wiegman had his skull fractured and his body badly scalded. Henry Meyer was badly scalded and his right arm nearly torn off. Another man, name unknown, received injuries necessitating the amputation of one arm. Others were more or less injured, but not seriously.

THRESHING MACHINE (125). Four men were instantly killed and horribly mangled by the explosion of a threshing engine boiler on the farm of Martin McAndrews, 12 miles northwest of Grafton, N. D., on October 7th. The killed are Edward McCaffrey, Wm. Paul, Richard Dailey, and Charles Frazer. John Burke, seriously but not fatally injured, has one leg broken and his head badly torn. The men had barely got to work when the accident occurred, and McCaffrey, Paul, the engineer, and Frazer, the waterman, were clustered about the engine, discussing some trouble in its operation, as the steam gauge did not seem to be working properly. The force of the explosion was in the direction of the separator, and McCaffrey was directly in its line. He was thrown 10 rods and his right leg and arm torn off, and the abdomen torn open. A flying fragment struck Dailey, bandcutter, in the middle of the back and tore every rib from the vertebræ. He lingered in awful agony, begging the horror-stricken people to end his misery, for three hours. Paul, the engineer, had nearly all his bones broken, and his face was flattened and distorted in death. The boy, Charles Frazer, had his arms and legs broken, and was almost driven into the earth.

SAW-MILL (126). At Baker saw-mill at the head of Mill Creek canyon, twenty-five miles from the Walla Walla, Wash., a boiler exploded on October 7th, tearing Alex. Harding, a night watchman, to pieces. He happened to be the only man in the mill at the time of the explosion. Harding's body was blown out of the boiler-room thirty feet, across the saw frames up to the main floor of the mill, tearing off the head, both legs, and one arm. One leg was found on a joint above the saw frame, and the missing arm 150 feet away from the mill. The head and other leg have not yet been found.

Shingle Mill (127). About six o'clock A. M. on October 10th, the town of Lindsay, Ont., was startled by a heavy explosion. Houses in various parts of the town felt the vibration, and the sound was heard miles away. The boiler in John Dovey's shingle mill had exploded. So terrific was the explosion that the frame mill was almost leveled to the ground, and parts of the building and machinery blown and scattered a quarter of a mile or more from the scene of the disaster. Several large plate glass windows in the stores on Kent Street, half a mile distant, were broken. The engineer, John Poles, was the only person on the premises at the time, and was killed. Had the accident occurred ten minutes later the employees would have been assembled for work.

Traction Engine (128). In McCanna, a small village of North Larimore, N. D., a traction engine belonging to A. E. Hanson exploded its boiler on October 12th, killing one man and injuring six others. They were going up a steep grade at the time, and the blame seems to rest upon the engineer, who is still demented from the injuries received. Bernt Rom, fireman, was instantly killed. Another man has his right leg and arm broken, and is badly cut about the face.

Planing Mill (129). Five boilers exploded in Hughes' planing mill, Chattanooga, Tenn., on October 12th, tearing out the entire side of the building, and killing a negro named Charles Bradshaw. The fireman, Dave Pullim, was blown fifty feet, but not fatally injured. The damage to the building and machinery was $13,514.75. The boilers in a brick house, separated from the other buildings, were in two batteries, one battery of two six-flue boilers, each 53 inches by 18 feet, in which the explosion took place, was literally blown to pieces. The second battery, consisting of three two-flue boilers, 40 and 42 inches by 20 feet, were ruptured and dismembered, and the settings demolished, by the force of the explosion. Although the explosion occurred at a time when the engineers and fireman were on duty, their reports were very conflicting. The shattered and torn iron plates, heads, and flues of the boilers, which were scattered in every direction for a distance of from 200 to 1,500 feet (the heads of the boilers being among the largest of the pieces recovered), all indicated an unusual pressure, and there were also some evidences of low water, all of which the attendants claim to have known nothing about; nor had they any theory to account for the explosion.

Sorghum Factory (130). The boiler at Heinlen's sorghum mill, Bucyrus, O., exploded at two o'clock A. M., on October 14th, tore through the brick wall, and landed eight hundred feet away. Engineer John Howard and his assistant, Ed. Heinlen, were thrown through a brick wall, both having their skulls fractured. They were also badly burned, Heinlen dying instantly and Howard a few hours later. Frank Raiser was literally roasted alive by the escaping steam, and died after lingering in agony for two hours.

Saw-Mill (131). The boiler of Ben Veach's saw-mill, five miles west of Marshall, Ill., exploded October 16th. Clem Benning, who had charge of the engine, was thrown several yards and badly bruised as well as terribly scalded. His wounds are thought to be fatal. Ben Veach had two ribs broken, his right leg crushed, and his whole body bruised and scalded. His hurts are very serious. Jack and Tom Keith and Tom Hudson were severely bruised by flying timber, but not fatally. The mill was completely wrecked. Parts of the boiler and large pieces of timber were blown hundreds of feet.

Threshing Machine (132). A threshing machine boiler exploded on the farm of W. Hanson, near St. Mary's, Ohio, on October 16th, killing Berry Sigler, fatally injuring Joseph Silvers, and badly scalding Jacob Hemlern and another man whose name we could not ascertain.

FERTILIZER FACTORY (133). The explosion of the large steam boiler in Rivenburgh's bone mill, one mile north of Carbondale, Pa., on October 17th, resulted in the total destruction of the establishment. Six men were at work when the explosion took place. Samuel Sly was thrown through a window and landed fully fifty feet from the building. He will recover. Three others were carried by the force of the explosion some distance and escaped injury. Two men, John and Peter Rivenburgh, were caught beneath the falling timbers, but both miraculously escaped instant death by being thrown close to the basement wall, which was strong enough to resist the weight of the great timbers of the frame building. Both men were extricated, and, aside from a few cuts, they suffered no serious injuries. The building in which the explosion occurred was 60 × 150 feet and three stories high. Men who witnessed the explosion say the structure was lifted from the foundations before it collapsed.

SAW-MILL (134). The boiler in the saw-mill of Wm. Titus, at Providence, six miles west of Franklin, Ind., exploded October 17th, seriously injuring three men and perhaps fatally injuring a little boy. The owner received injuries about the head and shoulders, Willis Deer about the side and abdomen, Edward Titus about the head. The Titus boy received internal injuries from which he may not recover. The workmen happened to be out of the mill at the time, or they would have been killed outright.

SAW-MILL (135). The boiler in Walton's saw-mill, Anderson, Ind., exploded October 19th. The mill was torn to atoms and pieces of the boiler scattered over three squares of territory. Horace Kuhn and Walter Mingle were killed and Wm. Rumler and Sam. Cook badly injured. E. G. Barlow, Wm. Stanley, John Biddle, and Perry Denny were severely hurt.

LOCOMOTIVE (136). At Wellsboro, O., a small station on the Chicago & Grand Trunk Railroad, on October 22d, as an east bound freight train, drawn by one of the huge Mogul engines belonging to the Atchison, Topeka & Santa Fe road, was pulling out of the station the boiler exploded with a frightful report, blowing the engineer and fireman to pieces and entirely destroying the locomotive. Fragments of the bodies of Thomas Callahan, the engineer, and Jack Hadden, the fireman, were found many yards distant from the scene of the disaster, and large sections of the boiler were discovered three hundred yards away half buried in the earth.

PLANING MILL (137). The boiler in T. M. Neal's planing mill, in Prescott, Ark., exploded with great violence on October 22d. It is said that the safety-valve had rusted to its seat, so that it did not blow off; and the proprietor of the mill testified that shortly before the explosion he had examined the gauge and found that it registered 140 lbs. He had remarked that there was danger of an explosion, and had just gone out into the yard with four or five of his men to help pull a wagon load of cotton on the scales, to weigh it. While he was thus engaged the boiler burst, nearly demolishing the buildings, and killing E. B. Raye, the fireman.

OCEAN STEAMSHIP (138). A boiler exploded on the Cunard line steamer *Cephalonia*, shortly after her departure from Liverpool for Boston, on October 24th. She put into Holyhead, and later, returned to Liverpool for repairs. The second engineer and four firemen were dangerously hurt. Three of these afterwards died, and it is believed that one other will not recover.

LOCOMOTIVE (139). A locomotive, while running at full speed between Valparaiso and Haskells, Ind., exploded her boiler on October 24th. The fireman, John Hadden, was killed, and engineer Thomas Callahan was fatally injured.

COKE WORKS (140). Two of the boilers of the Mount Braddock Coke Works, Connellsville, Pa., blew up on October 23d, wrecking the engine house and tearing down three brick stacks that have been recently completed. Edward Stull and Anthony Matheany, who were in the engine house, were buried under the debris, but not badly hurt, and were able to get loose from the wreckage.

Dry Goods House (141). On October 29th, the boiler in the new four-story brick block occupied by O'Neil & Dye, Akron, O., exploded. The building took fire, and in less than an hour all was a mass of ruin. It is said that not even a spool of thread was saved from the $175,000 worth of stock, and all that remained standing was the corner of one wall.

Mine Locomotive (142). A mine locomotive exploded with terrific force at the colliery of the Pierce Coal Company in Archbald, a short distance from Scranton, Pa., on October 29th, killing the engineer, Simon Horey, and the fireman, John Moyle, together with a small boy named Dougher. The engine was torn in pieces, and the men, who were terribly scalded and burned by steam and fire, were flung a considerable distance by the force of the explosion. The engine had been in use for many years hauling coal cars about the breakers.

Nail Works (143). A boiler exploded in the Bellaire Nail Company's works, Bellaire, O., on October 30th, doing much damage but fortunately killing nobody. One end of the factory was carried away, and several machines inside were demolished; but as the factory was not running at the time, nobody was hurt.

The Manchester Ship Canal.

Mr. W. Greer Harrison recently read an interesting paper on the great Manchester Ship Canal, before the Association of Marine Underwriters, and from his paper we take the following interesting particulars: The work may be classified under the following heads: — (1) The canal from Manchester to Runcorn, (2) the docks, (3) railroad divisions and branches, and (4) the estuary works in the Mersey.

The canal proper is $21\frac{1}{4}$ miles long, and its width at bottom is 120 feet, which is largely increased at the locks so as to give approaches wide enough to permit vessels to turn when necessary. At either end of the canal provision is made, by greater width, for large vessels to lie for the purposes of discharge, and yet to permit of two other vessels passing at any point. At the Runcorn end, for a distance of three-quarters of a mile, the bottom width is 200 feet, and for a length of four miles at the Manchester end the bottom width is 170 feet. The minimum depth of the canal at the lowest state of the water is 26 feet, three feet deeper than the Amsterdam canal, and within a few inches of the depth of the Suez Canal.

There are four sets of locks, viz.: Barton, Irlam, Latchford, and Runcorn. At each point there are three locks alongside each other of various sizes to suit the varying classes of vessels — one 550 feet long by 60 feet wide, another 300 by 40, and a barge lock 100 by 20. The fall at low water will be: Barton Locks, 13 feet 6 inches; Irlam Locks, 13 feet 6 inches; Lachford Locks, 15 feet; Runcorn Locks, 8 feet 6 inches. Total, 50 feet 6 inches. The total fall is given to the existing low water level at Runcorn. But at high water of average tides, there will be no fall at Runcorn locks, and as the spring tides flow to the Lachford locks, the fall thus will be diminished in proportion to the rise of the tide, which at high spring tides will be five feet. At average and high tides no delay will take place in passing vessels at the Runcorn locks, as the pound above them (that is to say, the waters from the Barton and Irlam locks) will be leveled by the tides and all the gates will be open. Hydraulic power is employed in working all gates and sluices, and the time occupied in passing a steamer will be about fifteen minutes.

The main supply of water will be the river Irwell, and that portion of the Irwell which, when united with the Mersey, is called by that name. The construction of the ship canal disposes of the Irwell, as that river will be diverted from its present course and turned into the canal. One can better understand the scheme if he will regard the new waterway as a canalized river. In the spring of 1883, which was an exceptionally dry one, gaugings in the Irwell showed an average flow of 26,000,000 cubic feet per day; with one-half of this flow there would be water sufficient to allow of the daily passage of 175 vessels, viz.: 25 steamers, 2,000 to 5,000 tons each; 50 steamers, 500 to 2,000 tons each; 100 barges, 50 to 150 tons each.

At each set of locks there will be flood sluices, 120 to 160 feet in the clear, resting on sills at the level of the bottom of the canal. The piers supporting the sluices will be high enough to avoid all danger from floods and consequent obstructions.

The traffic of the Bridgewater Canal, now the property of the Ship Canal, will be passed over the latter by an aqueduct at the same level as at present, but one span will be a caisson or wrought-iron trough which will be movable on a center like an ordinary turn-bridge. The ends of the trough, and of the aqueduct on which the trough closes, will have gates to prevent the escape of water while the trough is turned. We thus have one waterway operated over another. Elevators at Barton have been provided to connect the Bridgewater Canal and the Ship Canal, and turn-bridges have been provided for road traffic at the various locks.

Docks have been or are in process of being built at Manchester, Warrington, and Partington (the latter for the purpose of loading coal from branch railroads). The approach to the Manchester dock is by locks similar in size to those on the canal. These locks will keep the level of the water in the docks ten feet above the canal level. The area of the dock is 67 acres. On the projecting arms (4 in number) each 250 feet wide, divided by piers 200 feet wide, storage sheds are being erected. The largest vessel may safely turn inside or outside the docks. The dock quays will be 3 miles in length, with a further extension of 3 miles between Barton locks and Trafford Bridge — thus giving 6 miles of quays. Vast warehouses will be erected at these points. The area of the Warrington Dock is 20 acres.

Five railways cross the canal; these will be carried over it by high, level bridges allowing sufficient headway to enable large steamers to pass under.

The main low water channel will commence at the ship canal above Runcorn and terminate opposite Garston, a distance of 10 miles. The initial point of this channel will be 300 feet wide, gradually extending to a width of 1,000 feet. The depth will be 12 feet at low water spring tides, 20 feet at low water neap tides, 40 feet at high water spring tides, and 32 feet at high water neap tides. The channel will be made by tramming walls built of rock taken from the company's quarries. A subsidiary channel from the main channel to Sloyne deep, will complete this magnificent waterway.

Contracts have been let for the various works, based on the original estimates, as follows:

Construction of five deviation and three branch railroads,	$2,280,860
Dock at Manchester,	5,040,075
Dock at Warrington,	566,235
Ship Canal Works,	19,600,855
Estuary Works,	6,952,095
New Roads,	80,810
	$34,520,930

Eleven thousand men are at work along the line of the canal, and as a rule they are steady, sober workers, and are vastly better, morally and mentally, than the old-fashioned "navvies." At various points along the line temporary villages have been constructed for the accommodation of the men, and these villages are very pretty and picturesque, and exceptionally clean. The chief contractor, Mr. Walker, takes the deepest interest in his men, building churches, chapels, schools, and reading and smoking rooms for them in each temporary village along the line.

Along the line attention is frequently called to the work of the "steam navvies." "There was something weird and gruesome about these steam demons," said Mr. Harrison. "The way in which their huge steel teeth bit into the banks of the excavations and tore away mouthfuls big enough to fill a good sized cart, was a sight to see."

Many fossil remains have been found during the process of the work, and huge tree trunks have been uncovered which must have been buried ages ago.

A Chapter of Casualties.

A radiator explosion took place in Boston recently. Two teamsters were sitting in a room on the lower floor of the building No. 46 Federal Street, when they suddenly heard a loud noise in the adjoining room, and were both flung violently from their seats to the floor, one of them, Mr. O. H. Webber, being so badly injured that he had to be carried home. A radiator had exploded in the office of Mr. Theodore Pinkham, and the whole building was shaken on its foundations. The basement of the building, and the office in which the explosion took place, were considerably damaged, the office furniture being nearly all broken. Fortunately there was no one in the room at the time.

On the 28th of October, a boiler burst on board the General Transatlantic Line steamer *Ville de Brest*, as she lay in Tunis Bay. Five persons were killed.

A short time ago a large fly-wheel burst in the rail mill of the Pennsylvania steel works at Steelton, Pa. Happily no one was injured, although men were standing all around the big engine. The immediate cause of the accident is not known, but the destruction of the engine was almost complete, and several thousand dollars will be required to repair the damage. The engine was of 1,100 horse-power, the fly-wheel being thirty feet in diameter. It had been securely braced with heavy wrought-iron rods, and these were twisted and bent.

On the morning of October 17th, a bad accident occurred in a mill in Manayunk, Pa., occupied by the Manayunk Paper Company. The head of a large cast-iron paper drying cylinder, thirty-six inches in diameter and weighing 300 pounds, blew out. A number of men were at work near by at the time, loading paper on one of the mill wagons. Two of them, John Wardell and Patrick Dorsey, were badly hurt. Wardell received a compound fracture of the right leg, a fracture of the right thigh, a fracture of the right arm in two places above the elbow, and several bruises and lacerations on the back of his head. Dorsey sustained a fracture of the pelvis, and various lacerations about the head and body. Wardell is sixty-nine years of age, and it was thought that he could not recover.

Two days later a main steam-pipe burst at the new River Street rubber mills in Hyde Park, Mass., blowing a hole through the engine-house and displacing the roof. No one was hurt.

According to the *China Mail*, "The boiler of a launch, built for a stingy Chinese mandarin who would not pay money enough for a good article, burst in the Shanghai river recently. The Chinese builder, a number of his friends, and several friends of the mandarin were on board at the time. Upwards of twenty were killed or drowned." The fireman was saved, and was in a great rage at the engineer, who, he said, had carried too much steam. He had remonstrated with him, but had received instructions to mind his own business.

The Locomotive.

HARTFORD, DECEMBER 15, 1889.

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

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

OUR next issue begins a new volume: the year 1889 has come, editorially, to an end. It has been a prosperous one to us, and our sincere wish is, that the next may be like unto it.

WE publish, with this number of the LOCOMOTIVE, a title page and index for the year. We send these free to any one who may wish to have them to append to their file for the year. The bound volumes will be ready shortly, and will be sold at the regular price — one dollar each.

IN the death of James Prescott Joule, the discoverer of the mechanical equivalent of heat, the scientific and engineering world loses one of its ablest workers. A sketch of some of Mr. Joule's labors was given in the LOCOMOTIVE for April, 1889, on page 61.

DURING the month of October an unusual number of explosions took place, some of which were most disastrous. The worst of these was the wreck of the steamer *Corona* on the lower Mississippi, but several others were most frightful. The saw-mill boiler comes in for its usual share of space, and the threshing-machine boiler naturally holds its own at this season of the year.

FOR the benefit of our mathematical readers we will say that the problem that Leverrier and Adams had to attack was the solution of a series of simultaneous partial differential equations containing, we believe, nine unknown quantities. As Miller says of this problem, "Even the usual devices of the Planetary Theory, evolved by the genius of Lagrange and Laplace, failed in application in consequence of the inverse character of the problem. In fact, the old armory of Science was unavailable, and Adams and Leverrier, in fighting their great battle with Nature, had to invent a fresh weapon for every stage of the conflict."

WE have repeatedly cautioned boiler hands and engineers against opening or closing valves quickly. How often do we go into a boiler-house or an engine-room and see an attendant hurry to a valve and spin the wheel around as though it were a top! Now, if such men would consider matters a little, and read up the histories of boiler explosions and other such accidents, they would, we think, be more careful in their operations. How often do we read, "The works had been shut down during the noon hour, and at one o'clock the engineer went to the throttle to start up: as soon as he had touched the valve there was a deafening report . . . . ," or something of that general nature! When any structure is under a state of strain it should be treated with the utmost consideration, and no sudden variation of this strain should be allowed to take place. This is carefully looked after in railroad bridges and such structures, and the same principles that teach the locomotive engineer to go across bridges slowly should teach the stationary engineer to open and close his valves slowly.

It often happens that in making tests of boilers one out of a battery has to be shut off from the rest and run separately, and at a different pressure. In such cases, particularly, it would be highly dangerous to open the valves in the connecting pipes quickly. The valves should be barely started from their seats, so that steam will leak through very slowly. The gauges should be closely watched, and as they gradually come together the valves may be started a hair more. At the end of half an hour or so they will come together, and then the valves may be opened wide, though even then they should be started slowly, a spoke at a time, for greater security.

Some Experiences with Zinc.

Zinc is often used in boilers and hot water tanks to prevent the corrosive action of the water on the metal of which the tank or boiler is composed. The action appears to be an electrical one, the iron being one pole of the battery, and the zinc being the other. Under the action of the current of electricity so produced, the water in the tank is slowly decomposed into its elements, oxygen and hydrogen. The hydrogen is deposited on the iron shell, where it remains. It will not unite with iron to form a new compound, but if any iron-rust (known to the chemists as *oxide of iron*) is present, it will remove the oxygen from this and deposit the metallic iron on the plates. The oxygen of the water that is decomposed, instead of going to the iron, goes to the zinc, and forms oxide of zinc, and in the course of time the zinc will be found to be almost entirely converted into oxide, only a small fraction of the original metal being left.

On account of the action we have outlined above, it is generally believed that zinc is always a good thing to prevent corrosion, and that it cannot be harmful to the boiler or tank under any circumstances. Some of our experiences go to disprove this belief, and we have met with numerous cases in which zinc has not only been of no use, but has even been harmful. In one peculiarly marked case a one-hundred horse-power horizontal tubular boiler had been troubled with a deposit of scale consisting chiefly of organic matter and lime, and zinc was recommended as a preventive, some few weeks previous to our annual internal inspection. When the inspection was made, large amounts of detached scale from the shell and tubes were found in the bottom of the boiler, and the iron surfaces from which they had been detached showed markedly the action of the zinc, the crystals of which, deposited upon the iron, gave it the appearance of frosted silver work. On the rear portions of the tubes, the scale being much heavier and more obstinate to remove, partially remained; but it was easily loosened and detached, and when it was removed the same frosted appearance of the iron was observed. The beneficial action of the zinc was so obvious that its continued use was advised, with frequent opening of the boiler and cleaning out of detached scale until all the old scale should be removed and the boiler become clean. Eight or ten months later the water supply was changed, it being now obtained from another stream supposed to be free from lime, and to contain only organic matter. This change of feed water was unknown to the inspector, who two or three months after its introduction opened the boiler for inspection, and was greatly surprised at its condition. The tubes and shell were coated with an obstinate adhesive scale, clinging tenaciously to the iron, and composed of zinc oxide and the organic matter or sediment of the water used.

The deposit had become so heavy in places as to cause overheating and bulging of the plates over the fire. It was with difficulty that these patches were separated and removed by the use of long chisels made specially for the purpose. This action of zinc when the water supply is changed has been noted by us in many cases, but in no other case that we have yet met with has the contrast between its beneficial action at first and its injurious action afterwards, in the same boiler, been so marked.

Another very interesting instance of the peculiar action of zinc under certain conditions came to our notice not long ago. This time the trouble was with a tank used for heating water, and containing coils of brass pipe through which exhaust steam was passed. The shell of the tank corroded rapidly, and one day a large crack opened in one of the plates, and the hot water (which was under a pressure of 75 pounds) was discharged into the room. An entirely new $\frac{5}{16}$ in. shell, 42 inches in diameter, and 8 feet high, was then constructed, and when it was placed in position, a thirty-pound pig of zinc was hung between the tubes to prevent the continuance of the corrosion. The zinc certainly did prevent the species of corrosion that had given so much trouble before, but it gave rise to a very peculiar alteration of the iron of which the new shell was made. After the lapse of two years, the handhole plates were renewed, and it was found that although the old ones had preserved their form, they were softened on their inner surfaces so that a penknife point could be easily thrust into them about $\frac{3}{16}$ of an inch. The metal on these surfaces was black and lusterless, and had every appearance of being graphite or black lead. So soft was it that the strengthening ribs on one of the plates were entirely cut away by an ordinary pocket-knife. The interior surface of the tank presented the same appearance, but as the tank showed no signs of distress, it was continued in use, and for six years it has proved serviceable and satisfactory, no leaks or other symptoms of weakness having been observed. The old handhole plates were kept for subsequent examination, but in a short time they hardened up so that a cold-chisel would make scarcely any impression on them. The zinc pig that had been used was removed, and its character was found to be entirely changed. It had preserved its former shape and general outward appearance, but its fracture was no longer bright and metallic, resembling wood from which all the sap had been expelled. By carefully melting it in a clean black lead crucible, it was found that only fifteen per cent. of it remained in the metallic state. The remaining eighty-five per cent. was probably zinc oxide, though no analysis of it was made.

It appears from these experiences and from others of like nature that the action of zinc is not always as simple and harmless as it would appear to be at first thought. In fact, zinc is one of the numerous things that don't always work as we should naturally expect them to; and in making use of it, the boiler should be frequently opened and the action carefully watched, so that if any undesirable effects show themselves they may be checked in time to prevent serious trouble.

THE course of lectures at Sibley College, Ithaca, N. Y., by non-resident lecturers, on mechanical engineering, began late this year on account of Prof. Thurston's absence in Europe. On November 22d, Prof. W. LeConte Stevens opened the course with a lecture on "The History of Aeronautics." Among the later lecturers, it is expected, will be S. P. Langley (Secretary of the Smithsonian Institute), O. Chanute, C. E. Emery, Benjamin F. Isherwood of the United States navy, Alexander Graham Bell, J. M. Allen, president of the Hartford Steam Boiler Inspection and Insurance Company, and George H. Babcock. Later in the season it is hoped that Mr. Leavitt, the consulting engineer of the Calumet & Hecla Mining Company, Mr. Holoway, Prof. Anthony, Mr. Weston the electrician, Dr. Dudley, and Major Michaelis will be heard. An unusual amount of attention will be given, during the course, to aerial navigation.

Great Discoveries and Innovations of the Past Sixty Years.

VI. The Discovery of Neptune.

In these days everybody knows that the sun is the center of the system of worlds to which we belong, and that around him circulate the eight planets, Mercury, Venus, the Earth, Mars, Jupiter, Saturn, Uranus, and Neptune. These worlds or planets are held in their orbits by the wonderful force of gravitation exerted upon them by the sun. Without this marvelous force the earth and all the rest of the sun's numerous family of worlds would pass off into the dark, unfathomable emptiness that surrounds us on all sides.

Long ago it was known that some force of gravitation must hold us within the sun's dominion, but it was Newton who showed that this force is identical with what we know upon the earth as gravity. He announced that every particle of matter in the universe attracts every other particle with a force decreasing rapidly as the distance between the particles increases, but never entirely ceasing to act. He showed that the path of a single planet revolving about the sun must be of an elliptical shape ; but he showed more than that. According to his conception, not only must the sun attract the planets, and the planets in their turn attract the sun ; but also each planet must attract every other planet, thereby pulling it slightly out of the elliptical orbit in which the sun tends to make it travel. Here was a source of complexity that made it exceedingly difficult to calculate the *exact* position that any heavenly body will be in at any given moment. Yet Newton, Laplace, and other eminent mathematicians have set their wits to work upon the problem with such distinguished success that although even now it is quite impossible to calculate the motions of three or more bodies of anywhere nearly equal size, we find ourselves able to solve the actual problem that we meet, in which one of these bodies, the sun, is vastly larger than all the others together, without serious difficulty. We can now predict the position of any planet or of almost any satellite with an accuracy that is simply marvelous to the uninitiated, — in fact, our ability to do this furnishes the lecturer and preacher with many an illustration of the wonderful powers of the human intellect.

It will not be surprising, therefore, when we state that the slightest deviation of any heavenly body from the path the mathematicians have laid down for it to follow, at once arouses the liveliest interest in the astronomical world, even though the discrepancy can be detected only with instruments of great accuracy ; and immediately the air is rife with theories to account for the strange anomaly, and papers are read about it before learned societies.

One of the most historic of these discrepancies is that observed in the case of Uranus. This planet was discovered on March 13, 1781, by Sir William Herschel, who thought it to be a comet at first, but soon satisfied himself that it was indeed a planet, millions of miles beyond Saturn, which was at that time the outermost known member of the solar system. As soon as it was discovered it was carefully observed and its orbit calculated, and all went well until the year 1800. The planet had then followed its calculated orbit for nineteen years (about one-quarter of its period of revolution). About this time, however, certain slight irregularities in its motion were noticed, but at the beginning no great importance was attached to them. In 1805, however, they had increased so as to be what an astronomer would call prominent ; that is, they had grown to be so considerable that they attracted serious attention. In 1820 they reached a maximum, and then, as Herschel says, "an alarm was sounded." Various theories were proposed, as is usual in such cases, but none seemed to be satisfactory save one. This was, that there exists, beyond Uranus, a planet hitherto unknown, whose attraction on Uranus caused the slight but methodical deviation that the astronomers had detected. This suggestion, we believe, was originally made by Bouvard, an astronomer who concerned himself much with intricate calculations of orbits and ephemerides.

Granted that the hypothetical planet existed, who should say where to look for it ? Two eminent mathematicians, one English and the other French, undertook to answer this question. Great as are the difficulties of determining the minute irregularities of a planet's motion that are caused by the attraction of its neighbors, these men proposed to themselves, all unknown to one another, the vastly more difficult task of working the problem backwards — of taking the observed perturbations, trifling as they were, as a starting point, and calculating the position in the heavens that the hypothetical planet must have, in order to produce them ! The tremendous difficulties of such an operation cannot be conceived by the ordinary mind ; and to any but the greatest and most skillful of mathematicians they must have proven insuperable. The gentlemen who proposed for themselves such an enormous task were Mr. Adams of England, and M. Leverrier of France ; and both of them succeeded.

Both saw that it would greatly lessen the labor of computation if they could get some approximate idea of the distance the new planet is from the sun. How they obtained this approximate value will appear from what follows.

Professor Titius of Wittemberg, had pointed out, some time before, a curious numerical relation existing between the distances from the sun of the planets then known. The relation was this: If we write down the numbers 0, 3, 6, 12, 24, 48, 96, 192, each after the second being obtained by doubling the one before it, and then add four to all of them, we have the series 4, 7, 10, 16, 28, 52, 100, 196; and these represent, with a fair approach to accuracy, the distances of the respective planets from the sun. The actual degree of agreement is shown below:

PLANET.	MERCURY.	VENUS.	EARTH.	MARS.	?	JUPITER.	SATURN.	URANUS.
Real Distance, . . .	4 0	7.5	10.3	15 8	—	53.7	98.6	198.2
By Series, ...	4 0	7.0	10 0	16.0	28 0	52.0	100.0	196.0
Difference, . .	0 0	0.5	0.3	0.2	—	1.7	1.4	2.2

The first line of the table shows the distances of all the planets then known, taking Mercury's distance as 4. The agreement is not exact, but it must be confessed that it is remarkably close. There is every indication that it represents a natural law, and the presumption was, that if we only understood that law more fully we should see reasons for the slight discrepancies. There is one remarkable disagreement, however. Corresponding to the number 28 in the series was a vast stretch of space lying between Mars and Jupiter, and so far as known, absolutely empty. Professor Bode of Berlin suggested, as a possible explanation, that some small undiscovered body might be circling about the sun in this apparently empty space, and proposed that a search be made for it. Judge of the astonishment of the astronomical world when Professor Piazzi of Palermo, on the first day of January, 1801, announced the discovery of the pigmy planet Ceres, moving about the sun in the region under discussion, and when this announcement was followed by the discovery of three other such bodies by Olbers and Harding, in 1802, 1804, and 1807. These little bodies differed greatly in the shapes of their orbits, but their average distance from the sun agreed well with the number 28 in the series, and they filled the gap.

These circumstances, as Herschel says, "tended to create a strong belief that the law was something more than a mere accidental coincidence, and that it bore reference to the essential structure of the planetary system. It was even conjectured that the asteroids are fragments of some greater planet which formerly circulated in that interval, but which has been blown to atoms by an explosion." However that may be, it will be plain that at the time Leverrier and Adams started out on their laborious calculations, there was every reason to believe that the distance of the unknown planet from the sun might fairly be represented by the next term of the series given above; that is, by 388, the distance of Mercury being 4.

Thus one element in the orbit of the unknown planet was found; and then the calculators launched out into the unknown, and for two years nothing was to be seen but a wilderness of figures. At last the computations were completed. In September, 1845, Adams quietly communicated his results to Professor Challis, and one month later he communicated to the astronomer royal the same results slightly corrected. Incredible as it may seem, no steps were taken to discover the planet until the summer of 1846, "after the publication of Leverrier's second memoir, in which the same position, within one degree, was assigned to the disturbing planet as that given in Adams' paper." On August 31, 1846, Leverrier read before the French Academy his third paper on the subject, entitled "*Sur la planète qui produit les anomalies observées dans le mouvement d'Uranus — Determination de sa masse, de son orbit, et de sa position actuelle*" ("On the planet that produces the observed anomalies in the motion of Uranus — Determination of its mass, orbit, and actual position.") "Leverrier wrote to his friend Dr. Galle of Berlin," says Proctor, "requesting him to search for the planet with the large refracting telescope of the Berlin Observatory, in the place he indicated. This letter reached Berlin on September 23d, and on the same evening Galle observed all the stars in the neighborhood of the place indicated, and compared their places with those given in Bremiker's *Berlin Star-Map*. . . . He very quickly found a star of the eighth magnitude, nearly in the place pointed out, which did not exist in the map. Little doubt was entertained at the time that this was the planet, and the observations of the next two days confirmed the discovery." Thus, although Adams' results were published first, the honor of the actual discovery rests with Leverrier and Galle. Dr. Challis, it is true, had actually seen it on August 4th and 12th; but owing to the fact that he had no accurate map of this portion of the heavens, he did not recognize it as the object of which he was in search.

Thus ended one of the most brilliant exploits of the human intellect in the field of astronomy. The planet was of course observed closely after its discovery, and its orbit has been carefully calculated by several eminent astronomers. It was traced backward, too, to see if it had ever been observed before; and, wonderful to relate, it was found that it had been seen, and the observations placed on record, on no less than nineteen separate occasions, without its planetary nature being once suspected! Lemonnier, one of the men who had seen it, narrowly escaped discovering its true nature, for he had observed it on several different occasions. He recorded his observations in such an unmethodical manner, however, that it was difficult to compare them with one another properly. In fact, one of his most important observations, one that was used afterwards in computing Neptune's orbit, was found by Bouvard "scribbled upon a confectioner's paper bag."

Those interested in this historical discovery will find fuller accounts of it and of the principles underlying it in Herschel's *Outlines of Astronomy*, in Grant's *History of Astronomy*, in Airy's *Historical statement of circumstances connected with the Discovery of the Planet beyond Uranus*, and in the Encyclopædia Britannica under "Leverrier."

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ARTICLES MARKED WITH A STAR (*) ARE ILLUSTRATED.