The Locomotive.

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A Boiler Explosion from Low Water.

Whenever a boiler explodes the general public concludes, without further evidence, that the cause of the explosion was low water. Usually the fireman is blamed for it, especially if the poor fellow was unfortunate enough to be killed, so that he cannot testify on his own behalf; but this particular corollary of the theory is not essential. The one thing that everybody is certain of is that the water was low and the plates red-hot, and that somebody then proceeded to pump in some cold feed water. The first gush of feed water that struck the hot plate is supposed to have instantly passed into steam, causing an enormous increase in pressure, and bursting the boiler.

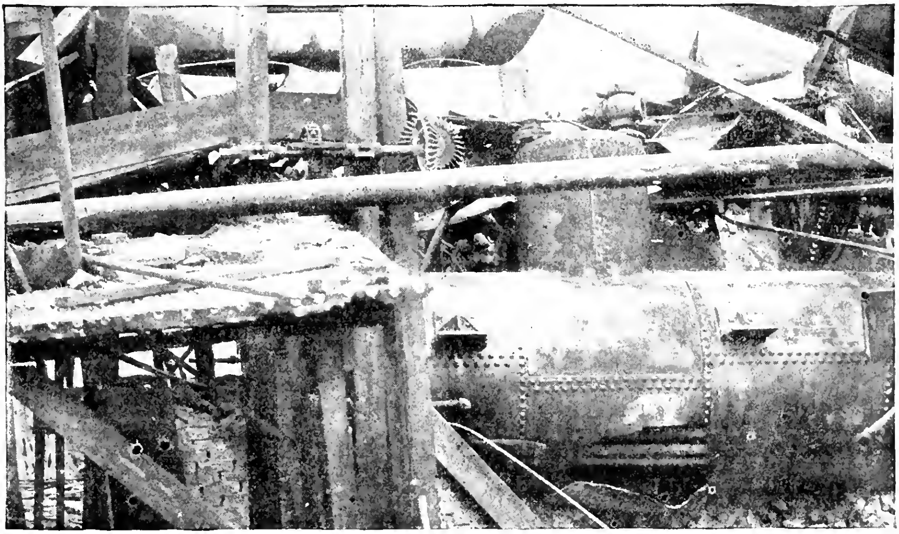

Fig. 1. — Showing the Exploded Boiler.

This theory is simple enough to satisfy any one, and it can be understood by anybody, no matter how unmechanical he may be. For these reasons, we suppose, it has fastened itself on the public so securely that they will have nothing else, and any attempt to explain the explosion in any other way is regarded with disfavor. It may be that there is evidence that plenty of water was present, and that the line of fracture passed through a serious and obvious defect in the material, or through an area where the plate was dangerously thinned by corrosion; and yet it is hard to make the average citizen believe, in his very heart of hearts, that low water did not figure in the catastrophe in *some* way or other.

We have said a good deal in the pages of THE LOCOMOTIVE against this low water theory, which appears to hold all inexperienced persons in its grip, and we have published illustrated accounts of many explosions which were certainly *not* due to low water: and we have tried to show that although low water certainly does produce explosions, there are a hundred other causes that must also be considered.

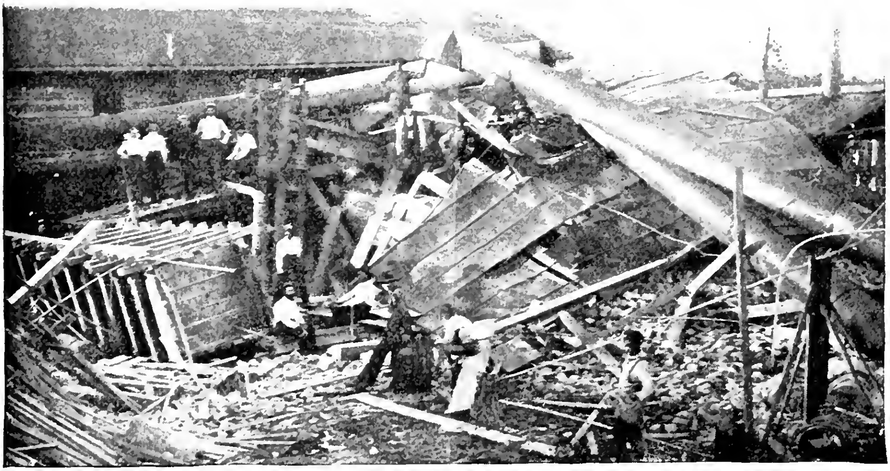

FIG. 2. — GENERAL VIEW OF THE RUINS.

This month we show the results of a boiler explosion in the South, which undoubtedly *was* due to low water. As will be seen from the first engraving, the boiler gave way on the sheet exposed to the fire, below the horizontal joint. The redness of the plates gave abundant evidence that the water had been low. We do not think, however, that the theory of a sudden generation of large quantities of steam from the flooding of the hot plate is likely to be true. (See THE LOCOMOTIVE for April, 1893, page 54). It is far more likely that the heat to which the plate was exposed damaged the material to such an extent that it no longer possessed the tensile strength to resist the stress to which it was subjected by the ordinary steam pressure; and we have an idea that the boiler would have exploded just the same, whether the feed valve was open or not.

The boiler here shown was 60 inches in diameter, with eighty 18-foot tubes, and a dome 36 inches in diameter and 36 inches high. The steel of which it was constructed varied in thickness, along the line of fracture, from 0.305″ to 0.824″. The longitudinal joints were double riveted, the rivets being driven in $\frac{13}{16}$-inch holes, pitched $2\frac{1}{2}$ inches from centre to centre. The break occurred about 12 inches below one of the horizontal joints, as shown in Fig. 1, and the escaping steam blew down the settings, destroyed the boiler house, injured two men, and overturned three iron stacks, besides seriously damaging two others.

The boiler was bought at the U. S. Navy Yard, at Norfolk, Va., and had seen but little service. It was believed to be in excellent condition prior to the explosion.

Inspectors' Report.

October, 1900.

During this month our inspectors made 11,352 inspection trips, visited 21,077 boilers, inspected 7,327 both internally and externally, and subjected 994 to hydrostatic pressure. The whole number of defects reported reached 13,160, of which 958 were considered dangerous; 42 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,060	100
Cases of incrustation and scale,	2,369	72
Cases of internal grooving,	129	1
Cases of internal corrosion,	632	21
Cases of external corrosion,	668	50
Broken and loose braces and stays,	124	28
Settings defective,	377	28
Furnaces out of shape,	340	12
Fractured plates,	294	45
Burned plates,	298	34
Blistered plates,	142	18
Cases of defective riveting,	1,339	22
Defective heads,	90	13
Serious leakage around tube ends.	2,880	236
Serious leakage at seams,	366	30
Defective water-gauges,	297	45
Defective blow-offs,	142	46
Cases of deficiency of water,	206	40
Safety-valves overloaded,	82	37
Safety-valves defective in construction,	65	32
Pressure-gauges defective,	401	45
Boilers without pressure-gauges,	3	3
Unclassified defects,	856	0
Total,	13,160	958

Boiler Explosions.

September, 1900.

(237.) — On August 30th the boiler of a clover-hulling machine exploded on John Beck's farm, at Ridgeville Corners, near Bowling Green, Ohio. Henry Hersch was fearfully injured, so that he died on the following day. William Beneke and John Beck were also badly hurt. [Our account of this explosion was received too late to include it in the regular August list.]

(238.) — On September 1st a boiler belonging to Philip Decker, an oil-well driller of Anderson, exploded near the Indianapolis pumping station, at Fortville, Ind. The men were in the derrick at the time, and escaped injury.

(239.) — A slight boiler explosion occurred, on September 1st, on the Coney Island steamboat *Sirius*, at Norton's Point, near New York City. The passengers were badly scared, but nobody was injured.

(240.) — On September 3d a boiler exploded in the Columbus, Ohio, "sanitary plant," at which the city garbage is disposed of. Jacob Schleppi was severely injured. The explosion wrecked part of the building, knocking the rear end out, and lifting the second floor.

(241.) — A boiler exploded, on September 3d, in the York Light and Heat Company's power station, at Biddeford, Me. William Hefferran was instantly killed, and Charles Meserve was injured so badly that he died a few hours later. The building was wrecked, but the dynamos and other machinery did not suffer to any great extent. The loss is variously estimated at from $7,500 to $10,000. The damaged plant lighted the streets of Biddeford and Saco, and also furnished the current for the electric lights in the stores and residences of both places.

(242.) — On September 3d a boiler exploded in the Suburban Electric Light Company's plant, at Scranton, Pa. Fireman Victor Andre was scalded. The boiler-room was badly damaged.

(243.) — A boiler exploded, on September 4th, in the stave factory owned by the McKay & Jones Lumber Company, at Meigsville, near McConnelsville, Ohio. Several employés were seriously scalded. The factory was wrecked.

(244.) — On September 6th a boiler exploded in Capstick & Son's works, at Montville, Morris county, N. J. Stephen Jaspo and John Corry were fearfully injured, and were removed to the Paterson hospital.

(245.) — A boiler exploded at Hazen, Ga., on September 7th. Two men were killed. We have not learned further particulars.

(246.) — A boiler exploded, on September 7th, in Dance Bros'. cotton-gin, at Columbia, Texas. Nobody was injured. The building was damaged considerably, and the boiler was thrown into the Brazos river.

(247.) — On September 7th the boiler of freight engine No. 557, on the Rock Island road, exploded some 45 miles east of Goodland, Kans. Fireman Robert Gowan was burned so severely that he died a few hours later. Engineer J. D. Farrell was thrown through the cab window, and although the train was running at 15 miles an hour, he was not seriously injured. The explosion consisted in the failure of the crown sheet.

(248.) — On September 10th a small boiler exploded in the electric light plant at Greenfield, Ill. Nobody was injured, and the damage was small.

(249.) — A boiler exploded, on September 10th, in Mr. S. F. Decatur Barrow's cotton-gin, about three miles from St. Francisville, La. Rufus Ard, George Smith, Joseph West, Charles Leslie, William Leslie, and S. D. Barrow were killed, and George Henderson, Rufus Williams, and a boy named Smith were badly injured. The building was entirely demolished.

(250.) — A boiler exploded, on September 10th, in the power-house of the Los Angeles–Pacific Electric Railroad Company, at Sherman, near Los Angeles, Cal. Nobody was killed. The roof over the south end of the power-house was blown off, and a portion of the wall caved in.

(251.) — On September 10th a boiler exploded in David Owen's sawmill, at Woody, some ten miles from Aspen, Colo. Harvey Denny was instantly killed, and the building was destroyed, fragments of it being thrown in every direction.

(252.) — An appliance connected with a boiler, and forming part of it, exploded. on September 11th, in the Baldwin Locomotive Works, Philadelphia, Pa. One man was instantly killed, four were fatally injured, and four others were seriously burned.

(253) — On September 13th a boiler exploded on the excursion steamer *Jacob Richtman*, while the steamer was on its way from Florence to Omaha, Neb. Caleb Haley, Edward Smith, Richard Allen, and Mrs. W Gwinn were severely scalded. The boiler was of the locomotive type, and the accident consisted in the breakage of stay-bolts and the failure of the crown-sheet.

(254.) — On September 13th a hot-water boiler exploded in the bathing department of the Metropolitan barber shop, on Sixth and Walnut streets, Des Moines, Iowa. Nobody was injured, and the damage was small.

(255.) — A boiler exploded at Sparrows Point, near Baltimore, Md.. on September 14th. William M. Nelson was burned so badly that he died during the following night.

(256.) — On September 16th the boiler of switch engine No. 2271, on the Atchison, Topeka & Santa Fé Railroad, exploded at Chicago, Ill. Engineer J. R. Jackson was thrown from the cab, and was somewhat bruised and scalded. The fireman had gone ahead to turn a switch, and so escaped injury. Brakeman E. Breckenridge was thrown from the top of a box car, and was painfully bruised. Conductor John Hayda was also slightly injured. The forward ring of the barrel of the boiler opened at the bottom, and was stripped entirely off. It was thrown 200 feet, over the round-house.

(257.) — On September 16th the boiler of Destrampe & Gauthier's threshing-machine outfit exploded on Mrs. William Johnson's farm, on the Sturgeon river, near Chassell, Mich. Joseph Gauthier, Peter Destrampe, Sr., Peter Destrampe, Jr., Narcisse Soumis, and Paul Mertsching were injured. The property damage is estimated at $1.500.

(258.) — On September 17th a boiler exploded in Frank Schmidt's grain elevator, at Carlyle, Mich. Mr. Schmitt, who was standing near the boiler at the time, was terribly scalded and bruised, and died from the effects of his injuries some hours later.

(259.) — A slight boiler explosion occurred, on September 17th, at the Lexington hotel, Chicago, Ill. Fire followed the explosion, but we do not know the extent of the damage.

(260.) — August Seber was killed, on September 18th, by the explosion of a threshing-machine boiler at Ocheydan, near Worthington, Minn. The fireman was also badly scalded.

(261.) — The boiler of a threshing-machine exploded, on September 18th, on John Goat's farm, in Hassan township, near Minneapolis, Minn. John Corcoran was severely injured, but it is believed that he will recover.

(262.) — A boiler exploded, on September 19th, on the steam yacht *Amadis*, near New Castle, Del. The fireman was severely burned.

(263.) — On September 19th several flues failed in the boiler of the tug *Valley Forge*, below New Castle, Del. We have not learned of any personal injuries.

(264.) — On September 22d a boiler exploded in Berry's woodyard at Chickasha, I. T. Mr. Berry, Zaccheus McRay, Ward Stinson, Eugene Stinson, and four others were seriously injured. Two of the injured may die. The boiler was thrown 150 feet, demolishing the rear end of Mr. Berry's feed store in its flight.

(265.) — An auxiliary boiler exploded, on September 22d, in the gas works at Delaware, Ohio. Engineer Charles Grebe was instantly killed, and Frank Gates and Levi Smith were seriously scalded. The building in which the boiler stood was partially wrecked.

(266.) — The boiler of freight engine No. 223, on the Chicago & Eastern Illinois Railway, exploded, on September 25th, at Johnson City, some six miles north of Marion, Ill. Engineer A. F. Padgett and Fireman Hardin Rains were killed. The locomotive was destroyed, and one fragment of it was picked up a quarter of a mile away.

(267.) — A boiler exploded, on September 26th, in Clinton Gillespie's dyeing and cleaning works, at Columbus, Ohio. The boiler room was badly damaged, but nobody was injured.

(268.) — On September 26th a boiler exploded in Albert Fisher's sawmill, at North Lebanon, Me. Frederick Fall was injured, and the mill was damaged to the extent of about $2,500.

(269.) — On September 26th a boiler exploded in the pumping station of W. C. Kinsolving, at Corsicana, Tex. The power-house, and Mr. Rockwell Brewer's residence, were totally destroyed, and two other dwellings in the neighborhood were damaged. It happened, however, that only one person was injured. Mrs. Hall Jones was struck by a flying fragment of the wreckage and injured painfully, though not dangerously.

(270.) — An auxiliary boiler exploded, on September 28th, on the schooner *Thomas Holland*, of Port Huron, Mich., while off Beaver Island, near Escanaba, Mich. The explosion tore up the forward deck and set fire to the sails and rigging, which were totally destroyed. Charles Marin and Anton Anderson were seriously scalded.

(271.) — On September 29th a boiler exploded in Calvin J. Tucker's cotton gin, near Greenville, N. C. One man was instantly killed, and another was badly scalded. Mr. Tucker was also scalded and bruised, though to a lesser extent.

(272.) — A boiler exploded, on September 29th, in Becker & Lane's furniture factory, at Camden, N. Y. Fortunately nobody was hurt, and the property loss was small.

OCTOBER, 1900.

(273.) — A boiler exploded on October 1st in R. C. Miller's lumber mill, at Shepherd, Tex. Britton Peters was instantly killed. Britton Grimes and William Hood were fatally injured, and two others were hurt badly. The boiler was thrown one hundred and fifty yards. The damage to property is estimated at $2,500.

(274.) — On October 2d a boiler exploded in Foster Bros'. cotton gin, some twelve miles east of Athens, Tex., killing James Sheptrine and Charles Ford. A man named Hale was badly injured.

(275.) — On October 4th a boiler belonging to W. H. Williams exploded on board the wrecked barkentine *Nellie M. Slade*, at Tortugas, Fla. Captain B. W. Johnson and a crew of nine men were trying to pump out the barkentine and float her, when the explosion occurred. Carryl Wetmore, Theodore Billbury, and two men named Owens and Nicholson were more or less severely injured.

(276.) — A boiler exploded on October 5th in a cotton gin situated six miles west of Flatonia, Tex., and belonging to Mr. Wink Winkfield. Flonie E. Winkfield, Elihu Anderson, Delia Kline, Ruby Kline, and Napoleon Nelson were killed outright, and Alice Watson, Effie Lee, Abner Bolton, Albert Martin, Wink Winkfield, and Henry McMicken were badly injured. The last two are almost sure to die. The cotton gin was entirely destroyed, and there was nothing left in its place to show where it had stood.

(277.) - On October 7th a hot-water boiler exploded in the basement of a tenement on Charles street, Manhattan, N. Y. Nobody was injured. The property damage was about $600.

(278.) — A boiler exploded on October 8th in Robert Parkhurst & Co.'s wood and coal yard, on Meridian and Kansas streets, Indianapolis, Ind. Reese Browning was killed, and Albert Stewart, Edward Brown, Robert Parkhurst, and Frederick Reddehase and his son Fred were injured.

(279.) — On October 9th a boiler exploded at Jericho, some eight miles southeast of Union City, Ind. John D. Brown was seriously injured.

(280.) — On October 11th a cable broke on the inclined plane of the Red Run Coal Company, at Ralston, near Lock Haven, Pa., letting three cars go flying to the bottom. The cars plunged into the boiler house of the Ralston Brick Works and caused the explosion of one of the boilers.

(281.) — On October 12th a mud drum of one of the boilers of the Youghiogheny Valley Railway Company exploded at Buena Vista, near Pittsburg, Pa. Fireman Walter Ready was badly scalded and burned, and the building was wrecked.

(282.) — On October 12th the boiler of locomotive No. 709, on the Chicago & Alton Railroad. exploded near Curryville, some thirty miles east of Mexico, Mo. John Mason was instantly killed. Engineer Patrick Markey and Fireman Crawford Wheeler were badly burned. Mrs. William Glasscock, W. E. Eckler, Dr. J. J. Kincaid, and a colored porter named Lindsley were more or less hurt. The locomotive was blown almost to atoms.

(283.) — A boiler exploded on October 13th in J. P. Odom's cotton gin, at Byron, some twelve miles south of Ennis, Tex. James Williford was seriously burned and bruised.

(284.) — On October 13th a boiler exploded in A. B. Turner's corn mill, two miles east of Greenville, Tex. Engineer Samuel Conder was seriously, and perhaps fatally, injured, and Mr. Turner was badly scalded also. The mill house was wrecked.

(285.) — A hot-water boiler exploded on October 14th, during the course of a fire at Waterbury, Conn. The boiler was thrown to a considerable height, and fell in Arch street, some two hundred feet from its original position.

(286.) — A boiler exploded on October 13th in the power plant of the Northern Ohio Traction Company, at Akron, Ohio. Fireman Joseph M. Clearwater was badly burned and scalded.

(287.) — A boiler exploded on October 15th in M. O. Gunter's sawmill, east of Black Lake, near Shreveport, La. One of the employés was slightly injured.

(288.) — On October 17th Michael Dvorak was instantly killed by a boiler explosion in True & Company's sash and door factory, Chicago, Ill.

(289.) — A terrific explosion occurred on October 19th in the boiler-room of the

Standard Milling Company, on the corner of Elm street and Broadway, Dallas, Tex. William Gadbury, James Brooks, and William Ingram were seriously injured.

(290.) — A boiler exploded on October 19th at an oil well which was being drilled by Benninger & Co., at Chester, near Parkersburg, W. Va. Nobody was injured.

(291.) — Frank Armstrong was badly scalded on October 21st by the explosion of a boiler in a cyclery, at Santa Cruz, Cal.

(292.) — On October 23d a boiler exploded at Hartford, Wis., slightly injuring George Hess and George Hall.

(293.) — A hot-water boiler exploded on October 25th in the barber shop of the Merchants' Hotel, at Little Rock, Ark. Nobody was injured.

(294.) — On October 25th a boiler exploded in the power-house of the Powelton Electric Light Company, at Philadelphia, Pa. William Beard was scalded so badly that he died a few hours later.

(295.)—On October 25th a boiler exploded in Richard Greenwood's sawmill, two miles southwest of Maysville, near Washington, Ind. Young Smith was killed, and his brother, Odle Smith, was fatally injured. Several other men were also injured in a lesser degree.

(296.) — A boiler exploded on October 26th at the shaft-house of the Chicago and Minonk Coal & Tile Works, at Minonk, Ill. Samuel Hayes, William Hayes, William Jackson, Edward Liston, and Mrs. Joseph Jezaorski were seriously injured, and five hundred men were imprisoned in the mine for some hours. The property loss is, perhaps, $10,000. This is the second time that boilers have exploded at this mine.

(297.) — On October 26th a boiler exploded in the office building of the American Steel & Wire Company, at Cleveland, Ohio. The explosion occurred during the evening, and nobody was injured by it. The damage was not great.

(298.) — William Kelly was killed on October 27th by the explosion of a boiler used for drilling an oil well on the Wilson lease, five miles west of Washington, Pa.

(299.) — On October 28th a boiler exploded in the basement of the residence of Mrs. Zilphar W. Spring, at Portland, Me. Nobody was injured, as the family was at church.

(300.) — A boiler exploded on October 29th, in Porter & Galihan's cotton gin at Beckville, Tex. Jack Carroll was instantly killed, and the building was considerably damaged.

(301.) — On October 30th a boiler used for drilling an oil well exploded on the Chase farm, near Findlay, Ohio. Nobody was injured.

(302.)—An accident similar in all respects to the immediately preceding one occurred on the same date on the Trout farm, also near Findlay, Ohio. Nobody was injured in either case, and the boilers did not leave their foundations.

(303.) — A large hot-water circulating boiler exploded on October 31st in the new Central High School building, on Broad and Brandywine streets, Philadelphia, Pa. Chief Engineer James H. Caldwell and his assistant, John W. Harrington, were severely scalded and bruised. The boiler passed through a twenty-inch brick wall in its course.

The Locomotive.

HARTFORD, JANUARY 15, 1901.

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

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

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WE desire to acknowledge the *Annual Register* of the Rensselaer Polytechnic Institute of Troy, N. Y., and also two other pamphlets relating to the work of the Institute. The "Partial Record of Work of Graduates" forms a very impressive list and shows that the Rensselaer graduates have done exceedingly well in the outside world. Men who have done so well must have received an education that really *educates.*

A CURIOUS view of boiler explosions, which is often taken by persons who ought to know better, is well illustrated by one otherwise intelligent account that we have received of explosion No. 237, the details of which are printed in this issue in our regular list. After admitting that the boiler steamed up until the safety-valve blew, and that the engineer, in order to get pressure enough to run his machine, then "moved the safety-valve weight back to the limit," the account goes on as follows: "The only explanation for the explosion is that part of the flues of the boiler had become so clogged that no water could enter them. The high pressure of steam, *possibly over 200 pounds*, forced the water into these red-hot flues, causing them to explode." Evidently it never occurred to the writer of these words that a pressure of 200 pounds per square inch on an old, and presumably more or less corroded boiler, had anything to do with the explosion, except its indirect influence in causing a little water to squirt in somewhere, through a crack in a chunk of scale. This idea that iron or steel will stand any kind of a strain, so long as it is only *wet*, is something that we cannot comprehend.

The Metric System in Congress.

Now that the House Committee in charge of the bill to substitute the metric system in place of our present system of weights and measures has decided to make a favorable report, the chances of our having to think and talk in terms of meters and kilogrammes become very real. The arguments in favor of the metric system are so many, so reasonable, and so well known, that it is not necessary to reiterate them now. Apart from the saving of time and labor among ourselves, there is the commercial advantage which will be gained by abolishing a system of weights and measures that seriously hampers us in our trade with almost all the foreign nations, and particularly with the Latin-American republics. The English-speaking races stand alone in the use of the old and largely discredited system; and although these races are far in the lead in manufacture and commerce, and have the power, if they wish, to perpetuate for many a decade to come a confessedly clumsy and antiquated system, every argument of utility and convenience calls for the substitution of a decimal system which, by long use, has proved its all-around superiority. It is scarcely likely, however, that such a change will be made during the present Congress, and the probability of the bill's becoming a law would be greatly increased if the other great branch of the English-speaking race could be induced to make the change simultaneously with this country. The agitation in favor of the metric system is as strong, possibly stronger, in Great Britain than it is here, and in view of the close trade relations and the enormous volume of business between the two countries, it is well worth considering whether an attempt at concerted, or rather simultaneous, adoption of the metric system would not be advisable.—*Scientific American.*

[The Hartford Steam Boiler Inspection and Insurance Company publishes a little book which tells all about the metric system. It is entitled *The Metric System*, and the price is $1.25.]

An Almanac King.

The *Old Farmers' Almanac* is one of the few American publications that have now lived in three centuries. It has made its bow regularly to the reading public for one hundred and seven years. The first number of the *Farmers' Almanac*, calculated on a new and improved plan for the year 1793, was issued on September 15, 1792, with an address to the "Friendly Reader," from "Yours and the Public's most obedient, humble servant, Robert B. Thomas." This first issue was so admirably arranged, and so well adapted to the use of the public, that in the century of the almanac's uninterrupted existence few radical changes have been made in it, and the number for 1901 is identical in size and makeup with the first venture of its author. Moreover, the almanac's title page still announces that it is "by Robert B. Thomas," although Mr. Thomas passed away in 1846, at the age of eighty years.

It was on a little farm, in Shrewsbury, Mass., that the man whose name is now a household word in thousands of New England homes, was born on April 24, 1766. Robert Thomas was the son of William Thomas, who was a schoolmaster by profession. Robert attended school as much as was usual among the children of his time, but as he grew older he divided his time between the study of astronomy, aiding his father on the farm, and learning the book-binder's trade. In 1789, when he was twenty-three years of age, he became greatly interested in almanacs, several of which were being printed at this time. The best of these was called "Isaiah Thomas's Massachusetts, Connecticut, Rhode Island, New Hampshire, and Vermont Almanac."

Bound to do something, Robert contracted with a Boston printer to furnish him the sheets of one thousand copies of Perry's Spelling-book, which he himself bound up, and with these and other school books he began his career as a bookseller at Sterling, Mass. About this time he called on Isaiah Thomas, at Worcester (a man to whom he was not related), and tried to purchase one hundred sheets of his long-named almanac. These Isaiah refused to sell, remarking that he disposed of them only to the trade. The curt refusal angered and mortified Robert Thomas, and he resolved to make an almanac of his own. He immediately set about learning how to make the necessary calculations, and in 1792 the first number appeared. His "copy" was sold to two young printers in Boston, Joseph Belknap and Thomas Hall, Mr. Thomas taking a percentage of the profits. In the preface to the first edition he offered a naive apology for anything in his almanac "that may appear of small moment," and the hope is expressed that "the literati will excuse it."

"As to my judgment of the weather," he continues, referring to those predictions which have been the occasion of much good-natured banter through all the almanac's long life, "I need say but little, for you will in one year's time, without any assistance of mine, very easily discover how near I have come to the truth." In view of this remark, it is interesting to note that quite recently the city clerk of Providence, R. I., kept a careful account of the *Farmers' Almanac* weather prognostications for one year, and at the end of this time announced that the predictions were correct in thirty-three per cent. of all cases. During that same year the weather bureau's forecasts, which are made only a single day in advance, were verified in thirty-five per cent. of the cases.

The fifty-fifth number of the *Almanac* contains the melancholy announcement of the death of Mr. Thomas, which occurred on May 19, 1846. In the address to patrons and correspondents the publishers say: "From respect to the memory of Mr. T., who first planned the *Almanac*, and has edited it so long, and whose name is associated with it in the minds of the friends of the work, that name will always be connected with it in future as in past time." This promise has been religiously kept by all succeeding publishers. In 1848, and in every year since that time, a facsimile of Mr. Thomas' signature has been appended to the address to "patrons and correspondents," an address which ends always with this, his own sentiment: "It is by our works, and not by our words, we should be judged; these we hope will sustain us in the humble though proud station we have so long held."

In 1892, a centennial number of the *Almanac* was published, and here was first printed an excellent, full-length portrait of Robert B. Thomas, together with a touching biographical sketch of Mr. Thomas, written by Dr. Samuel A. Green.

In recent years the *Almanac* has been the work of several men. An astronomer, well known in New England, but too modest to care for advertising, looks after the eclipses and the stellar complications; while one of those very men who make the weather for the daily papers supplies that same commodity for the *Farmers' Almanac.* Yet it is not for its weather prognostications, nor for its advice concerning sowing seed and avoiding earthquakes, that most people value the *Farmers' Almanac*; but rather because it has one of those old, familiar faces that Charles Lamb praised so delightfully. We like, from year to year, to welcome the quaint little book in its dull yellow cover. It takes us back to the days that are gone — days which, mellowed by perspective, seem happy, even if we did not think them particularly so when they were still in the present tense.— *Boston Globe.*

Casting a Great Lens.

It had just turned afternoon in the furnace house of the glass works of Jena. For upward of two hours everything had been in readiness for the casting of the great lens, — everything except the glass. The master had directed the placing of the huge circular iron mold near the open doorway and just between the two furnaces — the one from which now burst the fervid white radiance of the molten glass, and the one in which through weeks of lessening heat the lens, when cast, was to be cooled and toughened and tempered. The mold was a meter and a quarter in diameter — over four feet — and the lens here to be cast would make one of the largest in the world, large enough to bring the moon within a few score of miles of the earth, and one so perfect, perhaps, as to surprise new secrets from the sun itself.

The master had sprinkled the bottom of the mold with fine sand from a curious tin pot, that the hot glass might not take up impurities from the iron. A dozen brawny workmen, in blue blouses and wooden-soled shoes, had come in to man the long, wheel-mounted tongs which were to drag the crucible from the furnace bed. Other workmen with sledges and bars had torn a gaping hole in the front of the cooling furnace, so that it would be ready for the instant admission of the lens.

So everything was ready. The master, shading his face with his upraised arm, peered into the "glory" hole of the melting furnace, as he had been doing with ever greater frequency for hours past. He watched for a moment the shimmering, wrinkled surface of the molten glass within the crucible, and then he followed the movements of the stirring lever. Was the color exactly right? Did the sluggish waves which followed the stirring plunger show thick or thin enough?

At last the time came. The master gave the word, and a dozen men sprang forward with hooks and bars. The "glory" hole was hardly larger than a man's head — just sufficient for the passage of the stirring lever and to permit examination. With this as a beginning, the workmen tore out the whole front of the furnace, working with the utmost activity, their heelless shoes clattering on the stone floor as they rushed back and forth. The stirring lever was dismantled, and the stirring plunger itself, white-hot and sparkling with the dust that fell upon it, was cast outside, where it lay, a deep wine-red, in the sunshine.

The grappling tongs were thick bars of steel about thirty feet long, mounted on iron wheels. As soon as the furnace was open, the grappling ends were thrust inside, one on each side of the crucible, the men at the other end leaning back with heads averted to avoid the fervid outburst of heat.

Although the novice could not see it because of the brightness of the glow, there was a thick ridge around the crucible, about half-way up. Under this the tongs fitted themselves. The men at the other end bore down hard, but the crucible did not stir. It was firmly fastened to the furnace floor by the glass that had spilled in the melting. It was an anxious moment. Crucibles have been broken in lifting. The master raised his hand. Slowly the men added their weight at the far end of the lever. The crucible broke suddenly free, jogging a little, so that a bit of the glass overflowed and ran down like thick syrup. An instant later the crucible was outside the furnace, filling the whole of the high dim room with heat and light, like a new sun. And thus it was pushed down the room toward the mold, a thing of exquisite beauty, and yet of terror, showing a hundred evanescent colors, changing red, pink, yellow, violet.

The crucible was lowered to the floor, the tongs were removed, and a workman cast a beard of asbestos over the glass to prevent too rapid cooling. Here it stood a few minutes, and when the crucible began to define itself, one discovered that it was made of fine yellow-glazed pottery. Imperfections on its surface stood out like specks on a mirror, or as one would imagine the spots on the sun.

It had required long hours for a man to fashion the clay of this crucible, and many weeks for it to dry, and then for days before it was used it had been slowly heated to prepare it for the high temperature of the furnace. And with this single melting its service is finished and it is consigned to the scrap heap.

Three men with thickly-gloved hands are now fastening an iron band around the crucible just under the ridge. On each side of this band there is a protruding pivot of steel which fits into a socket in the ends of the grappling tongs, thus permitting the crucible to be tipped up as if on an axle. Again the men rest their weight on the other end of the tongs, the crucible is lifted, and an instant later it is poised over the iron mold. The critical point of all this labor has at last been reached. There is a pause as if the workmen felt the anxiety of the moment. The foreman, with his hand ready on the tilting lever, awaits the master's word. There is a shout, a quick upward swing of the foreman's arm, and out from the crucible slips the molten glass. It has been a moment of so much stress that one anticipates a crash as the glass touches the cool iron of the mold, but there is absolute silence — not so much as a hiss or the sound of the splash. There is something indescribable about the fluidity of this mass. It seems thick, like oil, and yet it spreads more swiftly than water; it is more like quicksilver than anything else that one can think of, and yet not at all like quicksilver.

The mold, with the glowing lens inside, was now covered with a plate of iron, wheeled to the mouth of the cooling furnace, and lifted with chain tackle to the height of the furnace floor. A movable-frame tramway was then placed underneath it, and it was quickly pushed into the furnace. Workmen were ready with brick and mortar, and in ten minutes the lens was walled in. Here it is cooled for two weeks, and then brought again to the open air, dull and milky of surface, and possessing only the general shape of a lens. After that, for days and weeks, workmen are employed in polishing it, not to give it the final form which it will have in the great telescope, but merely to prepare it for that important and anxious day when it will be submitted to those searching tests for imperfections, during which it must pass even the close scrutiny of microscopic and spectroscopic examination. A few bubbles it may have and pass, for bubbles have no effect, except to reduce the passage of light in a minute degree; but veins, denoting the improper mixture of the ingredients of the glass, it must not have. If it passes all the tests — and sometimes it requires many castings and costs many rejected lenses of this most precious of glass before the necessary perfection is attained — it is again sent to the furnace house, where, with even greater care than before, it is slowly raised to a high temperature, and thus annealed, and then as slowly cooled for two months or more. After that it is ready for the lens-maker proper, that skilled mechanician and mathematician of Jena or of America or of France, who polishes down its sides with infinite care, until they reach the most perfect curves appropriate to the refraction and dispersion of the glass disks employed. Each of these processes has absorbed precious time and has cost much money; the bare glass for such a lens would cost about $5,000. To this the skill of the optician would add, in polishing, perhaps $20,000 more, so that the finished lens, ready for fitting into the telescope tube, would represent an expenditure of some $25,000. Through such pains and expense as this must science pass, that mankind may add a few facts to its knowledge of some distant star.

The German workmen are standing back from the cooling furnace, perspiring, the lens finally cast. A boy comes in with his apron full of beer, a bottle for each, and they drink in characteristic German fashion to the success of the work. It may be many a day before such another lens is cast.— Ray Stannard Baker in *McClure's Magazine.*

The Hall of Natural History at Trinity College.

On December 7th the new Hall of Natural History of Trinity College, Hartford, Conn., was formally opened. The Rev. George Williamson Smith, D.D., president of the college, delivered the address of welcome, as follows: "It gives me great pleasure to welcome you to Trinity College on this occasion. It is the realization of what was undertaken by the trustees of Washington College, when they issued their prospectus in 1824. In that prospectus we find that professors had been appointed for departments of chemistry and mineralogy, of agriculture and political economy, and of botany. A professor of natural philosophy was to be appointed at an early day. It was a radical departure of the college curriculum accepted at that time, to give such a large place to scientific study, and the difference was increased by a provision that students could be admitted to 'pursue such particular studies as might be suited to their circumstances,' 'or as the inclination of their parents or guardians might require.' The additional announcement that if, in the end of their association with the college, the amount of attainments of special students 'should be judged by the faculty to be equal to the knowledge acquired in the regular course, they might be candidates for the Degrees in Arts, which would be conferred on the students in that course,' is still regarded as revolutionary in most of our colleges.

"The position and importance given to scientific studies attracted a large number of students who wished to prepare for the study of medicine, or for scientific pursuits, and among the early students a large proportion became distinguished physicians. Among the special students in 1829 was James H. Ward, a midshipman of the U. S. Navy, who was preparing for the examination for past-midshipman, and who found in Washington College the opportunities for such studies as he desired to pursue, and which were cultivated in only a few places. It was largely through his instrumentality that the U. S. Naval Academy was founded by Bancroft in 1844.

"But the men who founded Washington College, with its startling departure from the accepted course of study, were half a century in advance of their day; and it is as fatal to a man's usefulness to be fifty years ahead of his time as to be fifty years behind it. The college was compelled to recede from its advanced position and do the work called for in its generation. Yet the scientific studies, though reduced, were never abandoned. A few years ago, by the generosity of alumni and friends of the college, among whom the late Junius S. Morgan of London, and Mr. Walter Keney of Hartford, were conspicuous, but particularly by the large gift of the late George A. Jarvis of Brooklyn, N. Y., the laboratories for physics and chemistry were constructed and equipped. In 1888 tentative efforts were made to secure the funds for the erection of a building for the museum and department of natural history. The time was not deemed favorable, and the project slept until 1893. when another effort was made. But the flurry of a threatened war with England over the Venezuelan boundary caused another postponement. In 1898 the effort was renewed; several large subscriptions were obtained, W. C. Brocklesby, an alumnus of the college whose father had been for many years a professor in charge of the work of natural history, was engaged as architect, and to-day we have the satisfaction of seeing the completion of this part of the project of our venerated founder and his associates. In their name, as well as our own, I bid you welcome."

We take the following description of the building from a recent issue of *Science:* "The building, having a frontage to the north of 122 feet, and a width of 72 feet, is three stories high above an ample basement. The materials used are common brick, with molded brick and sandstone for finish. In plan the building is a parallelogram with a central projection 40 feet wide, flanked by octagonal turrets, extending through the several stories and finished above the main roof line. The principal entrance gives access to a wide staircase hall. Directly opposite this entrance is the doorway to the museum. The museum occupies three floors, the two upper ones having each an area of over 4,650 square feet, the first floor being connected with the second by an iron staircase and a large floor-well which forms a feature in the construction of the second floor. The whole museum has a southern exposure and is adequately lighted. A feature of the equipment is the aquarium and vivarium rooms in the basement. In the aquarium there are five tanks, each containing 290 gallons, paneled off from the main room as in the Berlin, Washington, Battery Park, and other aquaria. Thus the public can see the animals under the most favorable conditions, while in the aquarium section the students may work at problems in comparative physiology and comparative psychology without being disturbed. Three of the tanks are for marine and two for fresh-water animals and plants. The great advantage as an adjunct to teaching of having alive such animals as medusæ, star-fish, sea-cucumbers, and anemones, is apparent to any one who has attempted to gain a natural conception of such forms from alcoholic material only. In the attic is a large pigeon house for breeding purposes. Glass bee-hives and ant-nests are used for the study of community life.—In fact, it is planned to have every order of animals represented by typical species in the aquaria and vivaria, so that the study of function may go hand in hand with the study of form. In the museum each order is represented by specimens in alcohol, skins, skeletons, a dissection (accompanied by a water-colored sketch with all the parts plainly labeled), by and embryological models with explanatory charts, in order that the visitor or student may learn as much as possible of the forms exhibited, rather than become overwhelmed with the wealth of species."

A Census Prophecy.

The December issue of the *National Magazine* contains an article by Mr. H. J. Lewis entitled "A Census Prophecy of a Century ago." There doubtless were various prophecies of this sort made, but the particular one referred to in this article was that which was published by Professor Edward Wigglesworth, in the year 1775. Professor Wigglesworth included Nova Scotia (now Dominion of Canada) in his estimates, and he based his calculation on the hypothesis that "British Americans have doubled their numbers in every period of twenty-five years from their first plantation." Taking this statistical fact as a basis, and assuming that the population of the country in 1775 was two and one-half millions, Professor Wigglesworth estimated five millions for 1800, ten millions for 1825, twenty millions for 1850, forty millions for 1875, and eighty millions for 1900. These figures have proved themselves to be remarkably accurate. The population of the United States and Canada in 1900, for example, was about eighty-one millions, instead of eighty millions, as predicted.

"When we look back to the state of the colonies at the middle of the last century," says the Professor, in the course of his prophecy in 1775, "and compare it with the present, we are surprised to find that our ancestors, amidst all the difficulties they had to encounter, have been able in so short a period to put a face entirely new on all the country extended from Nova Scotia to Georgia, by changing the forest into a fruitful field; that they have opened such an extensive commerce as is carried on from America; and that by their cultivation of the liberal arts they have a posterity of two and one-half millions enjoying all the necessities and many of the elegancies of life." Professor Wigglesworth was evidently fully appreciative of the wonderful progress that the country had made up to his time; and that he appreciated the possibilities that lay before us is shown by his exclamation, "To anticipate the population and improvements at the close of the twentieth century overwhelms the mind with astonishment!" At the time when his paper was written the difficulties between England and America, which presently led to the war for independence, were abundantly in evidence, and in speaking of these difficulties he appears to foresee clearly that in a century or two we should be England's most valuable ally. "If these difficulties could be smoothed over," he says, "such a union of interest and affection would succeed, as would render the two countries the envy of Europe and the glory of the world."

The Locomotive.

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On Riveted Joints.

In a recent issue of *The Boiler Maker*, a little monthly publication issued by Joseph T. Ryerson & Son, of Chicago, Ill., we find an implied criticism of the methods used by the Hartford Steam Boiler Inspection and Insurance Company in calculating the efficiency of riveted joints. The criticism emanates from Mr. D. B. Dixon, of the St. Louis Association of Stationary Engineers, and it is based upon a comparison of a riveted joint designed by this company with another joint, which is alleged to be closely similar, and which was tested to destruction at the Watertown Arsenal. The two joints thus

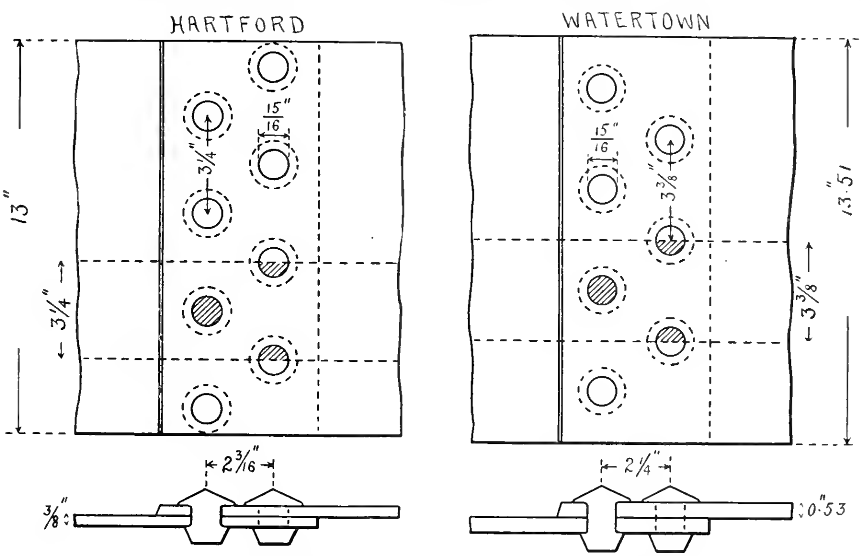

FIG. 1.—THE "HARTFORD" AND "WATERTOWN" JOINTS.—FIG. 2.

compared are shown in the engravings presented herewith, the one marked "Hartford" being one of our regular joints, while that marked "Watertown" is one that was tested at that place on May 29, 1896, the test being designated in the Arsenal records as "No. 9,374."

Mr. Dixon has a free-and-easy way of disposing of the case that would be charming if he had not made several important errors that spoil his argument altogether. He states the efficiency of our joint to be 70 per cent., as calculated by ourselves; and he gives the efficiency of the Watertown joint as 47.1 per cent., obtained by actual test. He then subtracts 41.1 from 70.0 (where he should have subtracted 47.1), and finds that there is a difference of 28.9 per cent. in the efficiencies of the two joints ; and this, he says, "is too great to be overlooked when the conditions are so nearly alike."

Now the difference, according to Mr. Dixon's own data, should be 22.9 per cent. instead of 28.9 per cent., but we will freely forgive him this even 6 per cent., because there is a yet more grievous error in his argument. He gives $\frac{5}{17}''$ as the thickness of the Watertown plate, and $\frac{3}{8}''$ as the thickness of the Hartford plate; whereas the Watertown authorities calipered the plate that they tested in four places near the joint, obtaining the respective results, 0.541", 0.517", 0.519", and 0.544", the average of these being 0.53", which is nearly *twice* the thickness given by Mr. Dixon.

With these amended data, let us calculate the efficiencies of the two joints. Taking up the Hartford joint first, the calculation is as follows :

Steel plate, tensile strength per square inch of section = 60,000 lbs.
Thickness of plate = $\frac{3}{8}''$.
Diameter of rivet holes = $\frac{15}{16}''$ = 0.9375".
Area of one rivet hole = 0.6903 sq. in.
Pitch of rivets = $3\frac{1}{4}''$ = 3.25".

Then, confining our attention to the unit of the joint contained between the two horizontal dotted lines, and noting that the rivets in our joint are supposed to be *iron* (not *steel*), and to have a shearing strength of 38,000 pounds per square inch, we have

Strength of solid plate = $3.25'' \times \frac{3}{8}'' \times 60,000 = 73,125$ lbs.
Strength of net section of plate = $(3.25 - .9375'') \times \frac{3}{8}'' \times 60,000 = 52,031$ lbs.
Shearing strength of two rivets = $2 \times 0.6903 \times 38,000 = 52,463$ lbs.

The net section is weaker than the rivets, and hence

Efficiency of joint = $52,031 \div 73,125 = 71.1$ per cent.

This calculation indicates that the "Hartford" joint shown in the engraving can be reasonably expected to have an efficiency of at least 70 per cent. The calculation is simple enough, and we do not see wherein Mr. Dixon can criticise it.

Let us now pass to the consideration of the "Watertown" joint. The rivets used in this joint were of steel, and the test showed that they had an average shearing strength of 41,760 lbs per square inch of sectional area. Using this as a basis, the efficiency of this joint would be calculated as follows :

Steel plate, tensile strength per square inch of section = 59,680 lbs.
Thickness of plate = 0.53".
Diameter of rivet holes = $\frac{15}{16}''$ = 0.9375".
Area of one rivet hole = 0.6903 sq. in.
Pitch of rivets = $3\frac{3}{8}''$ = 3.375".

Then, confining our attention to the unit of the joint contained between the two horizontal dotted lines in the figure, we have

Strength of solid plate = $3\frac{3}{8}'' \times 0.53'' \times 59,680 = 106,751$ lbs.
Strength of net section of plate = $(3.375'' - .9375'') \times 0.53'' \times 59,680 = 77,099$ lbs.
Shearing strength of two rivets = $2 \times 0.6903 \times 41,760 = 57,654$ lbs.

The rivets being much the weaker, the efficiency of the joint, as calculated according to the principles here laid down, is

$57,654 \div 106,751 = 54.0$ per cent.

We might look at the Watertown joint from another point of view, and merely ask what the test actually showed the strength of the joint to be, as compared with the strength of the solid plate. The Watertown authorities evidently figure this in the following manner :

The plate being 13.51″ wide and 0.53″ thick (on an average), with a tensile strength of 59,680 pounds per square inch, the total strength of the whole solid plate was

13.51″ × 0.53″ × 59,680 = 427,327 lbs.

If the joint had withstood a stress of 427,327 pounds before breaking, its efficiency would have been 100 per cent. Since, however, it actually did fail when the pull became 201,700 pounds, the efficiency, according to the method of calculation adopted by the Watertown authorities, was

201,700 ÷ 427,327 = 47.2 per cent.

(The Watertown report gives the efficiency 47.1 per cent. The difference is unimportant.)

This method of calculation does not appear to us to be entirely fair, because the joint tested is not an integral number of "units" in width. The total width is four times the pitch, it is true; but in an actual double riveted joint in a boiler there would be *eight* rivets in a section four units wide instead of only *seven*, as there were in the joint here described. The width of the specimen, in order to correspond to seven rivets, ought to be $3\frac{1}{2}$ units instead of 4. That is, the total width of the plate ought to be $3\frac{1}{2} \times 3\frac{3}{8}'' = 11\frac{13}{16}''$. The strength of the solid plate would then be

$11\frac{13}{16}'' \times 0.53'' \times 59{,}680 = 373{,}634$ lbs.

The efficiency of the joint, according to this amended mode of calculation, would then be

201,700 ÷ 373,634 = 54.0 per cent.,

which agrees perfectly, (as it should,) with the efficiency of this same joint as calculated by the first of the methods given above.

We trust that we have established, to the satisfaction of anyone who may be interested, the fact that the criticism upon our method of computing the efficiency of riveted joints has no just foundation. This is not a case where the doctors disagree, as Mr. Dixon phrases it. In view of the errors that he made in setting down the data which led to his comparison, it would be more accurate to say that this is a case where the patient refused to take the medicine that the doctor prescribed.

The year 1889 marked a revolution in the aluminum industry. Castner and Netto, by new and ingenious processes, had made metallic sodium (the reducing agent of Deville's process) at a greatly reduced cost, and had thereby largely reduced the cost of producing aluminum. New life had thus been put into the industry, and the yearly output had increased to 71 tons, while the selling price of the pure metal had decreased to less than $5.00 per pound. In fact, that very year it fell to about half that figure. Besides this, the electric processes of Cowles Bros. and of Héroult were furnishing aluminum in copper and iron alloys (but not the pure metal) at even lower prices. The last year of the century finds the industry upon an entirely different basis. From an annual production of 70 tons it has risen to the relatively enormous figure of 7,000 tons; and the price has fallen from nearly $5.00 a pound to the almost incredible figure of 30 cents. The seeds of this revolution were already germinating in 1889, for in that year pure aluminum, made electrolytically (by Hall in America and by Héroult in Europe) began to undersell the product of the sodium processes, and two years later the sodium processes were distanced and driven out of the business. The pure sodium exhibited at Paris in 1889 was all made by the sodium process; while that shown in 1900 was all made electrolytically.— Prof. J. W. Richards, in *The Journal of the Franklin Institute.*

Inspectors' Report.

NOVEMBER, 1900.

During this month our inspectors made 9,687 inspection trips, visited 18,758 boilers, inspected 6,874 both internally and externally, and subjected 862 to hydrostatic pressure. The whole number of defects reported reached 12,711, of which 857 were considered dangerous; 42 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	875	37
Cases of incrustation and scale,	2,517	82
Cases of internal grooving,	91	11
Cases of internal corrosion,	606	25
Cases of external corrosion,	511	31
Broken and loose braces and stays,	172	35
Settings defective,	321	28
Furnaces out of shape,	331	14
Fractured plates,	359	31
Burned plates,	349	26
Blistered plates,	89	4
Cases of defective riveting,	230	29
Defective heads,	185	16
Serious leakage around tube ends,	3,585	208
Serious leakage at seams,	380	22
Defective water-gauges,	203	40
Defective blow-offs,	146	49
Cases of deficiency of water,	13	4
Safety-valves overloaded,	60	37
Safety-valves defective in construction,	61	26
Pressure-gauges defective,	373	28
Boilers without pressure-gauges,	65	65
Unclassified defects,	1,189	9
Total,	12,711	857

DECEMBER, 1900.

During this month our inspectors made 11,071 inspection trips, visited 21,917 boilers, inspected 8,046 both internally and externally, and subjected 795 to hydrostatic pressure. The whole number of defects reported reached 17,423, of which 1,043 were considered dangerous; 103 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,044	42
Cases of incrustation and scale,	3,256	70
Cases of internal grooving,	160	11
Cases of internal corrosion,	985	50
Cases of external corrosion,	668	48
Broken and loose braces and stays,	177	45

Settings defective,	353	44
Furnaces out of shape,	395	20
Fractured plates,	467	78
Burned plates,	351	50
Blistered plates,	111	2
Cases of defective riveting,	2,989	27
Defective heads,	111	11
Serious leakage around tube ends,	3,524	229
Serious leakage at seams,	509	36
Defective water-gauges,	248	66
Defective blow-offs,	170	70
Cases of deficiency of water,	250	22
Safety-valves overloaded,	82	44
Safety-valves defective in construction,	75	35
Pressure-gauges defective,	408	28
Boilers without pressure-gauges,	15	15
Unclassified defects,	1,075	0
Total,	17,423	1,043

Summary of Inspectors' Reports for the Year 1900.

During the year 1900 our inspectors made 122,811 visits of inspection, examined 234,805 boilers, inspected 92,526 boilers both internally and externally, subjected 10,191 to hydrostatic pressure, and found 782 unsafe for further use. The whole number of defects reported was 177,113, of which 12,862 were considered dangerous. A summary of the work by months is given below, and the usual classification by defects is likewise given:

Summary, by Defects, for the Year 1900.

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	12,986	641
Cases of incrustation and scale,	32,157	870
Cases of internal grooving,	1,680	172
Cases of internal corrosion,	9,949	488
Cases of external corrosion,	7,502	537
Defective braces and stays,	2,152	585
Settings defective,	4,611	452
Furnaces out of shape,	4,687	218
Fractured plates,	3,963	646
Burned plates,	4,162	521
Blistered plates,	1,699	225
Defective rivets,	23,376	852
Defective heads,	1,176	155
Leakage around tubes,	37,405	3,290
Leakage at seams,	4,919	337
Water-gauges defective,	3,088	658
Blow-outs defective,	2,097	607
Cases of deficiency of water,	655	155

Safety-valves overloaded,	1,003	398
Safety-valves defective,	1,077	354
Pressure-gauges defective,	5,054	394
Boilers without pressure-gauges,	223	223
Unclassified defects,	11,492	84
Total,	177,113	12,862

SUMMARY BY MONTHS, FOR 1900.

MONTH.	Visits of inspection.	Number of boilers examined.	No. inspected internally and externally.	No. tested hydrostatically.	No. condemned.	Number of defects found.	Number of dangerous defects found.
January,	10,557	20,867	6,345	627	71	12,907	1,135
February,	8,898	16,964	5,385	649	48	10,869	1,074
March,	10,740	21,028	7,004	739	63	12,713	1,160
April,	9,834	19,874	8,411	867	47	16,072	1,131
May,	10,120	19,421	8,740	1,001	113	15,559	1,482
June,	10,392	18,141	8,926	1,033	113	15,715	1,347
July,	10,068	19,046	10,090	867	55	16,705	885
August,	9,380	17,623	7,580	862	32	13,624	827
September,	10,712	20,089	7,798	895	53	19,655	963
October,	11,352	21,077	7,327	994	42	13,160	958
November,	9,687	18,758	6,874	862	42	12,711	857
December,	11,071	21,917	8,046	795	103	17,423	1,043
Totals,	122,811	234,805	92,526	10,191	782	177,113	12,862

COMPARISON OF INSPECTORS' WORK DURING THE YEARS 1899 AND 1900.

	1899.	1900.
Visits of inspection made,	112,464	122,811
Whole number of boilers inspected,	221,706	234,805
Complete internal inspections,	85,804	92,526
Boilers tested by hydrostatic pressure,	9,371	10,191
Total number of defects discovered,	157,804	177,113
" " of dangerous defects,	12,800	12,862
" " of boilers condemned,	779	782

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

SUMMARY OF INSPECTORS' WORK SINCE 1870.

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

The following table is also of interest. It shows that our inspectors have made over a million and a half visits of inspection, and that they have made more than three million inspections, of which over one million were complete internal inspections. The hydrostatic test has been applied in over one hundred and sixty thousand cases.

Of defects, nearly two and a quarter millions have been discovered and pointed out to the owners of the boilers; and nearly two hundred and fifty thousand of these defects were, in our opinion, dangerous. More than thirteen thousand boilers have been condemned as unsafe, good and sufficient reasons for the condemnation being given in each case.

GRAND TOTAL OF THE INSPECTORS' WORK SINCE THE COMPANY BEGAN BUSINESS, TO JANUARY 1, 1901.

Visits of inspection made, - - - - - - -	1,539,432
Whole number of boilers inspected, - - - - - -	3,049,203
Complete internal inspections, - - - - - - -	1,176,097
Boilers tested by hydrostatic pressure, - - - - -	162,586
Total number of defects discovered, - - - - - -	2,226,256
" " of dangerous defects, - - - - - -	245,210
" " of boilers condemned, - - - - - -	13,215

Boiler Explosions.

NOVEMBER, 1900.

(304.) — On November 1st a boiler exploded at Angle, Tenn., some four miles northwest of Bethpage. Charles Bradley was instantly killed, and Luther Bradley and Jefferson Pressly were severely injured. It is said that Mr. Pressly cannot recover. Part of the wreckage was thrown three-quarters of a mile.

(305.) — A boiler belonging to Parks & Son exploded, on November 3d, at Macon, Mo. One man was badly scalded.

(306.) — On November 5th a boiler exploded in the Wylie Cooperage company's plant, at Interlochen, near Traverse City, Mich. Charles Hunks's skull was fractured, and he cannot recover. Albert Diler was seriously injured and several others received injuries that were more or less severe. The mill was badly wrecked.

(307.) — A boiler exploded, on November 6th, in the pump house on E. U. Morvant's plantation, on Bayou Lafourche, near Thibodaux, La. Clelie Campbell was painfully burned by the escaping steam.

(308.) — A locomotive boiler exploded, on November 6th, on the Houston & Texas Central Railroad, at Hearne, Robertson County, Tex. Engineer Harveson was badly injured about the head, but it is thought that he will recover.

(309.) — On November 7th, a boiler exploded in Gennet & Gauche's sawmill, at Georgetown, Ohio. Engineer Francis Fox was fatally injured. He was found pinned under one of the immense engines which had been overturned. Fox, with remarkable coolness, told his rescuers that the engine was settling upon him and crushing out his life, and urged them to hurry in their work of relief. He was imprisoned for two hours in this way, and during the entire time he gave orders to his deliverers how to proceed. The mill was almost totally wrecked.

(310.) — A boiler exploded, on November 9th, at Rizzleburg, near New Castle, Pa., in the Steele sawmill. Nobody was in the building at the time, but a party of hunters who happened to be near had a narrow escape from death. The mill was blown to pieces.

(311.) — On November 9th a boiler exploded in A. G. Atkins' cotton gin, some five miles south of Kingston, I. T. Mr. Atkins was badly injured, and may die. The entire plant was wrecked.

(312.) — A boiler exploded in a machine shop, at Indianapolis, Ind., on November 10th. Benjamin Osborn was struck on the head by a flying fragment, and his skull was fractured. At last accounts it was said that he would probably recover.

(313.) — A boiler exploded, on November 11th, in the basement of the Southern Hotel, at Chattanooga, Tenn. Engineer Hodgkins was fearfully scalded about the face and hands. The hotel was not seriously damaged.

(314.) — Oscar Brown, engineer at the Roane Iron Works, at Rockwood, near Nashville, Tenn., was fatally injured by a boiler explosion on or about November 12th.

(315.) — A hot-water boiler exploded, on November 12th, in a shop near the Mechanic Arts High School, Boston, Mass. John Boltz, a cabinet maker, was almost instantly killed by being struck by a fragment of iron. The damage to property was probably about $1,000. (We read in one account that the true cause of the explosion, "according to an engineer," was that "the water in the pipes formed a vacuum, which caused a back pressure into the boiler." We don't know what this means, but if a thing like that *can* happen, it sounds as though it might produce an explosion, or almost anything else.)

(316.) — A boiler exploded, on November 12th, in S. H. Stone's sawmill, at Brown's Valley, near Owensboro, Ky. Nobody was injured, and the damage was small.

(317.) — On November 12th a boiler owned by W. A. Gœhring exploded in the Crow's Run oil field, near Zelienople, Pa. Nobody was injured.

(318.) — A boiler exploded at Metz, near Mannington, W. Va., on November 14th. John Smith was painfully injured, but it is thought that he will recover. The accident consisted in the failure of the crown sheet of the boiler.

(319.) — A boiler exploded, on November 15th, at Clark's Corners, near Girard, Pa. George Offord was struck by the front head of the boiler and thrown about eight rods. He was almost instantly killed.

(320.) — On November 18th, a boiler exploded in Van Bergen & Company's foundry and machine shops, at Carbondale, Pa. Engineer David Wilson was thrown 100 yards and almost instantly killed. Several of the buildings about the plant were badly damaged.

(321.) — A boiler exploded, on November 19th, in the Y. M. C. A. rooms, at Elkhart, Ind. The boiler was used for heating water for the bath-rooms, and nobody was injured by the explosion. We do not know the extent of the property damage.

(322.) — On November 19th a boiler exploded in the Clipper feed mill, at El Dorado, near Wichita, Kans. Charles Dye received injuries that will probably prove fatal, and A. N. Crowther and Grant Rogers were also seriously hurt, though it is believed that both will recover. The south part of the mill was completely wrecked.

(323.) — On November 20th a boiler exploded on the Canadian Pacific steamer *International*, at Ogdensburg, N. Y. Four firemen were badly scalded, but it believed that they will recover.

(324.) — A slight boiler explosion occurred on November 22d, in the Plant shoe factory, at Roxbury, Mass. Engineer Henry Travers was badly scalded. Martin Griffin was also badly burned. The property loss was small.

(325.) — A pumping boiler exploded, on November 23d, on the Gonger lease, west of Rudolph, near Bowling Green, Ohio. Fortunately nobody was hurt. At the time of the explosion the boiler was carrying only about 70 lbs. of steam.

(326.) — A boiler exploded, on November 23d, on the farm of George Leiner, some three and one-half miles east of Wooster, Ohio. Charles Leiner and Edward Leiner were probably fatally injured. George Leiner was badly scalded, but will recover. The property loss was probably about $2,000.

(327.) — A boiler belonging to the Henderson Oil Company exploded, on November 23d, at Moore's Junction, near Marietta, Ohio. Fortunately nobody was injured.

(328.) — On November 23d a boiler exploded in Bowen's mills, near Hastings, Mich. Nobody was injured, and we have not learned further particulars.

(329.) — A boiler exploded, on November 23d, in Reisther's sausage factory, on Hutchins St., Houston, Tex. Nobody was injured. We do not know the extent of the property loss.

(330.) — On or about November 25th, a boiler exploded in Capt. J. H. Curl's saw-mill, on Bowen Fork river, near McMinnville, Tenn. Capt. Curl was severely injured about the face, and although we have not seen any estimate of the property loss, we understand that it was rather heavy.

(331.) — On November 25th, while lightering the cargo of the stranded steamer *Isaac Elwood*, in Mud Lake, near Detour, Mich., the forward boiler of the lighter *W. W. Stewart* exploded, killing Louis Carpenter, William McKenzie, and a man named Rankin, and injuring John Henderson, John Warner, Thomas Melvin, William McGregor, John Carns and Capt. Rawlins. Mr. Henderson died a short time after the accident, and Frank Hilder, who was on the *Stewart*, is missing, and was undoubtedly blown into the water and drowned.

(332.) — A small boiler explosion occurred on November 26th, at Newton, Kans., and Fireman Fritz Miller was badly scalded, but it is believed that he will recover.

(333.) — A small vertical boiler exploded, on November 26th, at Oil City, Pa. Alfred Waterson, Gillard Huff, William Hughes, C. D. Hughes and William M. Mills were seriously injured.

(334.) — On November 26th a boiler exploded in Ellis Short's planing mill, at Grannis, Polk county, Ark. Charles Harris and P. D. Batson were instantly killed, and F. H. Laing, William Frazer, Charles Harper and C. E. Killian were injured. The boiler house was utterly demolished. The property loss is probably about $6,000.

(335.) — Charles Pagel was instantly killed, Adolph Middlestadt was fatally injured, and Herman Podaweltz and Ferdinand Pagel were injured to a lesser degree, by an explosion in the Pioneer Wood Pulp company's mill, at Grand Rapids, Wis. One end of the mill and one side of the boiler room were completely wrecked.

(336.) — On November 27th a boiler exploded at the Raub Coal company's mine at Luzerne, near Wilkesbarre, Pa.

(337.) — On November 27th a boiler exploded on Graham & Mook's oil lease, at

Rising Sun, Ohio. The boiler house was wrecked, and a dwelling near by was badly shaken up. Orrin Graham was painfully injured by flying fragments.

(338.) — A slight boiler explosion occurred, on November 28th, in the electric light plant at North Baltimore, Ohio. Nobody was killed and the damage was small.

(339.) — The pump boiler that supplies the Central Illinois water tank at Little Cypress, Marshall county, Ky., exploded, on November 28th, seriously scalding Edward Sargent and otherwise injuring a section foreman. The boiler house was literally demolished.

(340.) — On November 29th a boiler exploded in the Chesapeake & Ohio Railroad pump house, at Somerset, Orange county, Va. James McGayhee was killed, and the building was completely demolished.

(341.) — James Coleman and D. C. Cook were killed, and John Peters, Charles Peters, Charles Gieberstein, Victor Kieffer and Joseph Wohl were injured, on November 29th, by the explosion of a boiler at the Davenport Glucose Works, Davenport, Iowa. The explosion completely wrecked the engine room, and demolished a part of the boiler house. The property loss is estimated at $10,000.

(342.) — A boiler used for shredding fodder exploded, on November 30th, some four and a half miles north of Spring Hill, near Bellefontaine, Ohio. Upton Moore and Harley Heater were killed, Charles Mohr was fatally injured, and John Makemson was also hurt.

(343.) — A boiler exploded, on November 30th, in the Henney Buggy plant, at Freeport, Ill. Engineer James Keene and Fireman A. Straus were seriously injured. A boiler exploded in the same place about a year ago.

(344.) — A slight boiler explosion occurred, about November 30th, in the power house at Forty-sixth street and Woodland avenue, Philadelphia, Pa. William Beard was fatally scalded.

About ten years ago an epidemic of flywheel explosions began, and in the three years 1892, 1893, and 1894, it prevailed to the extent of about one large wheel a month, not to mention those under twelve feet in diameter. These wheels, without exception, were of cast-iron, and of all sorts of designs and qualities of metal; and most of them went to pieces from overspeed, commonly known as "racing." In the following years, down to the present time, the casualties have been decreasing, and I have not noticed more than one or two since the beginning of last year. Flywheels, as their name implies, are primarily used to regulate the speed of an engine; — not the number of revolutions, but the uniformity of speed during any one revolution, storing power while the piston is exerting more than the average power, and restoring it when the piston is delivering less than the average; and this, of course, causes a series of fluctuations in the strains thrown on the wheel. With most engines the flywheel combines with its regulating function the office of main driving-pulley carrying the main belt, or it may take the form of a large gear wheel. The combination of these several functions and their accompanying strains subjects this member of the machine to greater variations, perhaps, than any other part. — *Extract from a Paper on "Flywheel Explosions," read by* Mr. Charles H. Manning *before the American Association for the Advancement of Science.*

The Locomotive.

HARTFORD, FEBRUARY 15, 1901.

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

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

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

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

WE have received a copy of the official *Report* of the fifth annual convention of the International Association of Municipal Electricians, held at Pittsburg, Pa., in September, 1900. It is very creditably gotten up.

COMMISSIONER Edmund Mather has favored us with a copy of the thirteenth annual *Report* of the Board of Commissioners of the Water and Lighting Department of the city of Harrisburg, Pa., for the year 1900. The *Report* is attractively gotten up, and is illustrate by several excellent half-tone engravings.

THE General Electric Company, of Schenectady, N. Y., has issued a neat and attractive pamphlet entitled *The Aging of Transformer Iron*, which contains a series of highly interesting papers on the magnetic properties of iron. This pamphlet will prove a welcome addition to the library of every student of the principles of electrical engineering.

THE January issue of *The Engineering Magazine*, which is described as the "Works Management Number", may be fairly said to be one of the most remarkable issues of a technical magazine that have yet appeared. It contains something over three hundred pages of reading matter, and nearly as many more of classified advertisements. It should be in the possession of everybody who is interested in the larger problems of engineering.

WE desire to acknowledge a copy of *The Copper Handbook*, compiled and published by Mr. Horace J. Stevens, of Houghton, Mich. This volume gives an enormous amount of information about copper mines and copper mining, and will be of great value as a work of reference. The compilation of such a work represents a vast amount of labor, and we trust that *The Copper Handbook* will meet with the favorable reception to which it is abundantly entitled.

WE have received a copy of the *Transactions* of the Engineering Society of Columbia University, for the year 1899–1900. The present issue is fully up to the high standard of the previous one, and the papers that it contains are of much interest. Prof. Francis B. Crocker's paper entitled "Electrical Notes on Japan" affords a good illustration of the enormously rapid strides that that progressive nation is making in the arts of civilization. The Tokyo electric light station, illustrated on page 83, might be situated in any American town, so far as appearances go; and the view of the telephone wires of Tokyo, on page 81, is strikingly suggestive of some of the overhead snarls that we have seen much nearer home.

Professor Elisha Gray.

A great American inventor has passed away in the person of Professor Elisha Gray. Born in 1835 at Barnesville, Ohio, he was compelled to shorten his school period in order to begin the battle of life. As the family was in straitened circumstances, the future inventor betook himself to the hammer and saw, and for several years earned his livelihood, like Gramme (of dynamo fame), as a carpenter's apprentice. The experience he acquired in this humble craft was not lost, for it served as an introduction to the refined handiwork in which he subsequently excelled. After a few years' toiling at the bench, Gray succeeded in entering Oberlin college, which was not far from his homestead. Here he spent five years, devoting himself specially to the study of physical science. We next hear of him in 1865, when he first gave public evidence of his powers for electrical invention by devising an automatic relay, the hotel annunciator, the telegraph line-printer, and telegraphic repeater. He soon became connected with the Western Electric Company, and about the same time established a manufactory of electrical appliances in Cleveland.

The year 1873 marks an epoch in his life, for it was then that he began to achieve success with his electro-harmonic system for transmitting sounds over telegraph wires. The system is based on the discovery that a sound produced near a magnet will cause a similarly adjusted magnet to respond to it, even when the latter is placed at a considerable distance. This is precisely what is known to-day as the electrical transmission of sound, or electric telephony. The problem was a great one from a theoretical as well as from a commercial point of view. It opened up new vistas to the scientist and great possibilities to the capitalist. But as it so often happened in the history of discovery and invention, others were at work in the self-same field. Dolbear and Graham Bell were actively developing their telephones, and were not far behind pioneer Gray. In 1876 Gray sought to protect his work by taking out a "caveat" at Washington for the specific purpose of enabling him to extend and perfect the "art of transmitting vocal sounds telegraphically." This was on February 14th, and shortly after he learned to his great surprise that a broad patent for "speaking telephones" was granted to Graham Bell on March 8th. Keenly resenting the injustice (as he considered it), he entered the courts and sought to recover his legal rights. Litigation went on briskly at first, and then more slowly, ending after a period of twenty-five years in a legal recognition of Bell's claims. It is only fair to add that opinion is still divided on this vexed question, and there are not wanting noted electricians who dissent from the finding of the courts.

These prolonged troubles worried the inventor and depleted his purse. One of his admirers recently wrote: "He benefited the whole human race, made twenty millionaires, and took boarders to get bread for his family and tools for his workshop." Despite these vexations, Gray toiled on, encouraged by the hope which springs eternal in the human breast; and, as the outcome of his later labors, we have his telautograph, which electrically transmits handwriting and drawings to a distance. This beautiful invention failed to elicit the patronage of capitalists, however, so that his pecuniary expectations were again dashed to the ground.

Gray was engaged on perfecting a method of submarine fog signals when the final summons came. It came suddenly, for he dropped dead at his home at Newtonville, Mass., on the morning of January 21st, succumbing to an acute attack of neuralgia of the heart. We cannot dwell on the various episodes in the life of Professor Gray without a feeling of sadness mingled with admiration: sadness for the cruel disappointments that he experienced, and admiration for the spirit with which he endured them all.—*Engineering* (London).

We desire to acknowledge a copy of *Engineering Practice and Theory*, written and published by Mr. W. H. Wakeman, of 64 Henry Street, New Haven, Conn., who will be glad to furnish full information concerning it. The price is one dollar.

Curiosity and Science.

Curiosity, it may be safely said, is the handmaid of science. And to the men who have found something mysterious in the common occurrences of life, and whose curiosity has been sufficiently aroused to unravel the mystery, we owe much of the progress we have made along almost every line of thought. It is true that the explanation of the mystery may require an extraordinary logical power and an imagination with which not all of us are blessed. But, nevertheless, the process of reasoning which has led to the greatest discoveries may be largely attributed to the very human impulse of inquisitiveness.

No doubt many a man before the time of Columbus had remarked the exotic fruits and branches tossed up by the waves of the Atlantic on the shores of the Canary Islands. Such fruits had never been seen in the Old World; yet the islanders had picked them up from time immemorial with never a serious thought as to whence they might come. But the Genoese mariner had both curiosity and imagination. To him these strange gifts of the sea became messages sent from a land which no European ship had ever touched. It may be that he was mistaken in his conception of that land; but the fact remains, if the story can be credited, that it was from seeing these strange things that the voyage of exploration which culminated in the discovery of the New World was first planned.

Then we have Newton's apple. It matters little whether or not the apple did fall, or opportunely strike Newton while he was sitting in his garden. Things have fallen ever since the universe was created. And yet no man seems ever to have asked himself why.

Robert Mayer, a ship's surgeon, cruising in the East Indies, noticed that the venous blood of his patients seemed redder than that of people living in temperate climates. Doubtless other physicians had also noticed the fact. Mayer pondered over this apparently insignificant difference in venous blood, and reached the conclusion that the cause must be the lesser degree of oxidation required to keep up the body temperature in the torrid zone. And it was this conclusion which finally induced him to look upon the body as a machine. The thought led to the discovery of the mechanical theory of heat, and to the first comprehensive appreciation of the great law of the conservation of energy. Blood-letting is a time-honored practice which is now fallen out of favor. But this inquisitive and discerning physician deduced from it conclusions so marvelous that he has been called "the Galileo of the nineteenth century."

Chemists speak familiarly and learnedly now of the law of substitution, by which they are enabled to explain so many of the eccentricities of carbon compounds. The discoverer of that law was a curious Frenchman named Dumas, who was once invited to a court ball given at the Tuilleries. A strong and penetrating odor pervaded the royal ballroom. The guests coughed and sneezed. Dumas also coughed and sneezed, and wondered why. He tells us that he finally recognized the odor as that of hydrochloric acid, and found that the wax tapers by which the ballroom was illuminated had been bleached with chlorine. Experiments which this discovery subsequently induced him to make proved to him that for the hydrogen in organic compounds other elements could be substituted, atom for atem, and that every organic compound was, therefore, a step to some other organic compound. No generalization has contributed more to the progress of organic chemistry than this law of substitution.

Such anecdotes can be told *ad infinitum*. Enough have been given to show clearly how simple things are often straws which have guided the current of scientific thought to epoch-making discoveries.—*Scientific American*.

[There can be no doubt about the great importance of curiosity in the development of science, and we can subscribe to all that is said above, except that the reference to Newton implies that he was the first to perceive that bodies fall because the earth attracts them. If we are not greatly mistaken this was held to be true before Newton's discovery of the law of universal gravitation; but the difficulty was that there was no apparent reason why this action should be confined to bodies *near by*;—that is, no reason why the earth should not attract bodies in space just as well as those near its surface, although with a less intensity on account of their greater distance. Nobody, before the time of Newton, knew enough mathematics to be able to prove that the earth really *does* attract the heavenly bodies in this way. Newton's fame, so far as it rests on his study of gravitation, is due to the fact that he solved the whole problem of gravitation, and showed that *every* body in the solar system attracts every other body according to a certain definite law, which is known as the "law of inverse squares." Newton was so great a man that the luster of his name will never be sensibly dimmed by giving all the credit we can to the other learned men of his time.—*Editor* The Locomotive.]

Abstract of Statement.—January 1, 1901.

Hartford Steam Boiler Inspection and Insurance Company.

ASSETS.		
Cash in office and bank,		$150,068.37
Premiums in course of collection (net),		223,391.28
Loaned on bond and mortgage, first liens,		458,450.00
Bonds and stocks, market value,		1,825,788.48
Real estate,		30,712.00
Interest accrued,		12,616.93
Total assets,		$2,701,027.06
LIABILITIES.		
Premium reserve,		$1,561,434.36
Losses in process of adjustment,		17,851.85
Capital stock,	$500,000.00	
Net surplus,	621,740.85	
Surplus as regards policy-holders,	$1,121,740.85	1,121,740.85
Total liabilities, including capital and surplus,		$2,701,027.06

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

VOL. XXII. HARTFORD, CONN., MARCH, 1901. No. 3.

A Few Small Things About Boilers.

A good many of the things that are wrong about boilers, are so because somebody didn't know any better. There are plenty of small troubles that are not of this kind, however, but are rather due to the fact that somebody didn't think hard enough about what he was doing. The boiler-maker is responsible for many slips of this sort, and it sometimes happens that a boiler that he turns out is just wrong enough to make the prospective buyer doubtful whether he ought to accept it or not. An illustration or two will make this clear.

The two heads of a horizontal tubular boiler having been made ready for riveting into position, it is not by any means uncommon for the builder to put them in so that

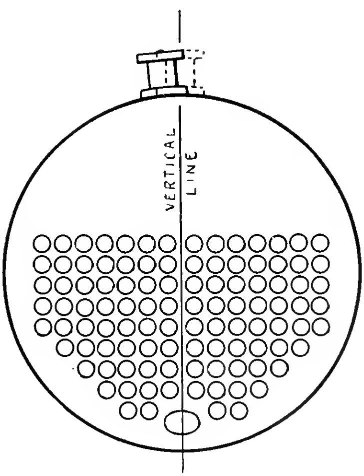

FIG. 1. — SHOWING A MISPLACED NOZZLE.

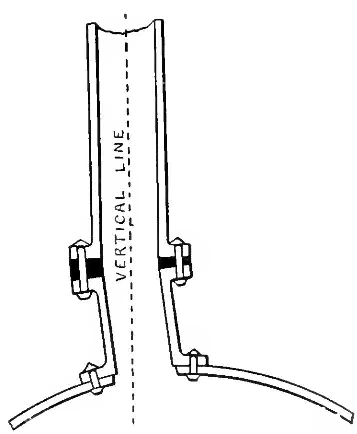

FIG. 2. — ILLUSTRATING THE USE OF A "DUTCHMAN."

they are not exactly "fair" with each other, one of them being twisted around (say) one rivet hole too far, so that the holes for the tubes do not exactly match the corresponding ones on the other head. This mistake is a very easy one to make; and if it is discovered before the work has gone too far, it is easily remedied by taking out one of the heads and replacing it correctly. It often happens, however, that the error is not noticed until the boiler is nearly completed and the tubes are practically all in position, so that it would be an expensive operation to make things right. The boiler is therefore delivered, in the hope that the mistake will be either overlooked or condoned.

This particular kind of defect is not especially serious, when the heads fail to match each other by only a single rivet hole, although a boiler the tubes of which lie along a warped surface is not at all what the purchaser contemplated nor what he proposed to pay for. One could hardly criticise the purchaser for rejecting such a boiler, and insisting upon having one that is right in all particulars. The only trouble that need be feared with a boiler defective in this way, is that if the tube-rows on the front head are set horizontally, some part of the tubes at the rear end may come too near the water level for security. All horizontal tubular boilers should be set, however, with the rear end some three inches lower than the front end, in order that the blow-off may properly drain the boiler; and hence the tubes are usually submerged some three inches more deeply at the back end of the boiler than they are at the front end. If the error in the placing of the back head is not more than one rivet hole, this greater submergence at the back head will therefore more than make up for the twisting of the tubes, and hence no trouble need be feared from the rear tube ends being too near the water surface on one side. Sometimes, in setting boilers that are defective in the way here considered, the front rows of tubes are not made horizontal, but are slightly inclined so that the tube-rows on the front head and those on the back head make equal angles with the horizontal. When this is attended to, the boiler may be set truly horizontal, if it is desired to set it so, without any apprehension being felt on the score of bringing

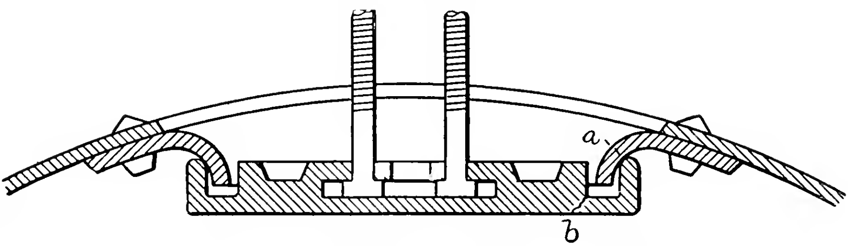

Fig. 3. — Illustrating a Man-hole Cover.

some of the tube ends too near the water level; but in such cases it is best to carry the water (say) one inch higher than it would be carried if the boiler were not defective.

Another common defect for which the boiler maker is also responsible, is indicated in Fig. 1. It consists in placing the steam nozzle a little to one side or the other of the center line of the boiler, instead of right upon that line, where it should be. The full outline in Fig. 1 shows such a misplaced nozzle, the correct position being indicated by the dotted lines. A small error of this kind will do no particular harm, provided the first horizontal length of steam pipe runs parallel to the length of the boiler. If this first run of steam pipe extends *across* the boiler, there will obviously be difficulties in making proper connections. In such a case it is usual to set the boiler so that the tube-rows are horizontal. The first vertical section of steam pipe is then secured to the nozzle by means of a wedge-shaped "dutchman," indicated in the cut by the heavy black area. It is rare that the nozzles are enough out of true to make one side of them more than a quarter of an inch above the other side; and hence this construction is always practicable, and the vertical pipe secured to the nozzle may be made truly vertical without using a "dutchman" of prohibitory thickness. The angle between the nozzle and the vertical line is purposely exaggerated in the cut, in order to make the idea clearer.

Another cause of trouble around boilers, which perhaps may be fairly classified with the foregoing, is the use of hand-hole plates, man-hole plates, and other accessories, which do not fit the places where they are to be used. An instance of this, which was recently reported by one of our inspectors, is shown in Fig. 3.

A good deal of trouble had been experienced, at this place, from the breakage of the cast-iron man-hole covers that were used. Our inspector, in examining one of the boilers, observed a bright spot on the man-hole frame at the point marked *a;* and upon investigation he found that the covers were of such a shape that the frames did not rest properly against the packing around the groove in the covers, because the outer lips of the covers were so deep that they were apt to come in contact with the frame at *a*, or at some similar point. The result naturally was, that it was hard to make a tight joint; and the workmen, with more enthusiasm and muscle than forethought, screwed the tightening nuts up so faithfully and earnestly that a tremendous strain was thrown on the covers. The result was, that these covers cracked, as shown at *b*, almost as fast as they were put in. In one case the crack was found to extend around the cover fully as much as is indicated in Fig. 4.

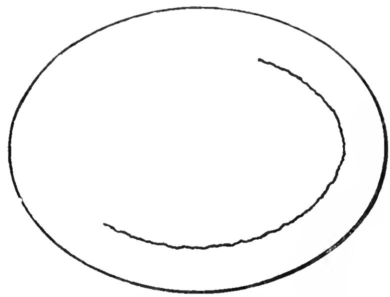

Fig. 4. — Showing the Extent of the Fracture.

These, and a hundred other small things that are not often described in point, serve to illustrate the advantage of having even the newest boilers examined by a competent inspector.

Boiler Explosions.

December, 1900.

(345.) — On December 3d a boiler exploded on Mr. Kern Craig's farm, in the northeastern part of the town of Celina, Ohio. Nobody was injured.

(346.) — On December 3d a boiler exploded in the electric lighting plant of the Chicago & Northwestern Railroad Company, on Kinzie and Kingsbury streets, Chicago, Ill. August Clamman, Anthony Krause, August Weiss, Joseph Speight and Henry Schnorr were killed outright, and Arthur J. Scully, George Kelles, and one other person died, not long afterwards, as the result of their injuries. Some nine other persons were also injured. Two sides of the boiler house were blown out, and the electric machinery was ruined. The property loss is variously estimated at from $50,000 to $100,000.

(347.) — A boiler exploded on December 5th, at the Pearson Coal Mine & Railroad Company's coal mine, near Birmingham, Ala. The boiler was thrown about 1,000 feet. Fortunately nobody was near the boiler at the time, so there are no deaths nor personal injuries to report.

(348.) — On December 5th a boiler exploded in the power house of the Los Angeles & Pacific railway company's plant, at Sherman, Cal. Fireman Robert Walsh was killed, and Engineer W. D. Langdon was painfully injured. The explosion occurred in the middle of the night, or there would doubtless have been a much larger list of casualties to report. The power house was destroyed. One of the drums of the boiler was thrown a quarter of a mile, and another was thrown an eighth of a mile. (An extensive illustrated account of this explosion will be found in the issue of *Power* for March, 1901.)

(349.) — On December 6th a boiler exploded in Robert McDaniel's sawmill, near Linton, Hancock county, Ga. William Prescott and Horace Ray were instantly killed, and two other men, whose names we have not learned, were injured. The mill was totally wrecked.

(350.) — A boiler exploded on December 6th, in the Cumberland Electric Light & Power company's power house, at Nashville, Tenn. Three men were injured, and fragments of the exploded boiler were thrown through the roof of the building. The property loss was not large.

(351.) — On December 7th the boiler of a locomotive exploded on the Lackawanna railroad, at Ray, near Buffalo, N. Y. Charles Miller and A. J. Auerbach were seriously injured, and will probably die.

(352.) — On December 10th a boiler exploded in the Riverside Rolled Oat company's plant, at Riverside, near Washington, Iowa. We have not learned further particulars.

(353.) — On December 11th a boiler used for operating a pile-driver exploded at Ashland, Wis. Night Watchman Rudolph Susman was instantly killed, and the pile-driving outfit was wrecked.

(354.) — A boiler exploded on December 11th, in Varney Carter's sawmill, at Spivey, Tenn. Bedford Pedigo and Granville Green were fatally injured, and Frederick Pedigo also received painful injuries, from which, however, he is expected to recover.

(355.) — A boiler exploded on December 12th, in the oil fields near Bowling Green, Ohio. Frank Houser was instantly killed. We have not learned further particulars.

(356.) — A boiler exploded on December 12th, at the Shamrock mines, at Coal Creek, near Knoxville, Tenn. The fireman was badly scalded. The property loss was small.

(357.) — A boiler exploded on December 12th, in Houston & Norton's greenhouses, at Somerville, N. J. The buildings took fire, and were totally destroyed. Nobody was injured.

(358.) — On December 13th a boiler exploded in the power house of the Rapid Transit railroad, at Syracuse, N. Y. We have not learned particulars.

(359.) — Engineer William Smith and Fireman James Kelley were killed on December 14th, by the explosion of the boiler of engine No. 107, on the Lehigh Valley railroad, at Cheektowaga, near Buffalo, N. Y. The locomotive was a new one, and the engineer and fireman were experienced men.

(360.) — A heating boiler exploded on December 14th, in the Rockefeller building, at Sunbury, Pa. David Seasholtz, who cared for the boiler, was seriously injured.

(361.) — A boiler exploded on December 16th, in the Highland Paper mill, at Johnsonburg, near Kane, Pa. Nobody was injured, but the damage to the property is said to have been considerable.

(362.) — A boiler exploded during the course of a fire, in the Lewis Roofing company's plant, at Rock Island, Ill.

(363.) — A boiler exploded on December 19th, in Zimmerman & Merriman's sawmill, some two miles south of Spearsville, Brown county, Ind. A fragment of the boiler struck Mr. Merriman (one of the proprietors) and fractured his skull. His recovery is doubtful. The main portion of the boiler was thrown some 75 feet, but fragments of it were found 900 feet away.

(364.) — A boiler exploded on December 20th, in Sheriff Blankenbeckler's sawmill, near Sneedville, Tenn. Pleasant Trent and William Edwards were killed, and Jesse Mehan and Lee Gordon were fatally injured.

(365.) — On December 22d a boiler exploded in E. A. Bennett's feed mill, at La Moure, N. D. Nobody was near at the time.

(366.) — Howard Potter, a fireman on a Lackawanna freight engine, was killed by the failure of the crown-sheet of his boiler, on December 23d, at Rockport Hill, near Hackettstown, N. J.

(367.) — A boiler belonging to Mr. R. G. Risser, exploded on December 26th, at Greenwich, near Kankakee, Ill. Nobody was hurt.

(368.) — A boiler exploded on December 27th, in John M. Miller's sawmill, in the Blue Ridge, near Rileyville, some eight miles north of Luray, Va. Engineer James Stoneberger was instantly killed, and John Miller (the proprietor), and John Rickard were injured so badly that they died a day or two later. John Deavers was also seriously injured, though it is believed that he will recover. (A similar accident happened at the same place about a month previously, and Deavers was injured in that explosion also.)

(369.) — On December 28th a boiler, used to operate a threshing machine, exploded on the farm of Dennis Regan, of Derrynane, near Waterville, Minn. The explosion occurred during the noon hour, and nobody was injured.

(370.) — A tube bursted in a safety boiler on December 28th, in the power house of the electric railway company at Terre Haute, Ind. Herbert Williams and John Gummere were scalded about the face and hands.

(371.) — A boiler exploded on December 28th, on Oliver Thornburg's farm, near Connorsville, Ind., destroying the building in which it stood, together with an automobile which was in the building. Nobody was injured.

Boiler Explosions during 1900.

We present herewith our usual annual summary of boiler explosions, giving a tabulated statement of the number of explosions that have occurred in the United States during the year 1900, together with the number of persons killed and injured by them.

It is difficult to make out accurate lists of explosions, because the accounts of them that we receive are often unsatisfactory. We have spared no pains, however, to make this summary as nearly correct as possible. In making out the detailed monthly lists from which it is extracted (and which are published from month to month in The Locomotive) it is our custom to obtain as many accounts of each explosion as possible, and then to compare these different accounts diligently, in order that the general facts may be stated with some considerable degree of accuracy. It may be well to add, too, that this summary does not pretend to include *all* the explosions of 1900. In fact, it is probable that only a fraction of these explosions are here represented. Many accidents have doubtless happened, that were not considered by the press to be sufficiently "newsy" to interest the general public; and many others, without doubt, have been reported in local papers that we do not see.

The total number of explosions in 1900 was 373, which is 10 less than we recorded for 1899. There were 383 in 1899, 383 in 1898, 369 in 1897, and 346 in 1896. In four instances during the past year two boilers exploded simultaneously. In such cases we have counted each boiler separately in making out the summary, as we have done heretofore; believing that in this way a fairer idea of the amount of damage may be had.

The number of persons killed in 1900 was 268, against 298 in 1899, 324 in 1898, 398 in 1897, and 382 in 1896; and the number of persons injured (but not killed) in 1900 was 520, against 456 in 1899, 577 in 1898, 528 in 1897, and 529 in 1896.

It will be seen from these figures that during the year 1900 there was, on an average, over one boiler explosion a day. The figures in the table also show that the average of the deaths and injuries during 1900, when compared with the number of explosions, was as follows: The number of persons killed per explosion was 0.72; the number of persons injured (but not killed) was 1.40; and the total number of killed *and* injured, per explosion, was 2.12.

Summary of Boiler Explosions for 1900.

Month.	Number of Explosions.	Persons Killed.	Persons Injured.	Total of Killed and Injured.
January,	36	21	56	77
February,	33	23	41	64
March,	25	19	35	54
April,	27	19	64	83
May,	18	18	22	40
June,	36	27	41	68
July,	32	28	58	86
August,	32	16	41	57
September,	35	25	45	70
October,	31	18	45	63
November,	41	27	50	77
December,	27	27	22	49
Totals,	373	268	520	788

It is hard to understand why boiler explosions are so much more numerous and destructive in this country than they are in England. In the year ending with July 1st, 1900, only twenty-four persons were killed and sixty-five injured by boiler explosions in Great Britain, making a total of 89 persons killed and injured. The contrast between this and the 830 persons who were killed and injured by boiler explosions in the United States during this same period is very striking. We cannot suppose that the returns as given for Great Britain are defective to any great extent, because the Board of Trade has special facilities for obtaining full knowledge of such matters. Neither can we suppose that the number of boilers in the United States exceeds the number in Great Britain by anything like the proportion of ten to one. It has been said that boilers in this country are run on a smaller factor of safety than those in England. We do not know whether this is true, on the whole, or not; but we are very sure that the difference, if any difference exists, is not great enough to explain the tremendous preponderance of deaths and injuries in the United States. In fact, we have been unable to arrive at *any* explanation which appears to be reasonable and adequate.

Liquid Fuel.

The *Annual Report*, for 1900, of the Chief of the Bureau of Steam Engineering, of the Navy Department, is at hand. Among other noteworthy passages we find the following concerning the liquid fuel experiments that have been conducted by the Bureau for some time past: "As far as has been possible with the facilities at hand, the Bureau has pursued these interesting experiments during the year. It has labored under the great disadvantage of not having available an expert engineer officer to devote his time to the work and make the necessary observations. An air-tight fire room has been built in one of the shops at the New York yard, representing, in a degree, the conditions obtaining on board a torpedo boat, but being free from many of the inconveniences always connected with experimental work afloat, and more particularly those upon small vessels. In this room is installed a water-tube boiler — small tube type — and all necessary apparatus for running oil-fuel tests with forced draft, it being my intention to get good results ashore before installing any further burners on board the *Talbot* — the torpedo boat turned over to the Bureau for these experiments. So far, the success with the jet type of burner does not seem to indicate possible satisfaction. The best type of jet or spray-burner jet used on the *Talbot* has failed to secure power for a sustained speed of more than three-fourths the full trial speed of the boat, even for half an hour, while the smoke feature is equally as evident as with soft coal, except at a speed as low as ten knots. Great convenience attaches itself to the use of oil fuel, especially in these small boats, owing to the instant control obtained thereby over the fires, and the avoidance of handling ashes or cleaning fires while under way. In point of economy and fuel efficiency, however, it has not yet been demonstrated, either in this country or abroad, that a change from coal is at present possible. The first desideratum in this field is to secure full power without smoke, the matter of economy in torpedo-boat class being of secondary consideration. By reason of this smoke question, the difficulties are greater than they otherwise would be. Experiments with a retort burner, in which the oil is volatilized and mixed with the hot air before issuance therefrom, are now in hand, and, while giving promise of a greater efficiency than did the jet apparatus, sufficiently definite results have not yet been obtained upon which to base positive conclusions. I wish to note here that none of the burners experimented with is of Bureau design. The great number and variety of oil burners extant, covering the results of the work of hundreds of inventors, has afforded opportunity for selecting types of ample variety for its experiments, and securing also the advantage, in many cases, of the inventor's personal directions."

We desire to acknowledge a circular issued by the Decimal Association, of London, England, reporting the progress of the metric agitation in England during the past year. We note that 170 members of parliament have signified their approval of the compulsory adoption of the metric system in England. The names of 150 of these are given in the circular before us, and it is stated that the names of the remaining 20 are withheld only because authority to publish them has not yet been received. (The address of the Decimal Association is "Botolph House, Eastcheap, London, E. C.")

The Locomotive.

HARTFORD, MARCH 15, 1901.

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

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

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

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

A BOILER exploded, on December 28th, in Calcutta, India, killing eight men and injuring many others.

WE have received a copy of the Twenty-Eighth Annual *Report* of the Sächsisch-Thüringischer Dampfkessel-Revisions-Verein, of Halle a. S., Germany, containing the statistics of the business of the association for 1900.

ON December 20th the British steamer *Domingo de Larrinaga*, Capt. Gibson, which left Liverpool on November 28th for Port Eads, La., arrived at Hamilton, Bermuda, in distress. During a gale on December 13th, her main steam pipe bursted, killing three firemen and scalding others.

WE are indebted to Mr. W. R. Macdonald, engineer for the Commercial Block, Salt Lake City, Utah, for a copy of an attractive pamphlet issued by the Oregon Short Line railroad, and entitled *In and About Salt Lake.* It contains a good deal of information about Salt Lake City and the Mormans, and is beautifully illustrated by half-tone engravings.

WE desire to acknowledge a copy of the Fifteenth Annual *Report* of the Illinois Society of Engineers and Surveyors, containing the proceedings of the society at its fifteenth annual meeting, held at Moline, Ill., in January, 1900. It contains a good many things that will be of interest to civil engineers. Copies may be had, at fifty cents each, of Prof. M. S. Ketchum, Executive Secretary, University of Illinois, Champaign, Ill.

REPORTERS with lively imaginations appear to be in evidence as much as ever. One of the New York *Sun's* young men sends in the following piece of mendacity from Syracuse, N. Y. "That milk is not equal to water as a steam producing agent, was demonstrated on the Erie & Central New York railroad by passenger train No. 1. The train stopped at the water pump and milk station at Cincinnatus, N. Y., for a supply of water. Fireman John Barney, a new employé, made a wrong connection and filled the engine tank with sour milk. The milk curdled as soon as it struck the heat, and clogged the pipes. Engineer Jonas Miller asked the dispatcher for an extra engine to haul his train to the end of its run."

A MARKED feature of technical journalism, in recent times, has been the issuing of "special numbers," devoted to the discussion of particular problems, or to the reports of expositions or conventions. In our last issue we noticed the "Works Management" number of the *Engineering Magazine*, and now we desire to call attention to the very creditable special issue of the *Railway Age*, designated as the "Engineering and Maintenance of Way Number." This appears under the date of March 15th, and contains, in addition to the usual selection of general articles, a complete stenographic report of the recent meeting of the American Railway Engineering and Maintenance of Way Association.

A CORRECTION.— In our list of boiler explosions for August last, we stated that "the boiler of a steam automobile belonging to Dr. A. S. Hill exploded, on or about August 5th, at Peru, near North Adams, Mass." Dr. Hill, who lives at Somerville, Mass., now writes us as follows: "While touring, last summer, in a steam carriage, I became stalled, owing to the clogging of a gasoline pipe, and of the water suppiy pipes and valves. Nothing in the nature of an explosion occurred." In editing THE LOCOMOTIVE we aim, above all other things, at accuracy; and hence we are pleased to print the foregoing correction. We desire to say that we obtained our original information from the North Adams (Mass.) *Evening Herald*, of August 9th, 1900, where the accident is certainly described as a boiler explosion.

IN the issue of THE LOCOMOTIVE for July, 1900, we paid our respects to "Poleforcia," the "new power produced by the multiple energising momentum engine." We have now received another pamphlet concerning this wonderful invention. We admit that it is wonderful, even though we don't believe that it will work; but the engine itself cannot be half so wonderful as the circulars that its promoters get out to describe it. For example, we read on the title page of the present installment, that the invention "involves the discovery of a new method whereby power may be produced and utilized, and it destroys the modern accepted theory of Energy, so far as regards its universal application." On the first inside page we find the following beautiful specimen: "The heat theory of Carnot is all very well. (NOTE. Re-published by Pro. Tait; but the theory was doubted by both Dr. Rankin and Pro. Claudius; besides it is no 'chip in the porridge.' It is a great big blunder, but capable of a pre-arranged exhibit, but no of universal application.) You can pre-arrange an experiment, which shows the power converted into heat, and heat converted into power. We use the word 'pre-arrange,' because of the conditions, and arrangement of our Mobile, shows that heat has nothing to do with the rims of our fly-wheels, that there are no atoms or globules put into the fly-wheels, and there is no heat, atoms or globules, that come out of our fly-wheels, therefore the theory is not capable of universal application." And so on. The degree of familiarity that the author of this circular has with the writings of Rankine and Clausius may be inferred from the fact that he has spelled both of their names erroneously. The assertion that the mechanical theory of heat is "a great big blunder, but capable of a pre-arranged exhibit," is one of ths choicest morsels that we have run across in many a day.

It is only fair to say, in conclusion, that the circular now at hand contains some tests made on "energiser momentum engines" on the Glen Echo Electric road, at Washington, D. C., which appear to show a considerable economy over the results obtained with Westinghouse engines. We do not question the integrity of the gentlemen who conducted these tests, nor of those who vouch for the accuracy of the results ; but, all the same, our disbelief in the "multiple energising engine" is not shaken. We have no doubt but that good and sufficient reasons for the apparent improvement would be readily discoverable, if such reasons were sought by a well-posted and disinterested party. We are content, however, to be so stubborn as to cling to the mechanical theory of heat, even at the cost of being counted among those who "bury their heads, ostrich-like, and obstinately refuse to be convinced," as our multiple-energising friends have graciously expressed it.

Boiler Explosions in Great Britain.

An important parliamentary paper has just been issued by the British Board of Trade, containing the results of the working of the boiler explosions acts of 1882 and 1890. The report covers the twelve months previous to July 1, 1900, during which period twenty-four persons were killed and sixty-five injured by boiler explosions in Great Britain. This period, it will be recalled, includes one exceptionally serious case, that of an accident at Sheffield in November, 1899, in which seven persons were killed and ten injured. With this exception, it is said that the recent report, where it concerns the loss of life, compares favorably with that of preceding years, as the average numbers killed and injured during the last eighteen years are 29.2 and 61.5 respectively.

On the other hand, the number of persons injured exceeds the average for other years. As regards the causes of the explosions, seven cases are attributed to ignorance or neglect on the part of boiler attendants, and under this head the figures for the last ten years seem to indicate that a steady improvement is taking place. In other respects there is no marked change in the general character of the causes of explosions. In twenty-eight cases the boilers which exploded had been inspected on behalf of insurance companies, classification societies, or in connection with the survey of passenger steamships. But in ten of these cases the explosions were not due to defects in the condition of the boilers. In one case, in which a formal investigation was held, an insurance company was ordered to pay £40 costs on account of negligence shown by its inspector.— *New York Times.*

Stop Valves and Inspections.

An esteemed correspondent at Newark, N. J., writes to THE LOCOMOTIVE as follows: "Your article in the October issue, under the title of 'Don't Touch the Valves,' suggests the idea that your inspectors could easily use the same system of guarding against carelessness that I use. Having charge of a large electric plant, I found it necessary to use a simple method of preventing switches being closed while at work on high tension circuits. I had a number of bright red cards printed with the words, 'DANGER ! DON'T CLOSE !' on them. One of these cards is fastened to the switch after opening it, and remains there until the work is completed and the engineer has been notified. Your inspectors could easily carry a set of these cards, and before a man entered a boiler he could attach a card to every valve opening into that boiler. In this way the likelihood of accidents through the careless opening of the wrong valve could be materially reduced. The idea may be of no value to you, or it may have been tried and abandoned; but I call your attention to it, because I have found it useful to myself and others. In a large plant there is always a more or less divided responsibility, and caution is a good thing."

Pump Troubles.

Pumps are tricky things, anyhow. There was a time when many of the pump phenomena that we get up against might have been explained as caused by witchcraft; but in this century that won't go, and we have to find some hydraulic or kinetic theory, or something else, to fit each particular case, and it does seem at times as though the homeopathic treatment, with monkey-wrench, packing, and perseverance, was rather too mild, and we would like to administer a massage with a ten-pound sledge, and supplement it with a course of cupola elixir — if we had the time, and didn't need that particular pump right then and there.

One of my first encounters with a pump was about the time when I had arrived at the know-it-all stage; and if I had any idea when I went for that pump that there was any mechanical knowledge in the world worth having that was not already in my possession, I came back, at least, feeling that I was an authority on that particular breed of pumps. When I reached the place I found a single-cylinder Knowles pump. I had never seen nor heard of one before, and it may possibly have occurred to me, when the engineer said he had a machinist there all the day before who "had her all apart and could't make her pump," that I might get points on so simple a thing as a steam pump before I got through. "She ran all right until yesterday. She lost her water and won't catch. There is plenty of water in the well; only ten feet lift; pipes all right and nothing wrong with the pump, for we had her all apart; only she won't pump."

"Can you start her up?" I asked. He gave the throttle a turn, and that pump just gave two or three shivers and then started off like a pneumatic calking tool, making about 4,000 one-inch strokes a minute, and was just beginning to walk off the foundation when I got her stopped. I walked around that pump twice; partly because I didn't know what else to do. I couldn't make out what that rocker-arm arrangement hitched on to the valve stem was for. I found there was a thing on the piston-rod which seemed to be to knock the rocker arm first one way and then the other. I had the engineer start it very slowly; but it only gave little convulsive jerks, as though its life as a pump was about at an end. I never knew just what inspired me to do it, but I put two fingers on the rocker arm, possibly to see if I could get them cut off, when suddenly the pump started off in the most well-behaved manner possible, and it continued to run so as long as my fingers remained there; but as soon as I removed them it took another fit. I finally got it into my head that that rocker arm worked too easily, and I discovered that the stud on which it was pivoted had a special spring washer under the nut for the purpose of making sufficient friction to keep the arm in one position until the pump made a complete stroke and knocked it back again. A half-turn on the nut made the pump all right. I think, now, that the other fellow must have been awfully stupid; still, subsequent experience has proved to me that there are others.

The duplex pumps have displaced many of the former annoying and complicated valve gears, with auxiliary pistons, which in turn were operated by auxiliary valves with ports drilled in them which looked like stray blow-holes of no particular importance — at least, that is what I thought they were when I first saw them. It was at a big brick works, two miles out. They telephoned in, just about quitting time, to have someone come out right away to fix a pump, because they couldn't get water into the boiler. I got there when I ought to have been sitting down at supper, and I was wondering what I had ever learned the trade for, anyhow. I knew the superintendent of the place; he was one of our customers, and none of us liked him. He tried to make us think he knew a whole lot, when he didn't know anything. He was leaving in a great hurry when I got there; said he had to meet a man. The engineer told me that the superintendent had worked all the afternoon on the pump, and that he had had it apart three or four times, but could not make it go. If I had known that before I started, I would at least have had my supper. It seemed as though the steam chest was carrying a young one on its back, and how it ever worked with so many blow-holes in it was a mystery to me; but presently I got it through my head that the holes were there for a purpose, and following this clue, I worked out the theory that the little valve had to move first and let the steam get through those holes to the piston on the big valve, and when the big valve moved it let steam into the pump cylinder. I found the little valve had got turned around so the blow-holes didn't match. I took it out and put it back the right way, and, although the engineer watched me closely, I had the pump running before he knew what I had done, and I wouldn't tell him how I did it. I was hungry; and when the superintendent afterwards tried to find out how it was done, I wouldn't tell him either. But we charged him enough to pay for my supper, all right.

There is one steam pump on the market which has a port cut in the gasket under the cylinder head. The space between the port and the bore is a narrow strip which sometimes blows out, and I have known two or three cases where all hands were stuck because they did not discover this.

A prominent mechanical engineer told me this story: "Several years ago I went to look after some work in a new power-house. On arrival I found the plant stopped on account of a pump which had refused to work, although an expert had been there and had gone away disgusted. They entreated me to see whether I could not fix the pump, but as it had nothing to do with my work, I turned a deaf ear to their entreaties and went on with my own task. I had never had much experience with pumps, anyway, and I thought I had better keep out of it. But when they all went over to the hotel I stayed behind a few minutes to take a look at it. I took off the cylinder head and found on the gasket the impression of a small port which had not been cut open. I stabbed my knife into it, put the head on again, and the pump went all right. I left it running and got up to the hotel only about fifteen minutes after the others, without their even missing me. After supper they were still berating the pump, and when I told them that it was running all right they would not believe me until I took them back and showed it to them."

Here is another incident that a friend once told me. "I was working in a shop in Philadelphia some years ago," he said, "when I was told to go to a brewery some thirty miles out, to fix a pump. I got there in the evening, and was much surprised to find a pulsometer. I had never seen nor heard of one before. I also found that two other men from different shops had been there and couldn't make it pump. My prospects were not very bright, but I tackled it. There was plenty of water in the well, and the piping was all right; so the trouble must be in that queer-shaped thing they called a pump. I took it apart, and there was nothing in it but a little ball in the top and four valves in the bottom, and they were all right. I tried it again, but it didn't work. There was nothing in the pump to fix but those valves, so I took them out, one at a time, looked at them, put them in again, and tried the pump. I kept doing that all night long, and, although it was not warm, I perspired from sheer exasperation. For some reason along toward morning that thing took a notion to pump. I don't know why, but it pumped. I got my breakfast, and when I came back up over the hill I fetched a great sigh of relief to see that the water was still pouring out of the pipe on the top of the tank. The proprietor greeted me very cordially. 'Ach,' he said, 'you are a fine mechanic. We had two men here and they could not fix dot pump. How much I owes you?' I charged him for time and expenses, and added ten dollars for knowing how. I don't know yet what I did to that pump, but we got all his work after that." — TIMOTHY BROWN, in the *American Machinist.*

Professional Courtesy in the United States.

No subject has received more attention, in recent times, in the technical and critical press of the world, than American competition. In all the arguments used to explain the preëminence of American engineering, one agency which has been overlooked, to some extent, is the growth of the splendid professional spirit which is characteristic of American practice to-day. One of the strongest evidences of this is to be found in the technical publications of this country, especially when comparisons are made with similar foreign publications. We use the term publication as inclusive not only of the periodical press, but also of the transactions of the scientific societies, as well as the various papers and books issued by the U. S. Government and others at irregular intervals. Any person whose observation extends over the field of current technical literature cannot fail to be impressed with the broad spirit which is displayed by the American engineer in the communication of facts and figures, gathered in his own practice, to his fellow workers. This is strikingly apparent, too, on personal contact with American and foreign engineers and manufacturers. Here offices and shops are thrown open to the visitor, often on slight acquaintance, and processes are described and permitted to be inspected in operation. Abroad, on the contrary, the visitor usually meets with closed doors and sealed lips, even when armed with the strongest credentials. If he is permitted to view a plant or process, he is usually escorted by some polite nonentity, who might as well be a deaf mute, so far as imparting information is concerned. There are notable exceptions, of course, but, speaking broadly, the conditions are as stated. If knowledge is power, then the methods adopted in America must be productive of material aid in the fight for commercial supremacy. Possibly the chief exponents of the dark lantern methods are the British engineers. Pick up a British engineering publication, and you are much more likely to find data and drawings of some American or Continental (European) machine or structure than of a British one. There will probably be some reproductions of photographs of British machinery, but no dimensioned drawings or data. Or, take the proceedings of a British technical society, and compare the number of actual working drawings and specifications contained in its volumes with those to be found in the transactions of similar societies on this side of the Atlantic. In no country is the art of talking and saying nothing so highly developed as in Britain, as a perusal of the discussions before British technical societies will show. Much of the credit for this professional spirit here must be given to the various technical colleges of this country, of which so many of our practicing engineers are graduates. It is noticeable among us, too, that the concerns that turn out the best work are those most willing to give out their experiences for the benefit of the profession and country at large. They have the consciousness of doing good work, and they are proud of it. In our special branch of engineering construction the influence for good in this direction of the

U. S. Navy departments is very great indeed. In the detailed reports of the various bureau chiefs and publications, and publications of the different departments, there is a mass of data vastly more complete and educationally helpful than that which any other nation has made available for consultation. In matters of pure science or abstract reasoning, scientists of foreign nations are very generous in their contributions to the sum of "get-at-able" knowledge. It is not to this class that our remarks are intended to apply, but rather to those more directly concerned with the commercial side of engineering. — *Marine Engineering.*

Yellow Fever.

Now that we have before us the full and authentic report of the proceedings of the Pan-American Medical Congress held in Havana last February, the most important subject of which was the presentation and discussion of the report of the special yellow fever commission, we are able to form an unbiased opinion and to estimate in some degree the far-reaching influence which the findings of this commission will have upon the theories of the causation of disease and of contagion and infection, as well as upon vaccination and preventive inoculation. Summarized, this report is as follows: Yellow fever cannot be communicated by contact with the patient or with the clothes or other articles worn by a patient before and during the course of the disease, even although these may be impregnated with the excretions of the body. The disease is therefore not contagious, in the usual sense in which that word is used. It can be communicated by inoculation, however, if a small quantity of blood from a yellow fever patient, taken during the first two days of the disease, is injected into a healthy person. If the blood is taken later in the disease, or before the attack has set in, no result is obtained.

Yellow fever is communicated, however, by the bite of a particular kind of mosquito (the *Culex fascinatus*) that has previously bitten a yellow fever patient during the first two days of the attack. It takes twelve days for the specific poison to develop in the mosquito. Healthy persons bitten by such inoculated mosquitoes before the twelfth day after the contamination of the insect showed no symptoms of the disease, while those bitten after the twelfth day, without exception, were stricken with yellow fever after a lapse called the "period of incubation" of from forty-six hours to six days. Disinfection of houses and belongings of yellow fever patients, fumigation of letters from yellow fever districts, and quarantining of passengers from infected localities, would therefore be unnecessary, provided the mosquito were destroyed.

The report concludes: "While the mode of propagation of yellow fever has now been definitely determined, the specific cause of this disease remains to be discovered." That is, the particular species of microbe to which it is due is still unrecognized. In the numerous reports of yellow fever epidemics in this country and abroad, and in the lengthy and erudite dissertations in medical literature, we find that the theory of contagion was by no means universally accepted by medical authorities, and that it was disputed as early as 1812 by Dr. B. Colomar in his report on the yellow fever epidemic in 1811 in Spain. We can therefore readily accept the demonstration of the commission of the non-contagiousness of yellow fever. There are many peculiarities in the transmission of the disease recorded in medical literature, however, which cannot, as yet, be fully explained by accepting the statement that the mosquito is the *only* carrier of the disease virus. It is true we can explain why General Butler succeeded in stamping out yellow fever in New Orleans by establishing proper sewerage and rendering the city habitable and healthful for human beings, but unhealthful for the *Culex fascinatus*, and why the epidemics invariably cease when the average temperature of the air falls below 70° Fahr. For we know that the insect cannot live in clean places, nor in a cool atmosphere.

Other malarial diseases have been stamped out in certain localities by planting eucalyptus trees, which by their rapid growth and greed for moisture drain swampy places, or by the artificial draining of swamps, thereby making it impossible for certain species of mosquitoes, which are the carriers of the fever, to exist in these localities. We cannot, however, as yet explain in what manner the virus is transported over great distances of land or sea, distances too great for the culex to traverse. We must look for an explanation in the results of experiments which will determine what is the specific virus and what is its origin. For it is very plain, almost self-evident, that it is not a bacillus or coccus. It must be ascertained whether or no the eggs and larvæ of the infected mosquito (for it is only the female insect which sucks the blood of animals) carry within them the specific poison in a latent form, to become potent in the fully developed insect, and if so what are the most favorable conditions of climate, temperature and surroundings for the development and life of the insects. Finally, we must learn what is the most practical and effective method of destroying the insects and their eggs and larvæ.

When these questions have been answered we will be able to stamp out yellow fever and a number of other epidemic and endemic diseases, and make the so-called "foci" of such diseases as yellow fever in Havana and the West Indies, and cholera in India, salubrious instead of disseminating depots of scourges for the whole world.— *Scientific American.*

The late General George B. McClellan, U. S. A., is credited with having made the statement, many years ago, that the sinking of clams into the sand along the ocean shore by closing their shells and ejecting the water from them in a thin stream, first suggested to him the use of the water jet as an aid in sinking piles in sand. At any rate, as long ago as 1852 a water jet was so used, by General McClellan's advice, in putting down piles for a wharf and warehouse. Water was forced through an ordinary rubber hose, with a piece of gas-pipe on the end for a nozzle. This was placed close to the point of the pile on the bottom, the jet of water scouring the sand away from the pile and making a hole in which the pile sank rapidly. From that time on, as recently recorded in a paper by L. Y. Schermerhorn before the Engineers' Club of Philadelphia, the water-jet method has been similarly employed in many different places by different persons. In the United States, in the improvement of the Mississippi and Missouri rivers, large numbers of piles have been driven for the construction of the brush and pile dikes, and in the sinking of these piles the water jet has been in use since 1881. A great variety of experiments were undertaken upon this work to establish the best details for the use of the jet. This experience demonstrated certain fundamental principles as contributing essentially to the best results, prominent among which were the following: That the water jet cannot be relied upon to give satisfactory results in material containing a large percentage of gravel; that it should be capable of such concentration of its force as will permit the stream to be delivered through a nozzle not more than 1½ inches in diameter, and frequently somewhat less, and with pump power capable of giving a nozzle-pressure of from 75 to 150 pounds per square inch; that in sand free from gravel the best results are obtained with the larger nozzle and reduced pressure, while the presence of gravel required the smaller nozzle and higher pressure.— *Cassier's Magazine.*

The Locomotive.

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The "Water Ram" in Blow-off Pipes.

It is of the highest importance, in boiler practice, to keep the blow-off pipe free from sediment or deposits of any kind; because if this is not attended to, the pipe is sure to become burned, and an accident — very likely a serious one — is the almost inevitable result.

The only way to keep the blow-off pipe free is to open the blow-cock often enough

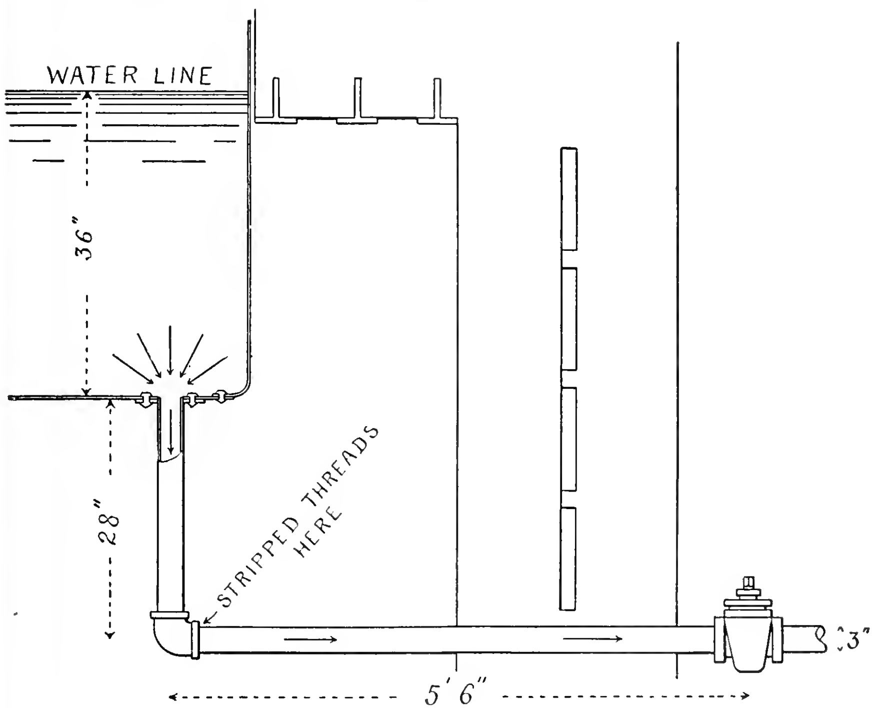


Fig. 1. — Illustrating a Blow-off Accident.

to keep everything flushed out of it. The frequency with which this must be done, in order to keep the blow-pipe clean, depends, to a large extent, upon the character of the feed water; but a good, safe rule to follow is to open the cock *at least* once a day, and twice or three times a day when the water is bad and the boiler is worked up to its full capacity. The best time to blow off a boiler is in the morning, before the fires have been started up; because a good deal of the sediment in the boiler will then have settled to the bottom of the shell, and much of it will pass out when the blow-cock is opened. Noon is also a good time, after the fires have been banked for half an hour or more, so that the water in the boiler has been quiescent long enough to deposit the particles that are ordinarily being whirled about with it through all parts of the boiler.

When a blow-off pipe is flushed it is not enough to open the cock a little way. The cock should be opened *wide*, even if only for a few seconds; because if this is not done the full boiler pressure is not realized, and the pipe may not be thoroughly cleaned out. It is not necessary to blow out any great *quantity* of water in flushing a blow-pipe. The main thing is to open the cock *wide* when you do open it, so that the opening through the cock is the full area of the pipe. This will prevent the lodgment of fragments of scale in the cock itself, and will also give a solid column of water through the whole pipe, to sweep out all deposit that may have accumulated there.

A word of caution is necessary, however, when advice of this sort is given, for it is not at all uncommon to see a fireman open the blow-off cock with a yank, and close it again with another one. This practice is very dangerous. No valve about a steam system ought to be opened or closed suddenly, except in time of great emergency, because sudden strains on either the boiler or the piping are much more destructive than those that come gradually. We have emphasized this point many times in THE LOCOMOTIVE, but our experience indicates that we may profitably repeat it, at short intervals, for a good while to come, because men get careless about these things, even when they know what is right.

It is particularly dangerous to *close* the blow-off cock suddenly, because strains are often produced in this way which are far greater than one who had not given thought to the matter would suppose. The importance of closing a blow-off cock slowly will be understood very readily by those who are familiar with the hydraulic ram, which is an apparatus in which the extra pressure resulting from the sudden stoppage of a current of water is put to practical use and made to raise a part of the volume of the water to a considerable height. In this apparatus water is allowed to flow through a "waste-pipe" until it acquires a considerable velocity, and the waste-pipe is then suddenly closed by an automatic clack-valve. The pressure in the waste-pipe at once increases greatly, owing to the momentum the water has acquired, so that a part of the water is forced out through a check-valve into a delivery pipe connected with a reservoir considerably higher than the level of the pond from which the main supply is taken. A hydraulic ram, if properly designed, may easily be made to deliver a portion of the water it receives into a reservoir when the delivery-head of the ram is twenty times as great as the supply-head.

The illustration on the first page of this issue of THE LOCOMOTIVE illustrates an accident which recently occurred from the water-ram action in a blow-off pipe, caused by closing the blow-cock too quickly. The boiler was 60 inches in diameter, and was fitted with a 3-inch blow-off pipe, arranged as shown in the cut. When the cock was closed the blow-off pipe gave way by stripping the threads at the point indicated, and the fireman was scalded so badly that he died three or four hours later.

We could calculate the actual stress thrown upon a blow-off pipe by the sudden closing of the cock, provided we knew just exactly how quickly the fireman closed it; but since everything depends upon this point, and there is no way to find out the time it took him, with any degree of precision, it is useless to try to make a very refined calculation of the exact stress that was thrown on the pipe in the actual case under consideration. However, we can calculate the stress that would be produced in the extreme case, in which the cock is closed instantaneously; and this will give us some idea, at least, of the forces that are in operation in the actual case.

For simplicity we will consider a straight, horizontal blow-off pipe that is attached directly to the back head of the boiler, as shown in Fig. 2. To conform to the actual conditions shown in Fig. 1, we will assume that this pipe is 3 inches in diameter internally, and 5½ feet long; and we will take the boiler pressure to be 60 pounds per square inch, as it was in the actual case.

The first thing to do, is to find how many foot-pounds of energy the moving column of water in the blow-off pipe possesses, on account of its velocity. The rule for doing this is as follows: Find the height, in feet, of a column of water which would produce a static pressure equal to the actual pressure at the entrance of the blow-off pipe. Then multiply this height by the total weight of water (in pounds) in the blow-off pipe, between the boiler and the cock; and the product is the number of foot-pounds of energy that the moving column possesses, on account of its velocity when the blow-cock is wide open.

In applying this rule to the case in hand, we will assume that it takes a column of water 2.4 feet high (at the temperature corresponding to 60 pounds pressure) to give a static pressure of 1 pound per square inch. The height of a column that would give a static pressure of 60 pounds would therefore be $60 \times 2.4 = 144$ feet.

To find the weight of water in the pipe, we multiply the sectional area of the pipe by the distance from the boiler to the blow-cock (expressing everything in inches), and then divide the product by the number of cubic inches of water that it takes to weigh

FIG. 2. — ILLUSTRATING THE "WATER RAM" IN BLOW-OFF PIPES.

one pound. The area of a 3-inch circle is 7.07 square inches, and the distance from the boiler to the blow-cock, in the present case, is 66 inches. Hence the volume of the pipe is $66 \times 7.07 = 467$ cubic inches (in round numbers). Taking the density of the water to be such that 29 cubic inches of it weigh one pound, we have $467 \div 29 = 16.1$ pounds (or, say, 16 pounds), as the weight of the water in the blow-pipe.

Following out the rule given above, we find that the energy that the water in the blow-pipe has, on account of its motion, is $144 \times 16 = 2{,}304$ foot-pounds.

Now if the blow-off pipe is closed *instantly*, what becomes of this energy? It has got to appear somewhere, by compressing things, or stretching things, or breaking things, or doing some other definite kind of work. If we assume the water to be incompressible, and the blow-pipe to be securely fixed where it enters the boiler, the kinetic energy of the water in the pipe (that is, the energy due to its velocity) must be expended principally in stretching the pipe itself. This fact enables us to calculate the maximum stress that can be produced in the pipe by the sudden closing of the valves. The rule for this part of the calculation is as follows: Multiply the area of metal in the cross-section of the pipe (expressed in square inches) by twice the "kinetic energy" of the moving column of water (expressed in foot-pounds, and calculated as described above), and multiply the product by the "modulus of elasticity" of the material of the pipe (which, in the case of wrought iron, is about 29,000,000); then divide by the distance from the boiler to the blow-cock (expressed in feet), and take the square root of the quotient. The result so obtained will be the greatest total *pull* (in pounds) on the material of the pipe that can be caused by the sudden stoppage of the flow of water within it.

The area of metal in the cross-section of a 3-inch pipe is about 2.23 square inches, and the "kinetic energy" of the water (or the energy due to its motion) we have already found to be 2,304 foot-pounds. Hence the calculation is as follows:

$$2.23 \times 2 \times 2{,}304 \times 29{,}000{,}000 = 298{,}000{,}000{,}000.$$

The distance from the boiler to the blow-cock being 5.5 feet, we then have

$$298{,}000{,}000{,}000 \div 5.5 = 54{,}200{,}000{,}000.$$

The square root of this is 233,000; and therefore the maximum stress that could be thrown on such a blow-off pipe, by the *instantaneous* stoppage of the solid column of water moving through it with a velocity due to 60 pounds of steam, is 233,000 pounds. There being 2.23 square inches of metal in the cross-section of a 3-inch pipe, it follows that the greatest possible stress that could come upon the material of the pipe, from the sudden stoppage of the stream of water within it, is 233,000÷2.23=104,000 pounds (in round numbers) per square inch; which is greater than the tensile strength of steel.

We do not pretend that such an enormous stress as this could be actually realized in a blow-off pipe, because in performing the calculation we have made various assumptions that cannot be rigorously fulfilled in experience. The most important of these is, that the cock is closed instantly. Now a fireman might be able to close the cock in a fraction of a second, but he certainly could not do it literally "in no time." The quicker he works, the nearer he will approach to the figures given above; but he can never come very close to them, no matter how spry he may be. Another important assumption that we made, is that the blow-pipe is filled with *solid water*, even when the cock is open. This cannot be the case, for the pressure in the pipe, while the current is passing, is less than that in the boiler, and hence a certain proportion of the contents of the pipe must be steam.

It is not worth while to discuss all these minor matters in detail, however. The main object of the calculation given above is to show that it is theoretically possible, under certain ideal conditions, to throw a stress on the blow-pipe, merely by closing the cock, which will be great enough to pull a sound steel pipe in two. When we come to the practical question of how great a stress could be *realized in practice*, all we can say is, that after making all reasonable allowances and deductions, there is still abundant reason for believing that the stresses actually produced by the too sudden closing of a blow-cock may be quite severe enough to break a fitting, or strip the threads from a pipe, especially when (as is often the case) the pipe-fitting is none too perfect.

The only safe way to close a blow-cock, is to turn it off slowly, so that the operation takes several seconds, at least.

Boiler Explosions.

JANUARY, 1901.

(1.) — On January 1st a boiler exploded in Hitchcock's mill, between Johnson & Cortland, near Warren, Ohio. The owners, Edward and Lucius Hitchcock, were instantly killed, and their bodies were blown to pieces. Charles Shaw, Bernard Buell, and Charles Schreit were injured. Shaw was injured internally, and may die. The mill was completely demolished.

(2.) — A boiler exploded, on January 2d, at the Marine Railway & Dry Dock Company's plant, at Cincinnati, Ohio. Frank Woodward, Frank McKinley, and Joseph McClelland were injured. The engine and boiler house were utterly destroyed.

(3.) — On January 2d a boiler exploded in the second story of the Sheldon block, on Fall street, Seneca Falls, N. Y. The explosion blew out the front of the first and second stories of the building. Frederick Miller and Miss Rena Stowell were injured. The building took fire, and the total damage to property was nearly $15,000.

(4.) — A boiler exploded on January 3d, in the Pure Food Milling Company's mill, at Watseka, Ill. L. D. Malotte and Jacob P. Smorley were instantly killed, and Ira Jones was slightly injured. The boiler was thrown two hundred feet, striking the wall of Gard & Bonham's hardware stores. The mill was badly wrecked.

(5.) — John Murphy, an employee of the Gloucester Ferry Company, was badly scalded about the face and hands, on January 3d, by the explosion of a tube in the boiler of a coal-hoisting machine at Gloucester, N. J.

(6.) — On January 3d a flue failed in a boiler at the Acme Cycle Works, at Elkhart, Ind.

(7.) — A locomotive boiler exploded, on January 4th, at Newtonburg, Clearfield county, Pa. John Miller and William McMasters were killed, and fireman Harry Patricks was injured.

(8.) — A boiler exploded, on January 5th, in Cooper's elevator at Elk Creek, Neb. Nobody was injured.

(9.) — On January 7th, a boiler exploded in C. H. Vanstone's mill, on Cow Creek, near Sulphur Springs, Mo. Engineer Leslie Service and S. E. Isbell were injured. One of our accounts reads as follows: "Jasper Murphy was also standing near the engine, but besides being slammed down abruptly on his mother earth, suffered no great harm. One of those who were standing near the engine, on being asked how he felt when the explosion came, said he felt kind of dazed, and kept wondering how that blamed old boiler came to be turning summersets in the air."

(10.) — A slight boiler explosion occurred on January 8th, in the Belmont Mill, at Wheeling, Va. Nobody was injured. The mill took fire, but the blaze was soon extinguished.

(11.) — On January 8th the Rochester Orphan Asylum, at Rochester, N. Y., was destroyed by fire; and shortly after the fire broke out a boiler exploded with terrific force, completely blowing out the lower part of the west end of the connecting wing, and thereby cutting off the escape of the children from the east end of the building. As the accident occurred in the night, and the sleeping apartments of the asylum were in the east wing, the isolation of this part of the building was a very serious matter; and in spite of the most strenuous efforts on the part of the firemen and the volunteers who tendered their energetic co-operation, twenty-six children and two adults were killed, and thirteen others were seriously injured. The asylum was practically destroyed.

(12.) — A boiler exploded, on January 10th, in Luther Brothers' stave factory, at Burns, Tenn. Nobody was injured.

(13.) — On January 10th, a safety boiler exploded in Charles M. Stieff's piano factory, at Baltimore, Md. John Smith was killed, and Frederick Hall, Richard Koch, and another man named Gray were badly injured.

(14.) — A boiler exploded, on January 10th, in J. W. Smith's saw-mill, at Bolen, near Waycross, Ga. Mr. Smith was painfully scalded and bruised.

(15.) — A boiler exploded, on January 11th, in Bedard & Morency's sash, blind, and door factory, at Oak Park, near Chicago, Ill. I. B. Procunier, Herman Beck, and Charles Foss were severely injured. The boiler house was wrecked, and a sixty-foot brick smoke stack was thrown down upon the ruins. The property loss is estimated at $4.000.

(16.) — A heating boiler exploded, on January 12th, in John F. Callahan's grocery store, at New Haven, Conn. John Leonard, William Keeley, Madeline Tucker, Gertrude Callahan, and Mollie Callahan were injured. The building was considerably damaged, and the property loss is estimated at $3,000.

(17.) — A boiler exploded, on January 12th, in Benjamin Jessie's saw-mill, near Edmonton, Ky. The accident occurred during the dinner hour, and nobody was injured. The building in which the boiler stood was wrecked, and fragments of the boiler were thrown to a distance of from four to five hundred feet.

(18.) — A boiler exploded, on January 13th in the Green Ridge Iron Works, at Scranton, Pa. Nobody was injured. The property loss was about $2,000.

(19.) — A boiler exploded, on January 16th, in Robert Boggs' flouring mill, at Suterville, Westmoreland County, Pa. John Boggs, the miller, was seriously injured. The boiler was thrown one hundred and thirty yards, demolishing Colonel Eli Suter's house, and considerably damaging the residence of Dr. Pierce.

(20.) — On January 16th, a boiler exploded at Woodville, near Bowling Green, Ohio. James Heltebrake was painfully injured, and the boiler house was completely wrecked.

(21.) — A boiler used for drilling an oil well, at Belfast, Allegany County, N. Y., exploded, on January 18th. Engineer Ives was badly bruised and scalded.

(22.) — A boiler exploded, on January 19th, at Marion, Ind., during the progress of a fire at the Marion Pulp Company's plant. Chief Butler, Harry Polling, Frederick Bennett, Thomas Hamilton, and Burr Hamilton, of the fire department, were badly injured by the explosion, as was also William Nessler, manager of the mill.

(23.) — A heating boiler exploded, on January 20th, in Mr. H. M. Berrill's residence, at Portland, Me. Nobody was injured, and the damage was small.

(24.) — A small boiler exploded, on January 20th, in Dr. John B. Zabriskie's carriage house, on Church avenue, Brooklyn, N. Y. Nobody was injured, and the damage was small.

(25.) — A small hot-water boiler exploded, on January 21st, in J. F. Morin's bakery, Lawrence, Mass. No one was hurt.

(26.) — On January 21st, a boiler exploded under the sidewalk in front of No. 14 West 29th street, New York. Several pedestrians barely escaped injury, and the whole neighborhood was thrown into confusion.

(27.) — A heating boiler gave way, on January 22nd, in C. B. Stow's new greenhouses, at Kingston, N. Y. No great damage was done.

(28.) — On January 22nd, a boiler exploded in William Haggard's sawmill, near Morgantown, Ind. The place was wrecked, but nobody was injured.

(29.) — On January 22nd, a boiler exploded in R. D. Callaway's mill, near Washington, Ga. Three men were seriously injured. The boiler was blown to fragments, and hurled into the air in every direction. One piece damaged Mr. Callaway's house, some three hundred yards away.

(30.) — Two boilers exploded, on January 22nd, in the Ohio Falls Iron Works, at New Albany, Ind. Martin Finley was instantly killed, and John Morgan, Peter Wagner, William Stephens, Thomas Jones, and James Stillings were injured. The building was badly wrecked, and the property loss is estimated at $10,000.

(31.) — A boiler exploded, on January 23rd, in the power house of the North Hudson County Railway Company, on Palisade avenue, Jersey City, N. J. Nobody was injured.

(32.) — On January 23rd, a boiler exploded in the Ninth street plant of the American Steel & Wire Company, at Braddock, Pa. The head was blown out of the boiler, seriously injuring Engineer George McVay.

(33.) — On January 24th a boiler exploded in the power house of the Dayton & Northern Traction Company, near Brookville, Ohio. Mr. E. B. Eversole, the watchman, was instantly killed.

(34.) — A boiler exploded, on January 25th, in the steel mill of Moorehead Brothers & Company, at Pittsburg, Pa. Joseph Russe, Rock Tress, and Michael Koback were badly scalded.

(35.) — On January 25th a boiler exploded at Green Forest, near Fort Smith, Ark. John Jones, Stephen Jones, and the engineer were injured.

(36.) — A boiler exploded, on January 27th, in the city hospital, at Augusta, Ga. The boiler room was wrecked, but nobody was injured.

(37.) — On January 27th a hot-water boiler exploded in the Fernwood Mansion, at Lansdowne, near Philadelphia, Pa. Mrs. Sadie Davis was badly injured. The room in which the boiler stood was wrecked, and the building took fire.

(38.) — On January 28th, a boiler exploded in a sawmill, at Ash, near Moberly, Mo. John Ash and John Patrick were badly scalded.

(39.) — Foreman R. C. Porter and head Fireman Walter O'Malley were burned and scalded, on January 30th, by a slight boiler explosion in Hammond's packing plant, at South St. Joseph, Mo.

(40.) — A boiler exploded, on January 30th, at the No. 1 mine, at Burnett, near Terre Haute, Ind. We have not learned further particulars.

(41.) — On January 31st a boiler exploded in William Wicke & Company's cigar factory, New York City. Fire followed the explosion, and the total property loss is estimated at $1,500,000. Two men were killed, and twenty-two others were injured so badly that they were removed to the hospital for treatment.

We desire to acknowledge a copy of *Bugle Calls*, a neat and attractive little book on the labor question, written by Mr. Benjamin Wood, and published by Brentano, New York city. (Price, $1.00.)

The Locomotive.

HARTFORD, APRIL 15, 1901.

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

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

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

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

In our leading article last month, we inadvertently said that "all horizontal tubular boilers should be set with the rear end some three inches lower than the front end." This is not correct. What we intended to say, was that such boilers should be set "with the rear end at least *one* inch lower than the front end."

In the May issue of *Insurance Engineering* we find some statistics of boiler explosions in the United States, which are said to have been prepared from "records kept in the Fidelity & Casualty office." We appreciate the compliment that the Fidelity & Casualty company does us, in accepting our data as authentic, and in publishing statistics that we have collected, in preference to any that they may have collected themselves; but as it is a good deal of work to keep track of these things, we feel that it would be more graceful and courteous to give the Hartford Steam Boiler Inspection and Insurance Company credit for what is taken from it so openly.

We have received from the publishers, Messrs. John Wiley & Sons, of 53 East 10th St., New York City, a copy of the fifth edition of Kent's *Mechanical Engineer's Pocket Book.* Some few errors that were discovered in the fourth edition have been corrected, and the new (1899) code of the Boiler Test Committee of the American Society of Mechanical Engineers has been substituted for the old code of 1885. We have previously spoken very highly of Kent's *Pocket Book*, and we are pleased to say, once more, that it is a most excellent and valuable work, which every mechanical engineer should possess.

Concerning Absolute Temperature.

In articles relating to the theory of the steam engine and other forms of heat motors, we are all the time running across something which is called the "absolute temperature," and we are told that to find the "absolute temperature" of a body we have merely to add something like 460° to its temperature as read from an ordinary thermometer. This is all simple enough to anyone who has studied thermodynamics, but other persons, to whom "thermodynamics" is nothing but a long name, are continually asking what this "absolute temperature" is, and why we have to add the particular number 460° in order to find it.

It is easy enough to give a general explanation of what absolute temperature is, provided we are not required to go into the subject too deeply and exhaustively. All thermometer scales reckon temperature from some point which is selected (arbitrarily, perhaps,) as *zero.* In the Centigrade system the freezing point of water is taken as the zero point, and temperatures are reckoned upward toward the boiling point of water, in degrees of such a size as to make the boiling point read 100 on the scale. In the original Fahrenheit scale, the temperature of the human body was taken as zero, and the scale was so arranged that lower temperatures were denoted by larger numbers, so that the numbers on the scale increased from the top towards the bottom. The present zero of the Fahrenheit scale was probably selected so as to avoid the use of "negative" temperatures so far as possible; and if this appears to be absurd, it should be remembered that Fahrenheit had never visited North Dakota in the winter, and that the only means he had of producing artificial cold was by the use of some such simple freezing mixture as pounded ice and salt. Every "zero" of this sort, which is selected merely because it happens to correspond to the freezing point of water, or some other fluid, is purely arbitrary. We might have as many such zeros as we wanted to, and no one of them would have the least advantage over any other one, except on the score of convenience. The absolute zero, or point from which we measure the absolute temperatures that we are discussing, was selected as a zero point for scientific purposes, because it differs from every other zero point that has ever been proposed in the one respect that it is not in the least arbitrary. The absolute zero, in fact, is the temperature of *absolute cold*. We shall explain this point a little more fully presently, but just for the time being we desire to consider the absolute zero from a slightly different point of view. We wish to regard it, namely, as the zero of the "perfect gas" thermometer.

Every reader of THE LOCOMOTIVE is doubtless aware that for accurate scientific purposes the ordinary mercury thermometer is no longer taken as the standard. Some form of gas thermometer is used in its place, in which the temperature is measured by the variation in pressure of a gas whose volume is kept constant. The gas used may be air, or hydrogen, or any other of the familiar ones that we used to call "permanent," before we knew better. Nitrogen is the particular gas that is used by the International Bureau of Weights and Measures, and the temperatures that such a thermometer gives are said to be given "on the nitrogen scale." There are slight differences between the readings of thermometers filled with different kinds of gases, and for this reason it is desirable to fix on one particular kind of gas as a standard. The choice of this standard gas is arbitrary, and is determined, not by any general fact of nature, but by the convenience with which the selected gas may be procured and purified, and by certain other practical considerations that we do not need to dwell upon in this place. The ideal gas to use for thermometric purposes would be one in which the pressure is precisely doubled when we compress the gas, at constant temperature, into half its original volume; and so on. In other words, one which *precisely* obeys Boyle's law, as explained in the issue of THE LOCOMOTIVE for January, 1900. Such a gas is called a "perfect gas." No perfect gas exists in nature, but those gases that can be liquified only with great difficulty approximate very closely to the state of a perfect gas, under ordinary conditions of temperature and pressure. Temperatures read from a thermometer filled with a perfect gas would be absolute temperatures. If we neglect, for the moment, the slight deviation of air from the ideal that we have in mind when we speak of a perfect gas, we may explain the existence of the absolute zero by the following quotation from Tyndall's "Heat a Mode of Motion":

"We have seen," he says, "that the pressure of air is augmented by an increase of temperature. It has been shown that if the volume of the air is not allowed to change, we have, for every degree of temperature, a certain definite increase of pressure. Reckoning from 0° Fahr. upwards, we find that every degree added to the temperature produces an increase of pressure equal to 1/460 of that which the air possesses at 0° Fahr., and hence, that by raising the temperature to 460° Fahr. we double the pressure. An image will fix all this forever in your minds, and enable you to see clearly certain consequences that flow from it. Supposing you have a purse containing at the outset 460 pennies, and that you have a volume of gas at the temperature of 0° Fahr. Let the air be gradually warmed, and for every degree of temperature imparted to it let a penny be added to the store already in your purse. A single degree would then raise your money to 461 pennies; 10° to 470 pennies; 100° to 560 pennies; while 460° would augment your store to 920 pennies. You have thus, at the end, twice the sum you possessed at starting, and you have also twice the pressure in the air whose temperature you have been increasing at the same time. Now let us invert the whole proceeding. Starting with a temperature of 460° Fahr., and with 920 pennies in the purse, let us gradually cool the air, removing a penny for every degree of temperature taken away from it. On reaching 0° Fahr., we should obviously have 460 pennies in our purse. But there is no magic in the temperature 0° Fahr. that could cause the value of a degree of chilling to change at that particular point. Below it, as above, the value will be still a penny. Let us, then, continue the cooling process, throwing away a penny per degree as before. One degree of chilling would lessen our cash one penny; 10° ten pennies; 100° one hundred pennies; while 460° of chilling would entirely empty our purse. The diminution of pressure would here follow the same rule as the diminution of cash, were it not that the molecular forces which are insensible at higher temperatures come into play. At 460° below the Fahrenheit zero we should empty, at the same time, our purse of pennies and our air of pressure. The air would then have sunk to *the absolute zero of temperature.* The absolute zero has never been attained, and long before reaching it all actual gases would become liquids, ceasing to follow the law of diminution of pressure which we have here applied." (We have modified Tyndall's phraseology somewhat, and reduced his figures to the Fahrenheit scale; but the sense of what he says has been carefully preserved.)

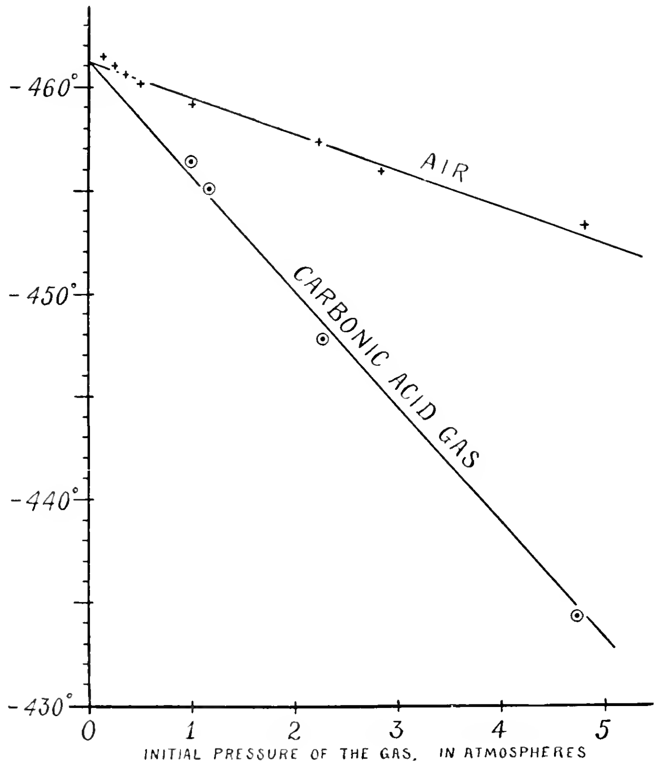
The foregoing explanation of the absolute zero serves fairly well to fix the main idea of the thing in the mind; but we admit that reasoning of this sort affords but a poor foundation upon which to build a general theory of absolute temperature. We have quoted it at some length, because Tyndall is admitted to be a competent authority, whose writings are usually very logical and simple and clear; and if a writer as well informed and experienced as he was finds it hard to give a really satisfying exposition of the subject, it is reasonable to suppose that the proper presentation of the theory of absolute temperature, without the use of mathematics, is indeed a difficult thing.

If the foregoing extract represents the best that so competent a man as Tyndall could do in the way of making the subject of absolute temperature intelligible in simple language, it is not to be wondered at, that many writers and many mechanical engineers of good standing should treat the absolute zero, and the absolute scale of temperature, as though it were merely a convenient artifice, useful in simplifying calculations, but not corresponding to any real thing in nature. Inventors, in particular, appear to be afflicted with this delusion, and every once in a while motors are devised which receive a great share of public attention, and sometimes a considerable amount of financial backing, even when they are opposed to sound thermodynamical principles; and when these motors refuse to work, there is great disappointment among those who had insisted upon opening their pocket-books, instead of their books on the mechanical theory of heat.

Let us examine Tyndall's exposition somewhat critically. In the first place, he uses air instead of the ideal perfect gas, upon which the absolute scale is supposed to be based. It is true that air behaves, under ordinary conditions, very much as a perfect gas would behave; but so do numerous other gases. The question arises, therefore, why we should prefer air to hydrogen, or nitrogen, or any other gas which shows a similarly close approach to the state of a perfect gas. Let us see how much difference would be introduced if we should apply Tyndall's argument to some of them.

Beginning with air itself, let us note that the recent accurate measurements of Chappuis show that the fraction for air, which we have taken above as 1/460, ought really to be 1/458; so that if we accept his measurements, we should conclude, from air, that the absolute zero is 458° below the ordinary Fahrenheit zero. Chappuis found 1/459 as the corresponding fraction for hydrogen, and 1/453 for carbonic acid gas; so that from these two gases, respectively, we should conclude that the absolute zero is 459° and 453° below the Fahrenheit zero. These differences cannot be attributed to errors in the experimental data, for Chappuis worked with the greatest care; and moreover it has been known, for a long time, that small differences of this order of magnitude do really exist among the various "permanent" gases. The differences referred to, therefore, prove one of two things. Either there is no such thing as a real, absolute zero, or else the method that we have been using in this paper to determine it is not strictly correct. Some will doubtless take the former position; but this would be an error. The trouble is, that we have sacrificed accuracy to simplicity of treatment, just as all other writers of popular articles and books on this subject do.

We can reconcile the data given by different nearly-perfect gasses, in the way pointed out by Rankine. (See his paper, entitled *On the Absolute Zero of the Perfect Gas Thermometer*, in his "Miscellaneous Scientific Papers," page 307.) Rankine takes the position that the actual gases of nature differ from the ideal perfect gas, for the sole reason that their molecules are near enough together to exert a sensible amount of attraction upon one another; and he points out that we can approach as nearly as we please to the ideal condition of a perfect gas by working with gases at small densities. In a rarefied gas the molecules are (on the whole) so much further apart that their attractive action on one another may be quite negligible, so that the gas, in its rarefied state, would be indistinguishable from a perfect gas. The behavior of a perfect gas may therefore be taken to be the same as the behavior of any of the so-called permanent gases, when the said permanent gas is taken in a sufficiently rarefied state. Practically, it is difficult to experiment with a highly rarefied gas, and so we have to carry out the idea that Rankine suggests in something like the following manner: We first experiment with the gas in its ordinary state, and we then calculate, just as Tyndall does, the position of the absolute zero. Next, we experiment with the same gas after reducing its density to (say) one-half what it was at first, and again calculate the position of the absolute zero. This process is repeated as many times as we find it convenient to do so, and then we compare the various estimates that have been so obtained of the position of the absolute zero. As the gas grows rarer and rarer, the estimated position of the absolute zero may be expected to approximate nearer and nearer to the true position, as it would be found if we could work with an ideally perfect gas. We regret that we have no data at hand more recent than those of Regnault for carrying out the calculation thus described. Using his data, however, the results are interesting and instructive, even if they are not as accurate as might be wished. He found that carbonic acid gas, of such a density that it has a pressure of 0.9980 of an atmosphere at 32° Fahr., gives —456.4° as the position of the absolute zero; and that the same gas, when of such a density that it has a pressure of 4.7225 atmospheres at 32° Fahr., gives —434.4° as the position of the absolute zero. Two other experiments were also made with carbonic acid gas at the initial pressures 1.1857 and 2.2931 atmospheres, respectively, the resulting estimates of the position of the absolute zero being —455.2° and —447.7°. These results are shown plotted in the diagram, the separate experiments for carbonic acid gas being represented by dots, enclosed within small circles. The horizontal distance of each of these dots from the vertical line on the left represents the initial pressure of the gas when the corresponding experiment was made; and the heights of the respective dots represent the corresponding estimates of the position of the absolute zero. The experimental data are evidently not perfect; but if we draw a straight line as nearly as



possible through the dots and prolong it until it cuts the vertical line, we find that it does so at a point corresponding to —461.1°. We therefore conclude that if we had worked with carbonic acid gas of a density so low that its pressure at 32° would be practically nothing, we should have concluded that the absolute zero is 461.1° below the ordinary zero. In other words, this is the zero point of the perfect gas thermometer as indicated by our experiments on carbonic acid gas.

Regnault also made a similar series of experiments on air, which we can treat in precisely the same way. It will not be necessary to give the numerical data, but the points that are obtained by proceeding in the same manner as before are indicated in the diagram by crosses; and if we draw a straight line through these crosses, as nearly as we can, we find that this line cuts the vertical line at the same point as before, as it ought to, if our reasoning is correct. If we had a sufficient number of experiments of this sort, made upon various gases, we could obtain a very good idea of the position of the zero of the perfect gas thermometer.

So much for the temperature scale of the perfect gas thermometer, and for its absolute zero. The question now arises whether we have any reason to suppose that the zero so defined is really the point at which bodies are *totally deprived of heat*. It will be remembered that we begged this question at the beginning of this article by first defining the absolute zero as the point at which bodies are totally deprived of heat, and then discussing it as the point at which the pressure in a perfect gas thermometer would entirely vanish. Is there any good reason for supposing that these two points coincide? This is a perfectly fair question, and its reasonableness will be the more apparent if we remember that Rankine, before the science of heat was advanced as far as it is now, recognized a possible difference between the two points, and that he distinguished them carefully in his writings. Thus, in a paper published in the *Philosophical Magazine*, in 1851, he distinctly states that the "absolute zero of temperature is not the absolute zero of heat"; and in another paper, published in 1853 or 1854, he actually calculates the difference between the absolute zero of the perfect gas thermometer and the temperature at which bodies are totally deprived of heat. His general result in this last-mentioned paper is that "the temperature of absolute privation of heat is a real fixed point on the scale, somewhat more than two Centigrade degrees (or say 3½ Fahrenheit degrees) above the absolute zero of a perfect gas thermometer."

These citations from Rankine, who was one of the founders of the mechanical theory of heat, and a very capable mathematician, afford another excellent illustration of the exceeding difficulty of giving a correct popular account of the subject of absolute temperature; for if Rankine, with his extensive knowledge of mathematics and physics, fell into the error of separating two things that we now know to be identical, and even calculating the difference between them when no real difference exists, how can one hope to make the subject entirely clear, by the aid of simple language, to readers who presumably have not given a hundredth part of the attention to the subject that Rankine had!

It will be necessary to content ourselves with merely *stating* what has been proved without attempting to go through with the proof.

Everybody knows that we can cool a body by taking away heat from it; and there is nothing in our everyday experience in life that would suggest that such a body could ever be so cold that we could not cool it still more by a further abstraction of heat. Yet a careful mathematical study of nature has demonstrated that there *is* a temperature so low that no substance can ever be made cooler than that temperature, by any means whatever; and that this temperature is in fact precisely the "absolute zero" of the perfect gas thermometer. This strange fact was solidly established by the joint labors of numerous scientific men, among whom Carnot, Clausius, and Lord Kelvin may be prominently mentioned. The proof by which it was established is just as sound as the proofs that we find in geometry; but it is unfortunately of such a nature that it cannot be properly explained without the use of the differential calculus. It may be said, however, that the reasoning by which the proposition is established on a firm foundation is quite different from that which we have advanced above. The "perfect gas" thermometer is not an essential feature in the argument at all, and the absolute scale can be established and the existence of the absolute zero proved without any reference to a perfect gas. Lord Kelvin has shown all this in his article on "Heat," in the Encyclopædia Britannica. In following through an argument like that of Tyndall, one naturally inquires why we must use a *gas* in our argument; and the answer is, that in the rigorous treatment of the problem by the mechanical theory of heat it makes no difference whatever, so far as theory is concerned, whether we use a gas, or a liquid, or a solid. The same result would be reached whatever substance were used in the experiments. We have said that it makes no difference so far as the *theory* is concerned; and we may add that the only difference of any sort is that the properties of some substances are much better known than those of others, so that in carrying out the actual numerical calculation it happens that we have better data for gases than we have for liquids and solids. This, however, is merely because experimental science has not yet been pushed to a very high degree of perfection. We use gases at present because it is easier to get the necessary numerical data for them than it is for other bodies. It is probable that the exact position of the absolute zero will be determined in the near future much more accurately than we know it at present by studying the electrical resistance of platinum wire.

The actual experiments upon which our present sound knowledge of the absolute scale rests were made many years ago by Joule and Lord Kelvin; and they consisted in causing various gases to expand through a plug of cotton or silk. The amount of cooling that the gases experienced in passing from one side of the plug to the other was carefully noted, and it was this cooling effect rather than a direct study of the expansion of the gases which furnished the data for the construction of the absolute scale.

Our intention, in submitting this article to our readers, has been to emphasize the fact that there *is* a line of reasoning by which the existence of the absolute zero as an actual, incontrovertible fact in nature is firmly established; and also to advance a line of argument which will at least make the existence of such a zero appear plausible, and afford some idea of how its position can be determined.

The Spread of Machinery.

Sir Richard Temple, one of the leading authorities on India, said in London the other day that the Indian manufacturers of cotton goods were supplanting the products of Manchester to a large extent. The question of the British trade with India in cotton manufactures was beginning to be a serious matter for the Lancashire cotton industry.

The introduction of machinery in parts of the world where household manufactures have hitherto almost monopolized industrial life is a matter of great interest. Manufacturers, particularly in Great Britain, are beginning to feel some effects of the new competition. Machinery is working a revolution in some of the industries of India.

Before the British occupied the peninsula, India sent to foreign countries only art fabrics or luxuries mostly produced in the homes of the humble workmen. These objects had a good sale abroad because they represented the art development of the East Indians. They did not interfere with the trade of other countries because they were peculiar to India. Then the British overran the land and new phases of the export trade developed. For many years rice, wheat, raw cotton, oil seeds, and raw jute have been large exports. The export trade of India has thus been pre-eminently related to raw material.

In the past few years, however, another great feature has been introduced into this export trade. In consequence of the new departure in the manufacturing industries through the introduction of machinery, a great deal of cotton and jute goods are now sent to foreign lands where they compete directly with the trade that England has built up at the expenditure of much time and money.

Not many years ago, most of the jute crop of Bengal was sent raw to Dundee and other manufacturing centers. To-day the exports of manufactured jute goods amount to $20,000,000 a year. Machinery has been introduced by British capitalists and India herself is reaping the benefit of the various economies which have resulted from the substitution of machinery for hand labor. The jute mills have been built most largely in Calcutta and in the few other parts of Bengal. About 100,000 workmen are employed in them and the jute bags and other articles they produce are sent in large quantities to the United States, Great Britain, Australia and the Straits Settlements. So large a development of jute manufacturing has not failed to have considerable effect upon this great industry in Dundee.

The progress of cotton manufacturing has been still more remarkable. In 20 years the cotton spindles of India have increased 221 per cent. and the looms 189 per cent. There are now 4,728,000 spindles and 38,000 looms in India. Last year they consumed 1,641,000 bales of raw cotton. These mills have cheaper raw material and labor than the British mills. In this respect they enjoy the advantage which our Southern cotton mills possess over those of New England. Bombay is the greatest center of cotton manufactures. Its mills are operating 3,500,000 spindles and 25,000 looms. But while Bombay produces about three-fourths of the Indian product of manufactured cotton the industry is also important in other parts of the country. The industrial revolution is transferring the spinning and weaving of cotton from the home to the factory. It is making cotton fabrics cheaper in the home markets. It is beginning to curtail the large cotton imports from Great Britain, and it is encroaching upon the British markets in other lands.

The Indian mills, for example, are comparatively near the great China yarn market. China is one of the largest buyers of cotton yarn in the world. Vast quantities of yarn are sold to China not only for the cotton mills which have recently been introduced there, but also to supply the demand of the hundreds of thousands of women folk who in their humble homes turn cotton yarn into fabrics. India's export of cotton yarn has now reached an annual value of $30,000,000, and the trade is increasing every year.

India does not yet manufacture the finer grades of cotton goods, but her coarse fabrics are becoming more and more popular in markets where she has the special advantage of comparative proximity. Thus she is now selling $15,000,000 worth of coarse cottons, most of them in Mozambique, Zanzibar, and Aden, whence they are distributed in East Africa ; her trade in these goods is also growing in Abyssinia, Ceylon, Turkey, and the Straits Settlements. Her increasing product of cotton fabrics enables the home industry to keep pace with the growing demand both in India and foreign markets.

These observations with regard to India may also be applied to Japan, whose factory interests are constantly growing. Japan promises to become a competitor with the large cotton-cloth producing countries in supplying her home trade and the oriental markets. Though there are now a considerable number of cotton mills in China there seems to be no prospect that that country will have a large influence in the cotton industries of the world. All China is likely to do is to supply a part of her home demand.

It is different, however, with India and Japan. Their competition is not likely to be important outside of the Orient. But in the field that is nearest to them there is considerable prospect that they will become in time a very influential factor in the cotton trade, and that this fact must be taken into account by the manufacturers of Great Britain who until a few years ago almost monopolized the import cotton trade of that part of the world.—*New York Sun.*

The Locomotive.

PUBLISHED BY THE HARTFORD STEAM BOILER INSPECTION AND INSURANCE COMPANY.

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A Common Defect in Bracing.

We have discussed the matter of bracing boilers very fully in previous issues of The Locomotive; and the subject is so comparatively simple that it might be supposed that we had practically exhausted it. But there is always something more to be said about every topic under the sun, — even about bracing.

These remarks are called forth by the fact that boiler makers have a habit of not making their braces equally strong *in all parts*. We have met with numerous cases of this sort, and have called the attention of the builders to the trouble, as the occasions arose; but quite recently we met with a boiler right out of the shop of one of the best builders in the country, and were informed, when we called attention to the defect, that its importance had been hitherto overlooked in the shop in question. Hence we concluded that an article in The Locomotive, calling general attention to the point, would be timely.

In order to fix the ideas, let us consider the brace shown in the accompanying illustration (Fig. 1), which was recently met with in our work of inspection. The boiler

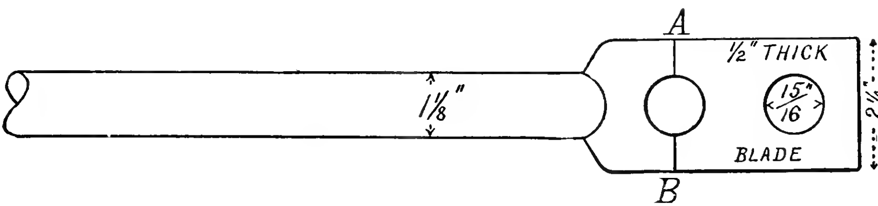

Fig. 1.— Illustrating Weakness Across Rivet Hole.

from which this was taken was new, and was supposed to be built in accordance with specifications issued by the Hartford Steam Boiler Inspection and Insurance Company. These specifications required that each brace should have an area of at least one square inch, in the weakest part. The body of the brace was round, and $1\frac{1}{8}$ inches in diameter, as indicated in the illustration. If the brace were precisely of the specified diameter in the body, it would have a sectional area, in that part, of 0.994 sq. in., which is near enough to the required full square inch to be accepted as conforming to the specifications.

The *blade* of this brace, however, was only $2\frac{1}{4}$ in. wide and $\frac{1}{2}$ in. thick; and it contained two rivet-holes, each $\frac{15}{16}$ in. in diameter. If the resistance of the brace to fracture across the line *AB*, in Fig. 1, is considered, it will be seen that the sectional area here is much smaller than it is in the body of the brace. The area resisting fracture along *AB* is shown by the shaded portions of Fig. 2. The diameter of the rivet-hole being $\frac{15}{16}$ in. (the decimal for which is 0.937 in.), the combined width of the shaded parts is

2.25 —0.937 =1.313″; and the thickness of the blade being $\frac{1}{2}$, it is evident that the area resisting fracture along AB, in Fig. 1, is only

$$1.313'' \times \tfrac{1}{2}'' = 0.656 \text{ sq. in.},$$

or only about two-thirds of a square inch. The weakest part of this brace is therefore across the line AB; and at this point it falls decidedly below the requirement of the specifications.

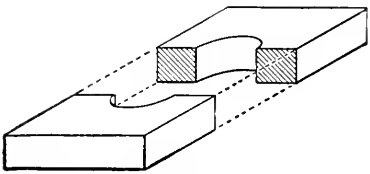

Fig. 2.—The Weakest Section.

It is much better to make the blade of a brace $\frac{5}{8}$ in. thick and $2\frac{3}{4}$ in. wide, when it is $1\frac{1}{8}$ in. in diameter in the body. This will give a considerable margin of safety across the rivet-hole, as is easily seen by repeating the foregoing calculation with these new data. We do not wish to be understood as *requiring* these particular dimensions, however. We are satisfied if the requirement of the specifications with regard to minimum sectional area is fulfilled, no matter whether the dimensions are precisely as here indicated, or not; but we wished to draw attention to the fact that boiler-makers often overlook this very simple yet very important matter of having a sufficient sectional area across the rivet-hole in the blade, and to say that a more careful attention to it in the future will save a good deal of time and trouble to all concerned.

Inspectors' Report.

January, 1901.

During this month our inspectors made 11,820 inspection trips, visited 22,331 boilers, inspected 6,742 both internally and externally, and subjected 758 to hydrostatic pressure. The whole number of defects reported reached 12,734, of which 1,238 were considered dangerous; 59 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	875	46
Cases of incrustation and scale,	2,325	91
Cases of internal grooving,	132	4
Cases of internal corrosion,	620	30
Cases of external corrosion,	526	47
Broken and loose braces and stays,	227	73
Settings defective,	370	44
Furnaces out of shape,	375	19
Fractured plates,	293	46
Burned plates,	368	51
Blistered plates,	92	2
Cases of defective riveting,	1,982	102
Defective heads,	59	16
Serious leakage around tube ends,	2,549	395
Serious leakage at seams,	478	30
Defective water-gauges,	249	43
Defective blow-offs,	152	46
Cases of deficiency of water,	36	22

Nature of Defects.	Whole Number.	Dangerous.
Safety-valves overloaded,	79	29
Safety-valves defective in construction,	67	31
Pressure-gauges defective,	466	47
Boilers without pressure-gauges,	13	13
Unclassified defects,	401	11
Total,	12,734	1,238

Boiler Explosions.

FEBRUARY, 1901.

(42.)—On February 4th the boiler of a Shea locomotive, belonging to the International Paper Company, exploded at Berlin, N. H., while the locomotive was opposite mill No. 1. Switchman Thomas Stone, who was in the cab at the time, was injured so badly that he died some three hours afterwards. Engineer Edmund Guilmette and Leon Crotteau were also injured, but they will recover. The locomotive was utterly destroyed, and it is said that the property loss was about $15,000. The burning coal was thrown from the fire box of the locomotive through a window in the mill, and the mill took fire. No great damage was done by the fire, however.

(43.)—On February 4th a boiler exploded on the McDonald oil lease, at Primrose Station, Penn., on the Panhandle road. Charles Lemon was instantly killed, and his brother, Frank Lemon, was fearfully scalded. The pressure at the time of the explosion is said to have been sixty pounds. The body of Charles Lemon was found two hundred and fifty feet from the boiler. He had been hurled through the air into the top of a tree, and had fallen thence to the ground.

(44.)—A boiler exploded, on February 5th, in the railroad shop planing mill, at Roanoke, Va. J. F. Peters was badly scalded, and W. J. Allison received lesser injuries.

(45.)—On February 7th a boiler exploded at No. 7 slope, at Wilburton, near Dennison, Tex. A man named Edwards, who was sleeping near by, was killed. The building and some of the machinery were wrecked.

(46.)—On February 8th a boiler exploded at J. Swann's sawmill, Dandridge, Tenn. The fragments of the boiler flew about the mill in all directions, but, fortunately, nobody was injured.

(47.)—A boiler exploded, on February 8th, in the Ingraham block, at East Providence, R. I. Nobody was injured, and the damage to the property was not great.

(48.)—On February 9th a boiler exploded at No. 2 shaft of the Valentine Mining Company, at Leadville, Colo. Arthur Ball had his leg broken, and considerable damage was done to the property.

(49.)—On February 10th the boiler of locomotive No. 1822, on the New York Central railroad, exploded at Geneva, N. Y., as the result of a collision. Nobody was injured, but the combined collision and explosion destroyed two locomotives.

(50.)—On February 13th a boiler exploded at the mill of Hanly Brothers, McHenry, Ill. Nobody was injured. We have seen no estimate of the property loss.

(51.)—A serious boiler explosion occurred, on February 13th, at the sawmill owned by Charles Desch, at Chickasaw, about twelve miles south of Celina, Ohio. Charles Desch was seriously injured, and his son John was instantly killed by having his skull and chest crushed by a flying fragment. His two other sons, Jacob and August, were also more or less injured. No estimate of the damage to property is given.

(52.) — A boiler exploded in the Belmont brick works, at Bellaire, W. Va., about February 14th. We have not learned further particulars, except that this explosion (presumably on account of its violence) was for some time believed to be a dynamite explosion.

(53.) — On February 14th a boiler exploded in the J. K. Davidson Commission company's elevator "A," at Parsons, Kans. Engineer William Olin received injuries from which he may not recover. The fireman and one other man were also badly scalded. The boiler room was wrecked.

(54.) — The crown-sheet of a locomotive on the Northern Pacific railroad gave way, on February 14th, near Winnipeg, Man. Fireman Prendergast was blown out of the cab, but was not seriously injured.

(55.) — On February 15th a heating boiler exploded in Henry S. Farnum's hardware store, at Uxbridge, Mass. Nobody was injured, and the damage was chiefly confined to the heating apparatus.

(56.) — On February 15th a boiler exploded in Cheves & Sons' sawmills, at Damascus, Ga. William Green and James Garsi were killed, and W. C. Etler and another man whose name we have not learned were injured. The boiler and its settings were scattered all about, over a radius of 300 feet, and the surroundings were completely wrecked. The boiler was a new one, and had just been put in.

(57.) — An auxiliary boiler, used to keep steam up, ready for emergencies, exploded, on February 18th, in the basement of the building occupied by fire engine company No. 144, on West Fifteenth street, Coney Island, N.Y. John Bowen, Henry Ericher, and Charles Wakerman were seriously injured, and the engine house was badly damaged.

(58.) — One of a battery of eight boilers exploded, February 18th, in Greenwood Colliery No. 4, at Tamaqua, Pa. Fireman Milton was injured so badly that he will probably not recover. The boiler house was demolished.

(59.) — Fireman George Brittain was instantly killed, on February 19th, by the explosion of a dry kiln boiler in Kurth's mill, at Lufkin, Tex. The property loss was about $2,000.

(60.) — On February 22d a boiler exploded in Wiliam Webb's brickyard, at Tuscola, near Vassar, Mich. Nobody was injured, but considerable damage was done.

(61.) — On February 22d a boiler exploded in D. F. Adams' sawmill, at Baywood, near Independence, Va. Mr. Adams and Thomas Hutchins were killed, Adams' body being blown to pieces. Thomas Hightower was injured so badly that it is thought that he cannot recover, and his son also received painful injuries. We have seen no estimate of the property loss.

(62.) — On February 23d a heating boiling exploded in the basement of the Farmers' bank building, at Princeton, Ind. We have not learned further particulars.

(63.) — A heating boiler exploded, on February 24th, in the Reformed church, at Albany, N. Y.

(64.) — A boiler exploded in Prior Bros'. mill, near Carthage, Tex., on February 25th. John Hawkins was killed and Claude Pryor was fatally injured. One other man whose name we have not learned, was badly injured, but will probably recover. The mill was wrecked.

(65.) — A boiler exploded, on February 25th, on the tug *Burton E. Coe*, at Tampa, Fla. Captain King and one other man were injured. The tug was not very badly damaged.

(66.) — A heating boiler exploded, on February 26th, in the Normal school at Fairview, Ohio. The explosion occurred early in the morning, and nobody was injured. The building was slightly damaged, but the loss was mostly confined to the heating system.

(67.) — On February 26th a boiler exploded on George Hoover's farm, in Pleasant Township, near Bellefontaine, Ohio. Henry Herring, Norman Key, William Key, Harley Wills, William Walcott and a Mrs. Key were badly injured.

(68.) — On or about February 27th a heating boiler exploded in the city hall at Vincennes, Ind. The damage was small, and, so far as we are aware, nobody was injured.

(69.) — A boiler exploded in D. S. Detrick's elevator, at New Carlisle, Ohio, on February 28th. The boiler had given some indication of impending trouble, and the proprietor and Engineer Ora Ammerman were investigating it at the time of the explosion. Both men were painfully injured, and the side of the elevator was blown out. We have seen no estimate of the property loss, beyond the statement of the Springfield, Ohio, *Republican*, that "the loss to Mr. Detrick is very heavy."

(70.) — A boiler exploded, on February 28th, at Monument City, near Huntington, Ind. One end of the mill in which the boiler stood was blown out, but fortunately nobody was injured. Several workmen had very narrow escapes.

The Future of Steel.

The cheapness with which steel is made is multiplying its uses to such an extent that estimates made of the possible wants of the world in the future can only be guesses. So says Andrew Carnegie, in a recent issue of the *New York Evening Post*, in reviewing the developments of steel manufacture in the United States. Indeed, so rapidly is the use of steel extending, that it is difficult to see how the world's demands can be filled. At present, the mines of ironstone and of coking coal in Great Britain are worked to their fullest capacity and yet the output is not greatly increased; it is the same with those of Germany, except that in the latter country there remain some inferior fields capable of development if prices rise, as is probable. Russia, so far, has not been much of a factor in steel-making; if she is able to supply her own wants by the middle of the century, she will be doing well. Except by the United States, Great Britain, and Germany, little steel is made, nor is any other nation likely to make much. The hopes in regard to China and Japan making steel, Mr. Carnegie believes, are to prove delusive. Great Britain and Germany cannot manufacture much beyond what they do now, so that the increased wants of the world can be met only by the United States. The known supply of suitable ironstone in this country is sufficient to meet all possible demands of the world for at least half of the century; and the known sources of coke will suffice for the entire century. It is not to be supposed that other deposits will not be discovered before known supplies are exhausted.

A few years hence the export of steel and the manufactures of steel from the United States to many parts of the world, which, in 1899, were valued at $119,000,000, promises to be so great as to constitute another chapter in the record-breaking history of steel. The influence of American steel-making capacity upon development at home must be marvelous, for the nation which makes the cheapest steel has the other nations at its feet, so far as manufacturing is concerned in most of its branches. The cheapest steel means the cheapest ships, the cheapest machinery, the cheapest thousand-and-one articles of which steel is the base. The progress and commanding position of the United States as a steel-producer are told in a few words. In 1873, only twenty-seven years ago, the United States produced 198,796 tons of steel; Great Britain, her chief competitor, 653,500 tons — more than three times as much. Twenty-six years later, namely, in 1899, the United States made more than double as much as England, the figures being 10,639,957 and 5,000,000 tons, respectively,— an eightfold increase for Britain and a fifty-three fold increase for the United States. The production of the United States had become, in other words, almost forty per cent. of all the steel made in the world, the world's production for 1899 being about 27,000,000 tons. Industrial history has nothing to show comparable to this.— *Cassier's Magazine.*

The Nobel Prizes.

Dr. Alfred Bernhard Nobel, a Swedish manufacturer of dynamite, was worth something like $10,000,000, and he left a unique will. One of his heirs, and a very considerable one, is the whole world of his fellow-men; for the interest on the larger part of this great fortune — a sum approximating $350,000 a year — is to be given annually to the five men who have done most during that time for the advancement of humanity. To encourage the same activities, otherwise than by prize-giving, there are now being formed the Nobel institutes, as provided for in the will. The first prize distribution is to take place this year. The inauguration of the plan, indeed, began almost with the reading of the last testament, and at once attracted the attention of the savants of the world.

Unlike the Hall of Fame of New York University, the Nobel endowment will mark out its famous men from among the living. And better than that, it will urge those not yet great and good before the world, to become so. The Swedish philanthropist had no wish to build monuments. He wanted to bring out more men to deserve them. On the other hand, he modestly did not think that he could help mankind directly. He would be satisfied if others could do it for him. In the same spirit wealthy men have founded universities, where youth is wrought into a better tool for life's work. But Dr. Nobel has gone a step beyond. He seeks the products of those better tools.

Dr. Nobel's prizes are to be awarded as follows: first, for the most important discovery or invention in the field of physical science; second, the same in chemistry; third, the same in physiology and medicine; fourth, for the most remarkable literary work from the standpoint of idealism; and, finally, the fifth goes to the man who has been the most efficient in promoting fraternity among people, in suppressing or reducing standing armies, or in forming and propagating peace congresses.

The testator, perhaps unconsciously, has already set the example of universal brotherhood, for he expressly states, and emphasizes it, too, that the award shall go to the most worthy, without favor or prejudice whatsoever as to nationality.

The by-laws governing the endowment were approved and signed last June at Stockholm Palace by King Oscar of Norway and Sweden. Those who award the prizes are named as follows: For physical sciences and chemistry, the Swedish Academy of Science, of whose 175 members seventy-five are foreigners; for medicine, the Carolin Institute of Medicine and Surgery, of Stockholm; for letters, the Academy of Stockholm, — that is, the Swedish Academy; for peace works, a commission of five members chosen by the Norwegian Storthing [*i. e.* the national parliament]. Each of these corporations appoints a corresponding Nobel committee, which will act and report on prize contestants in their respective fields. The committees are composed of three or five members, foreigners as well as Scandinavians. Foreigners may also be members of the commission appointed to decide the peace prize. The business and financial affairs of the endowment as a whole are in the care of a council of administration at Stockholm, which is made up of Swedes, five in all, four chosen by the corporations, and the fifth, or president, by the King. One of its duties is to pay out the prizes. This will take place on each anniversary of the founder's death, December 10th, when the corporations will assemble in solemn conclave, and formally proclaim the successful laureates. Each of these will receive, besides the cash prize, a diploma and a gold medal bearing an effigy of the donator. Then, within six months, the winners are expected to deliver public lectures on their subjects, either at Stockholm or at Christiania.

In case two leading competitors are equal, the prize will be divided between them, or, as regards the peace prize, the reward may be bestowed on an organization. But should none of the candidates be deemed worthy, the prize will be witheld till the year following. And should the same thing occur for two years in succession, the amount will be turned into the principal fund, or else be used for the creation of a special fund, which can be employed to encourage the same objects by other means than prizes. These special funds and this auxiliary encouragement fall under the management of the Nobel institutes. And just here enters another phase of the philanthropist's comprehensive behest. He has provided for the founding and maintenance of five institutes, corresponding to the five sections, bound together by a central organization. These are to aid in the examination of works and documents submitted as exhibits in behalf of prize competitors. And in addition, they are to do all possible to encourage profitable activity in these several lines of human endeavor. Each institute is to be founded by the corresponding corporation, but afterwards it will enjoy the dignity of an independent patron of learning.

To cover expenses of organization, 300,000 crowns for each section, or 1,500,000 crowns in all (about $350,000), may be taken from the endowment. The king authorizes the project, the corporations appoint the council, and all is in readiness for the award of prizes on the 10th of next December. So perhaps those who devotedly admire some living hero, and would like to see him honored with the rich man's laurel of gold, might care to know something of the methods of this prize distributing.

There are several general provisions which apply equally to all five sections. To start with, no one can propose himself as a candidate for a prize—a naïve reminder, by the way, that selfishness and egotism are to be combated and not encouraged. The case of each nominee must be made out by writings or documents. These supports of the claim for a prize may be in English, or in French, German, or Latin,—besides of course, the native language. Invitations to those qualified to nominate contestants are sent out every September by the Nobel committees. The nominations with documents should be sent to the committees at Christiania before February 1st of the year following. An exception was made this year, however, and nominations were received up to April 1st.

The competent Nobel committee will report on these nominations during October to its corresponding corporation, which in turn will decide on the prize winners by the middle of November. From this decision there is no appeal. And as has been stated, the distribution of prizes will take place December 10th.

The general public cannot name candidates, but provision is made whereby no worthy man need escape. In the two sections of physical and chemical sciences, those who may nominate are: members of certain Scandinavian learned bodies and professors of those studies in certain native universities and schools; also the professors of six foreign universities named each year by the Academy of Science; besides savants specially invited by the Academy, and former prize winners. This is an honor invested in the prize winners of all sections.

The Nobel science institutes are really one, but are composed of two sections for each of the two branches. The institute is to have scientific control of discoveries that are proposed for prizes, and to encourage researches in the same fields. The two sections will have suitable homes, with an assembly hall, archives room, library, etc., in common. A general inspector with high powers of supervision is named by the king. Besides, the Academy appoints a special director for each section. These men may be native or foreign, so they be scientists of solid reputation, and especially well grounded in their respective fields. They will have the title of professor, and are to give their time exclusively to their positions. The special funds of the scientific Nobel institutes may be employed as subsidies for prosecuting works in physics and chemistry. Preference is to be given those works that have already proved worthy of being perfected by means of this donation.

The rules for the other three sections are the same in their general outlines. But a few special provisions should be mentioned. It is understood, for instance, that the works submitted for the literary prize need not be purely literary. They may include all works whose form and style entitle them to the distinction of literature. In this section the right to present candidates belongs to members of the Swedish, French and Spanish academies, as well as to literary sections of other academies and to literary institutions analogous to academies, to university professors of ethics, literature, and history, and to former prize winners. The Nobel institute for literature will have a library devoted especially to modern literature. Here the Swedish Academy will place in charge an able literary man and corps of assistants to prepare questions relative to the prize, to furnish reports on receipt of literary works from foreign countries, and to make necessary translations of such.

As to the physiological and medical section, those who can present candidates are: professors of the Carolin Institute; members of the medical section of the Royal Academy of Science; faculties of medicine of certain native universities; faculties of six foreign medical schools named each year by the Carolin Institute; savants invited by the Academy of Science, and former prize winners. The Nobel committee appointed by the Carolin Institute will decide which of the works submitted shall be specially examined and will carry out the same. It is understood that any work must undergo this examination before it can be given the prize. The decisions of the committee are received by the Carolin Institute in April, and in May it may admit other works to the final contest. In October it will decide who is the successful contestant, by secret ballot. Printed works accompanying prize compositions are to be preserved in the Carolin Institute library. The instruments submitted will remain in the same hands till they can be transferred to the Nobel Medical Institute. The Nobel Institute is under the surveillance of the *chancelier* of the universities of the kingdom. The special funds will be devoted to medical researches and their application.

The fifth and last section aims to reward labors for peace among nations and good will among men. The procedure is the same generally as above mentioned. Those who may propose contestants are: members of the Nobel committees; of legislative bodies of all countries; of the Interparliamentary Council; of the Commission of the International Permanent Bureau of Peace; of the International Institute of Law; university professors of law, political sciences, history, and philosophy, and former prize winners.

For this prize a champion has been chosen in France who appeals to every one at all familiar with his lifelong fight as peculiarly fit to enter the lists. He is a merciless besieger, and knows no compromise. He demands the unconditional surrender of war, and characterizes all improvements and mitigations as devices of the devil, who fears that this ablest work of his may be abolished unless it is made less frightful. Frederick Passy is a very old man, within a few months of eighty, and almost blind; but he is still a worker as ever. Since his first article against war, written when he was twenty-five, he has given himself to the cause as wholly and unreservedly as it is conceivable that a man can strive for one idea. So this makes something over half a century that he has fought for peace. He is a noble paradox, this veteran warrior.

As accurately as those things that fail to happen can be judged, M. Passy has certainly prevented one or two wars. Owing to his letter to *Le Temps* in April, 1867, popular wrath died down and another sentiment took its place, with the direct result that France and Germany decided not to take to arms over the Luxembourg broil. Instead of war there came into being the Permanent International Peace League, of which M. Passy is still general secretary and the most active member.

He has probably hit upon the most effective weapon for the putting down of weapons. He is crafty enough to know that men will fight, all morality to the contrary notwithstanding. But will men make themselves absurd, if they know it? Ridicule has already smothered duelling. So M. Passy points out the utter idiocy of war. He presided over the Universal Peace Congress of 1889, which became a regular annual institution from that year on. He has been a member, since its organization, of the Central Bureau of Peace Societies at Berne. With Randal Cremer, M. P., he founded the International Interparliamentary Union, wherein the legislatures of Europe and America are represented. Wars keep on happening, but he refuses to know what defeat is. A general war might break out to-morrow, and he would not give up; for he ever holds loyally to the creed of his youth,—namely, that the development of science, means of communication, mixture of products, men, ideas, and language will in the end do away with war forever. His hope is his faith in human nature.— EUGENE P. LYLE, JR., in *Everybody's Magazine*.

WE have received, from the author, a copy of Mr. Henry C. Tulley's *Handbook on Engineering*, which we have examined with much pleasure. This book is intended as a manual of instruction for engineers and others who have to do with the practical care and management of dynamos, boilers, engines, pumps, and other steam engineering appliances. Mr. Tulley has had some twenty-five years of this kind of experience himself, so that he knows the seamy, practical side of the case, as well as the theoretical side. The information given ranges from the general principles of electricity to the setting of engine valves. The author appears to have done his work very well. (Henry C. Tulley & Co., Wainwright B'ldg., St. Louis, Mo. Pocket form, flexible leather covers, 792 pages; price, $3.50.)

The Locomotive.

HARTFORD, MAY 15, 1901.

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

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

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

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

WE desire to acknowledge a copy of a new and very useful book, entitled *Steam Boiler Economy*, and written by William Kent, author of the well-known pocket-book bearing his name. The present work is comprehensive in character, and covers practically all important questions relating to boiler economy. We could wish that the section on liquid fuel were more complete, as there is a considerable demand for information on this subject at the present time, especially in the southwestern part of the country; and there does not appear to be much solid, practical information available, concerning American methods of burning liquid fuel. There is plenty of other information in the book, however, to make it well worth the price that is charged for it. (John Wiley & Sons, 53 East 10th St., New York; 458 pages, $4.00.)

IT is growing more and more common, to write books in which good, practical information is served up under the guise of stories or anecdotes, the reader being beguiled into learning something useful to himself, when he seems to be reading nothing but a pleasant tale. The latest work of this sort that has come to our notice is *Central Station Experiences*, which is correctly described on the title page as "a series of narratives on the trials and tribulations of a steam engineer while learning to run an electric station." These narratives, which are reprinted from *Power*, are very well done, and the book can be read with profit by any engineer who is in the same position as the one whose troubles are here related. The book is well illustrated, and the paper and press work are excellent. (Power Publishing Company, World Bldg., New York; 106 pages. Bound in stiff boards, 75 cents; bound in cloth, $1.00.)

Gravitation.

Gravitation is one of the most elusive and mysterious of all the forces of nature; and while we have made some progress towards an understanding of the machinery by which other forces operate, there has been very little progress indeed towards an understanding of the real reason why two masses of matter attract each other.

To be sure we know what is called "the law of gravitation." That is, we know that the attraction that the sun (for example) exerts upon a mass of matter in space is proportional to the quantity of matter that the attracted body contains; and we also know that it is inversely proportional to the square of the distance of the attracted body from the sun, so that when this distance is one million miles, the attraction is nine times as great as it is when the distance is three million miles; and so on. But this law, for which we are indebted to Sir Isaac Newton, is merely a statement of the way in which the intensity of gravitative attraction varies with mass and distance. It does not throw any light at all upon the *reason why* one body attracts another one.

The main difficulty in the way of learning something about the real *nature* of gravitation is, that there does not appear to be any starting point from which we can begin our investigations. If we could only find some little peculiarity or apparent irregularity of gravitative action, we should have a foot-hold at once, and we could then begin a series of experimental researches into the nature of this peculiarity or irregularity, which might end in our learning something about the nature of gravitative action.

Wherever we look for such a starting point, however, we find nothing in the least encouraging. For example, most of the properties of bodies vary according to the quantity of heat they contain. It is natural to inquire, therefore, whether this may not be the case with the earth's attraction for a body. There could be no good reason assigned in advance, for example, why the earth should attract a given mass of ice with precisely the same force as it would exert on the same mass after it has been melted into water by the addition of heat. Yet Rumford, who investigated this particular point very carefully a hundred years ago, says that he could find no difference whatever. He found that the earth attracted the ice and the equivalent water with precisely the same force; and no subsequent experimenter has found any other result.

If we inquire whether the earth attracts a body with precisely the same force, whether the body is hot or cold, we meet with the same unpromising result. Some experimenters who have worked at this particular problem (among them the writer himself) have fancied that there *is* a slight difference in the weight of a body when it is heated; but it is not easy to weigh a hot body with precision, and it has not yet been proved that the slight differences that have been observed are not due to errors in the weighings.

Again, it might be supposed that two chemical elements might be attracted by the earth with a different force when they are separate, than would be exerted upon them when they are chemically combined, so as to form a third substance. Careful experiments have indeed indicated a slight difference here also; but if such a difference really exists, it is so small that experimenters have been unable, as yet, to prove that it is real, and not due, as before, to errors in the weighing, or to slight losses in the chemical manipulation.

Certain kinds of crystals have different properties in different directions. That is, their tensile strength and shearing strength vary according to the direction in which the force is applied; when warmed they expand differently in different directions; light passes through them with different speeds in different directions; and so on. It is natural to inquire whether the earth attracts these crystals with precisely the same force, no matter what the direction in which the pull acts; and when the experiment is tried, it is found that the *direction* of the pull makes absolutely no difference at all. The earth attracts them with precisely the same force, in all positions.

There is one other most amazing thing about gravitation that we must notice; and that is, that two given masses of matter will attract each other with precisely the same force, whether the space between them is empty, or filled with other matter. This may be expressed otherwise by saying that matter appears to be absolutely *transparent* to gravitative action. The best way to test this point is by calculating what the motions of the planets would be, on the supposition that matter is more or less opaque to gravitation, so that a given ton of the sun's mass, on the *remote* side of that luminary, does not attract the proposed planet with the same force that it would exert if the intervening body of the sun were removed. We shall find, if we carry out this calculation, that the main effect would be to cause the perihelion of the planet's orbit to revolve much faster than it is actually observed to revolve, in any of the planetary orbits. Hence we are driven to make the supposition that matter is *not* sensibly opaque to gravitation; but that, on the contrary, two masses of matter attract each other with just the same force, whether the space between them is filled up, or empty.

So gravitation is still the greatest riddle of the physical world. Several explanations of it have indeed been offered, but none of these has met with any very great measure of favor, and it would be out of place to review them here. The main trouble appears to be, as we said at the outset, that there is no visible joint in nature's armor into which the physicist can insinuate his experimental lever. In all probability, if such a joint could be found, the shell of the mystery would soon be pried open.

Ethics of the Engineering Profession.

No profession can be regarded as stable until it has such a body of well-established principles as will guide a member of the profession in determining the actual value of his work, will teach him that his calling is honorable to himself and valuable to the community, and will determine what line of action may elevate the profession and instill into him the lesson that he must do nothing to bring reproach upon his chosen profession. In a word, they give him ideals to struggle for, and to struggle for an ideal is the only method for gaining true and lasting satisfaction. Pure professional success, as distinguished from mere money getting, depends upon acting in harmony with these principles.

A trade may be distinguished from a profession in its not recognizing the importance of these basal principles. Not that the man at the bench, the machine, or the loom, does not need guiding principles in his work, but that they assume a distinctly subordinate place. The professional man must be a broader man, must have a wider grasp of relations, must have the ability to solve new complications, must be the leader and the thinker as well as the doer. The machinist may run his machine, but the mechanical engineer understands machinery. The electrician may close the circuit, but tho electrical engineer understands polyphase machinery. The engine man may open the throttle, but the railway engineer understands railroading. The engineer, whatever his specialty may be, must base his practice upon the well-established laws of nature. If he belongs to the group of the successful rather than the unsuccessful, he must have plain, practical sense, a scientific education, tact, business ability, and a strong personality.

The relation between the engineer and the laws of nature is unique, and differs from the relation that exists between any other professional man and nature. Unlike the geologist, who is limited in his observations to those favorable localities which nature has been kind enough to unfold for his inspection, or the biologist, who must wait for nature to act and then stand as an observer, the engineer pins nature down and forces her to answer his question. It may be only a yes or no, but it is an answer, and since he can vary his questions — that is, the conditions of his experiment, — he can ultimately get the information he desires. He deals with the immutable, the unchanging laws of inorganic nature. He alone of all professional men has an unvarying criterion by which he may decide the right and the wrong, the correct and the false. He gets accurate data by which he may build his bridge, construct his dynamo, or lay out his railroad. Departure from these data means failure. Other professional men are subject only to varying human laws and human notions, and so get along without ever having before them an absolute standard but the engineer is forced to be in harmony with natural laws; his work must be absolutely truthful; his logic must be without flaw. Sophistry and ignorance are not for him. He must know, and know accurately; he must reason, and reason logically. If he does not know the stresses in his bridge, the endurance of his material, or the details of his dynamo, he cannot rank as an engineer. Nature, calmly and dispassionately, is always on guard over him. No other man in the world, I believe, unless it is the chemist or the physicist, is subject to such rigid and unceasing discipline; no man's errors are so glaringly brought to light as his. The lawyer can fall back on the plea that the judge was biased, or the jury packed; the doctor may, perchance, bury his mistakes; but the mistakes of the engineer bury him. We accept his success as natural, because it is in harmony with nature's laws; his errors are glaring, because they are out of harmony with nature. All the world sees his failures. A mere tyro can recognize a poor roadbed, defective machinery, or a dangerous bridge. The engineer has, then, for his ethics the most dignified and exalted standard; he has an absolute and unvarying criterion for truth and error; he has over him a judge who will decide with unerring swiftness that his work is a failure if he violates the law. We have found, then, the ultimate lines of distinction between the engineering profession and all other professions.

Recognizing, therefore, that the judgment of the engineer's work rests upon harmony with nature's laws, and that she is merciless in showing his weakness, that this is the most nearly absolute criterion of which we know, we can draw some deductions from these principles and see what effect such a standard has upon the profession as a whole and upon the mind and character of the individuals. Who is the final arbiter of professional eminence? In the case of the lawyer, the doctor and the minister, reputation is made and success determined by the public at large — by clients, who know, as a rule, little of real professional worth. Since the ultimate standards of judgment rest on human models, quackery is possible and all too common. In the case of medicine and law, legislation defines who shall practice, but the requirements are far too low. Legislation, however, recognizes no such profession as engineering, consequently, the entire burden of maintaining professional standing rests solely upon the profession itself. Presumably, then, quackery should be more common, but the facts show that it is less common in engineering than elsewhere, for this reason — the final judgment of the success of the lawyer, the doctor, or the minister, rests with his clients, while in the case of the engineer judgment is rendered by his peers. In no other profession is this judgment so pronounced, in no other profession is quackery so quickly discovered and held up to criticism. As a result, the engineering profession is the best educated for its work of any of the professions. True, there may not be so many stars of the first magnitude in the engineering firmament, but more emit a strong, steady light, and very few show a false light. From the nature of his work the engineer does not have an opportunity to pose before the public; he cannot be the idol of the forum. His success or failure is determined by the judgment of a most competent board of critics — his professional associates.

Every field of activity in the whole realm of nature may yield something of value to the engineer. His interests are world-wide. As man has climbed slowly up the rugged pathway we call civilization, he has needed more and more the service of the engineer. What was yesterday a theory, becomes a demonstration to-day, and to-morrow we expect the engineer to apply it for our comfort or convenience. As agencies for civilization, engineering works have been given far too little prominence. True it is that

Greece has left us a priceless heritage of art and Rome a code of laws, but in the wake of the Roman armies went the engineer building bridges, roads and aqueducts, making intercommunication the easier and civilization more advanced. To-day, thanks to our railway experts, the world is smaller than ever before — and is steadily growing smaller; for distance is no longer computed in miles, but in length of time in transit. Once New York and Liverpool were three months apart, now less than a week. With the aid of bridges like the St. Louis, the Brooklyn, and the Forth; tunnels like the Mersey, the Sarnia, the St. Gothard; canals like the Manchester and the Suez; trains like the Limited and the Empire State Express, the engineer has done noble work for advancing civilization by making intercommunication easier and removing that ever recurring obstacle — ignorance of other peoples. The influx of people to the large centers of population has brought forward new problems, not only of travel but of pure water supply, disposal of drainage, public health, all of which the engineer is called upon to solve. Industrial history may be dry reading, because it does not fire the ardor with thrilling deeds on the field of battle. Some enthusiasm may be kindled over the success of Robert Fulton with his steam engine and Edison with his phonograph, but little or none over the success of John A. Roebling in building the Brooklyn Bridge, or the struggle of our civil engineers to make our present railway travel fast and safe. But to the engineering profession as a whole we must grant the credit for being the greatest practical civilizing agent we have.

From the principles underlying the profession of engineering only one result can flow as a guide to what is, in a narrow sense, termed professional ethics or the guide to professional conduct in particular cases. Whether the relation is with the employer, the client or the public, the ideals of the profession are high and well maintained. Men in other callings get wide experience, great learning and national reputations. Their opinions are sought after, and they frequently get into the dangerous condition of thinking that their opinions are of weight merely because they are their own opinions. The engineer, however, is daily and hourly trained by nature to know that his opinions are worthless unless they are carefully deducted from authentic data. Naturally, then, we get sounder and more mature judgment from engineers than from any other class of men; we find less conceit in them, and more straight thinking from accurate data to logical results. Like other professional men the engineer has his clients whose interests are his own. Honor and duty, therefore, are essential to his success, and become so much a part of his professional equipment that he does not talk about them. The reputable engineer takes for granted that he must love truth and truth only; that he must have a direct purpose; that he must be devoted to his work, and that he must be guided only by the loftiest standards of conduct. All this comes from the exacting requirements which nature puts upon him. Consider the responsibility attached to the engineering profession. In matters religious a man selects his own church, his own minister. In time of sickness he chooses the physician who shall attend him. Should he be sued, he selects a lawyer to defend him; but, if he rides on a railroad train, does he select the superintendent of motive power, by means of whose professional skill his journey is made in safety? Are the future users of the new new East River Bridge, between New York and Brooklyn, consulted in the selection of the civil engineers who are to construct the bridge? The trust which the public has in the engineering profession lays upon it a heavy obligation — greater than upon any other profession. For this reason the engineer does not rely upon superficial observations. It is a peculiar trait of human nature that the wish is father to the thought. If, then, observations prove to be as we wish them, we are not apt to be critical; but, if they give undesired results, we examine them again with great care. The true engineer is as cautious with favorable as unfavorable data. If he is called upon to make a report, he should make it with the utmost frankness, even though it may displease a client. A proper regard for his own professional standing and the dignity of the profession at large demands that the engineer should hide nothing from his client; doubts as well as favorable facts should alike be submitted. Honesty and truth, then, follow as a natural consequence of his ideals. He need not make special effort to be truthful, for his work follows so closely upon the truths of nature that departure means failure. Every hour and every minute he is trained to truth and honesty. They form an ingredient of his daily tasks, and, unconsciously to him, influence his character. The unchangeable laws under which he works, and which he must rigorously apply, exert a constantly elevating influence upon him. His work is to control, to resist, or to guide the forces of nature. If his data are correct and his reasoning is sound, his finished work stands as permanent evidence of the fact; but, if his data are incorrect or his reasoning is faulty, the merciless laws of nature will discover and lay bare to every observer his own incompetence. These very qualities of mind and character, which caused him to choose the engineering profession, and which make his work a pleasure, combine to bring his entire work into harmony with the laws of the universe. If his mind and character are not attuned to the laws of the universe, if he is not guided by strict adherence to facts and logical deductions from them, and his ethics are not in harmony with right doing and clear thinking, then he is to that extent not skilled in the application of the forces of nature to the uses of man, and is not an engineer.

Extravagance is a fault of which no true engineer is guilty. One of the greatest claims the engineering profession has upon the respect of the public is that it works constantly and persistently to increase efficiency, to reduce cost, to convert what is harmful or useless into sources of wealth, and to avoid waste. Numerous are the examples which might be cited to maintain this assertion, but they are needless.

One other consideration which results from fundamental principles should be noticed, even though it is purely intellectual. The psychologist recognizes the faculty of constructive imagination, which is not merely the reproduction of images previously obtained, but the re-arrangement of these in new forms, adapted to new purposes. This is the intellectual work of the engineer when he designs a new engine. His drawings are but the language by which he communicates his ideas to the workman; they embody the object in every detail which he has mentally formed by his power of constructive imagination. The man who does not possess this intellectual faculty can never be a successful engineer.

In conclusion, I am willing to grant that, in the minds of many laymen, engineering is not regarded as a profession, but as a refined trade or a business; yet I am confident that, if the advocate of engineering as a profession is given a fair hearing, he can easily prove his case. I have claimed that the effect of the engineer's work upon civilization has been very great,— greater than most persons realize; but the claim must be made upon the reason rather than upon the feeling, and consequently is more slowly granted; but calm, dispassionate historians will place the credit where it justly belongs. The effect upon the mind and character of the individual engineer, due to the principles which underlie the profession, cannot be easily estimated; but I am confident that if the lives of our prominent engineers could be unfolded to the public gaze, they would show in abundance those qualities of honor, honesty, integrity, and manliness which naturally follow from intimate association with nature's inexorable laws.— VICTOR C. ALDERSON, in *The Railroad Digest.*

The Locomotive.

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On Circular, Stay-bolted Water-Legs.

Several years ago THE LOCOMOTIVE published an article on stayed surfaces, in the course of which we discussed the effect of *curvature* on the stresses that fell upon the plates and bolts, and showed that in the curved structures (such as water-legs in upright boilers) that occur in practice, it suffices to design the stay-bolting as though the surfaces were flat. The formulæ that we gave have been criticized somewhat extensively; and while long years of exposure to criticism have hardened our editorial hearts to some extent, we have thought it wise, in this present case, to hearken unto the voices of the dissatisfied ones, and explain the way in which the formulæ in question were derived. We did not go into this part of the problem in the original article, because

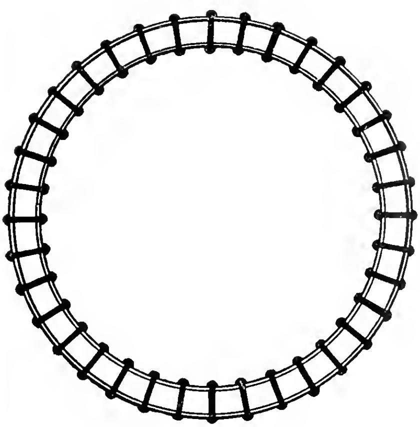

FIG. 1.

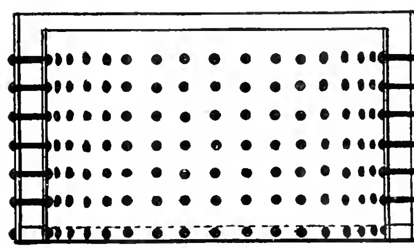

FIG. 2.

A CYLINDRICAL WATER-LEG.

the discussion is purely mathematical, and we do not intend to print matter of this kind in THE LOCOMOTIVE, except when it appears necessary to do so.

We shall use the same notation as before, the significance of the letters in the formulæ being as follows:

R_1 = internal radius of external shell.
R_2 = external radius of internal shell.
S_1 = additional tension, per sq. in. of sectional area, on external shell.
S_2 = " " " " " internal shell.
T = tension, per sq. in. of sectional area, on each stay-bolt.
t_1 = thickness of outer shell.
t_2 = thickness of inner shell.
A = area of outer shell to which one stay-bolt is allotted.

a=net sectional area of each stay-bolt.

P=pressure of steam, per square inch.

It should be understood that S_1 and S_2 do not represent the *whole* stresses on the shells. They stand for the *excesses* of the stresses in the curved shell, over and above what they would be if the stayed surfaces were flat.

We have first to note that the area of the inner shell to which one stay-bolt is allotted is less than the corresponding area on the outer shell in the proportion of R_2 to R_1, because the vertical spacing of the stay-bolts is the same on both shells, while the horizontal spacing (since the bolts are all radial) will be proportional to the radii of the shells. Confining our attention to the unit consisting of one stay-bolt and the portions of the inner and outer shells which this one stay-bolt is supposed to support, we see that the steam pressure against the outer part is PA, and the pressure against the inner part is $\frac{PAR_2}{R_1}$ (because the area of the inner part is $\frac{AR_2}{R_1}$ as has just been said). Consider, now, the outer end of one stay-bolt, together with the attached unit of plate, as shown in Fig. 3. There is an outward steam pressure of PA pounds against the unit of plate, and an inward pull of Ta pounds exerted by the stay-bolt on the same unit of plate. Hence the resultant force, acting outward on the unit of plate, is $PA - Ta$. The stay-bolts being supposed to be spaced as closely together as is common in good practice, we may consider that the stresses produced in the outer shell by a force of $PA - Ta$ pounds acting on each unit, will be substantially the same as would be produced if we cut away the stay bolts altogether, and subjected the outer shell to a uniform steam pressure just great enough to produce a total pressure of $PA - Ta$ pounds on every unit of the shell containing A square inches of area. That is, we may consider the stresses on the outer shell to be due to a uniform steam pressure of $P - \frac{Ta}{A}$ pounds per square inch. The radius of the outer shell being R_1, the usual rule for finding the stress in such a shell when the steam pressure is known, gives us

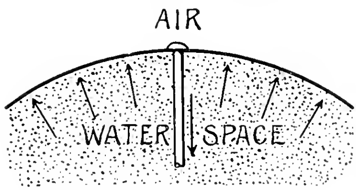

FIG. 3.—THE OUTER SHEET.

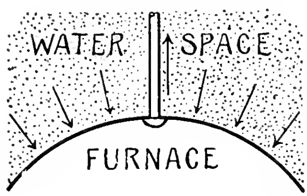

FIG. 4.—THE INNER SHEET.

$$S_1 t_1 = \left(P - \frac{Ta}{A}\right) R_1 ,$$

which is easily seen to be equivalent to

$$S_1 = \frac{(PA - Ta)R_1}{t_1 A},$$

which is the formula given for S_1 in the original article. (See THE LOCOMOTIVE, March, 1892, page 34.)

Turning now to the *inner* shell, and noting that each unit of this shell is pulled outward by the stay-bolt with a force of Ta pounds, and simultaneously pushed inward by a total steam pressure of $\frac{PAR_2}{R_1}$ pounds, there will be a resultant force on this unit of shell, acting *outward* (*i. e.* away from the center of the boiler), of

$$Ta - \frac{PAR_2}{R_1} \text{ pounds.}$$

(It may happen that the actual resultant force on the inner shell acts *inward* instead of outward; but the assumption that it acts the other way can do no harm, because if it is wrong, we shall merely come out, in the end, with a *negative* value for S_2, and this would show that S_2 is a compressive strain, instead of a tension, which would be precisely the result that would be reached if we assumed, at the outset, that the resultant force acted *inwardly*.)

As before, we may now assume that the stress on the inner shell, due to an outwardly-directed force of

$$Ta - \frac{PAR_2}{R_1} \text{ pounds}$$

acting on each unit containing $\frac{AR_2}{R_1}$ square inches of area, is the same as would be produced by a uniform steam pressure, acting outwardly with an intensity just sufficient to give a total pressure of $Ta - \frac{PAR_2}{R_1}$ pounds on every $\frac{AR_2}{R_1}$ square inches of area; that is, by a steam pressure of

$$\left(Ta - \frac{PAR_2}{R_1}\right) \div \frac{AR_2}{R_1} = \frac{Ta\,R_1 - PAR_2}{AR_2}$$

pounds per square inch. Finding, by the same method as was used for the outer shell, the tensile stress, S_2, that such a pressure would produce in a shell of radius R_2 and thickness t_2, we have

$$S_2 = \frac{TaR_1 - PAR_2}{t_2 A},$$

which is the formula given for S_2 in the original article.

It will be noted that we have made no allowance for the fact that on each unit of each plate there is an area of a square inches taken up by the stay-bolt, and therefore not exposed to steam pressure. This could be readily taken into account; but the formulæ would be considerably more complicated, and the gain in accuracy would be too small to be of practical importance. Hence we have neglected it.

To apply the foregoing formulæ, we need to know T, the stress on the stay-bolt per square inch of its cross-section. To obtain this, we have to consider how much the various parts of the boiler stretch when a given steam pressure is applied. Let us suppose that the letters R_1 and R_2 represent the radii of the two shells before the pressure is applied, and that when the full working pressure is reached, the radius of the outer shell becomes $R_1 + \Delta R_1$, and the radius of the inner one becomes $R_2 + \Delta R_2$. Now nothing can make the shells stretch except the tensile stress that comes on them; and while the stresses denoted by S_1 and S_2 are not the *total* stresses on the shells, yet they are, by hypothesis, the extra stresses that are due to the fact that the plates are circular instead of flat; and hence we shall take S_1 and S_2 to be the significant stresses for our present purposes, and shall consider the extension that is due to these forces alone.

The circumference of the outer shell, after the stretch, is 3.1416 $(R_1 + \Delta R_1)$, as against 3.1416 R_1, its circumference *before* the stretch. Hence the total stretch of the outer shell is 3.1416 $(R_1 + \Delta R_1) -$ 3.1416R_1 = 3.1416ΔR_1. Now we know that the stretch due to a given force is equal to the length of the piece stretched, multiplied by the stress per square inch of sectional area, and multiplied again by a constant which depends upon the nature of the material, and which we will denote by k. Hence in the present case the stretch due to the force S_1 in the outer shell is given by the following equation :

$$3.1416 \Delta R_1 = 3.1416 R_1 \times S_1 \times k, \text{ or}$$
$$\Delta R_1 = R_1 S_1 k.$$

In the same way we find that the stretch of the inner sheet is

$$\Delta R_2 = R_2 S_2 k.$$

Passing now to the stay-bolt, we note that its original length (neglecting the ends that are within the sheets) is $R_1 - R_2$, and that the tension to which it is subjected, per square inch of its sectional area, is T. Hence, if we assume that the material of which the stay-bolt is made has substantially the same resistance to stretching as the material of the sheets, we shall find that the increase in the length of the stay-bolt is

$$(R_1 - R_2)\ Tk.$$

But since the stay-bolt is secured to the sheets, its stretch must be precisely equal to $\Delta R_1 - \Delta R_2$, as will be seen upon examining the diagram, Fig. 5. Hence

$$(R_1 - R_2)\ Tk = \Delta R_1 - \Delta R_2.$$

But we have already obtained the values of ΔR_1 and ΔR_2, and if we substitute these in the equation last given, we have

$$(R_1 - R_2)\ Tk = R_1 S_1 k - R_2 S_2 k,$$

or, dividing through by k,

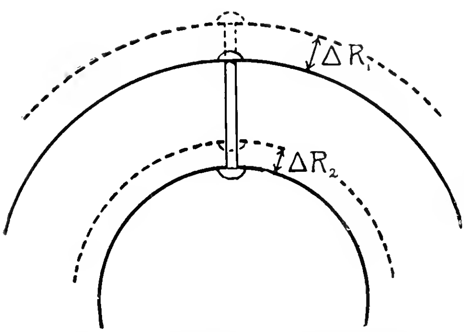

Fig. 5. — Illustrating the Stretch of the Shells.

$$(R_1 - R_2)\ T = R_1 S_1 - R_2 S_2.$$

Substituting in this equation the values of S_1 and S_2 already found, we have

$$(R_1 - R_2)\ T = \frac{(PA - Ta)\ R_1{}^2}{t_1\ A} - \frac{(Ta\ R_1 - PA\ R_2)\ R_2}{t_2\ A};$$

and upon solving this equation for T we have

$$T = \frac{PA\ (t_2\ R_1{}^2 + t_1\ R_2{}^2)}{a\ R_1\ (t_2\ R_1 + t_1\ R_2) + t_1\ t_2\ A\ (R_1 - R_2)},$$

which is the formula given for T in the earlier article.

These formulæ may be tested for special cases, if their trustworthiness is doubted. Thus if we make $a = 0$, we see that T remains finite, and hence the total pull on the stay-bolt (Ta) vanishes, as it should. Making $a = 0$ in the formulæ for S_1 and S_2, we find (since $Ta = 0$) that

$$S_1 = \frac{PR_1}{t_1} \text{ and } S_2 = \frac{-PR_2}{t_2},$$

which are correct for this case. (It will be observed that S_2, being negative, is now *compressive* stress.)

Again, if we make the surfaces flatter and flatter by increasing R_1 and R_2 until they both become infinite, we have

$$T = \frac{PA\left(t_2 + \frac{t_1 R^2_2}{R^2_1}\right)}{a\left(t_2 + \frac{t_1 R_2}{R_1}\right) + t_1 t_2 A\left(\frac{1}{R_1} - \frac{1}{R_1} \cdot \frac{R_2}{R_1}\right)}$$

so long as the radii are finite; and when they become infinite, keeping the distance between the sheets constant, we have $\frac{R_1}{R_2} = 1$, and $\frac{1}{R_1} = 0$. Hence for flat sheets we have

$$T = \frac{PA(t_2 + t_1)}{a(t_2 + t_1)} = \frac{PA}{a},$$

which is also correct. In this case, however, it appears as though S_1 and S_2 became infinite when R_1 and R_2 become infinite. This is not the case, however; for we have just seen that in this case $PA - Ta = 0$, and hence the formula for S_1 becomes $S_1 = 0 \times \infty$; — that is, the expression for S_1 merely becomes indeterminate, which signifies that the method does not apply when the plates are flat. Looking now at S_2, we see that we can write the expression for it thus:

$$S_2 = \frac{Ta - \frac{PA R_2}{R_1}}{t_2 A} \times R_1,$$

and when R_1 and R_2 becomes infinite as before, $\frac{R_2}{R_1} = 1$, and since $Ta - PA = 0$ in this case, S_2 also reduces to the indeterminate form $S_2 = 0 \times \infty$.

In our earlier article we gave a numerical example illustrating the use of the formulæ, and showing that in practical work such curved plates may be treated as though they were flat, because the values of S_1 and S_2 come out small. It is therefore unnecessary to provide stronger joints on a water-leg of the sort here described, than would be required on a similar flat surface. This result was questioned for some time after our article appeared, and to be on the safe side we have sometimes required a stronger joint to be used on such water-legs. The experiments made by President J. M. Allen and Mr. Geo. S. Barnum in 1898 may be considered to have definitely decided the matter, however, and to have shown that the mathematical analysis here given leads at least to results that may be safely used in practice. (See The Locomotive for May, 1898.)

We are well aware that the analysis given above may be criticised in some respects; but to this we would reply that there are few rules that are used in calculating the strengths of such structures as boilers, which are not open to the same objection. We are always desirous of using the best formulæ that can be had; but as this analysis is the only one that we have seen, which pretends to give anything approximating to a reasonable treatment of the question of curved stay-bolted structures, we propose to make use of it until a better one is found.

If you are not paid as much money for running your engine or boiler as you consider the job worth, do not fail to keep the plant in first-class condition, for visitors will not stop to ask how much pay you get. — *The Power and Lighting Economist.*

Inspector's Report.

FEBRUARY, 1901.

During this month our inspectors made 10,308 inspection trips, visited 19,479 boilers, inspected 5,672 both internally and externally, and subjected 730 to hydrostatic pressure. The whole number of defects reported reached 11,523, of which 764 were considered dangerous; 57 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	784	53
Cases of incrustation and scale,	2,218	42
Cases of internal grooving,	95	15
Cases of internal corrosion,	505	22
Cases of external corrosion,	359	25
Broken and loose braces and stays,	104	36
Settings defective,	302	20
Furnaces out of shape,	294	31
Fractured plates,	211	48
Burned plates,	306	32
Blistered plates,	97	3
Cases of defective riveting,	2,151	126
Defective heads,	41	7
Serious leakage around tube ends,	1,788	91
Serious leakage at seams,	438	21
Defective water-gauges,	257	44
Defective blow-offs,	159	40
Cases of deficiency of water,	16	9
Safety-valves overloaded,	93	39
Safety-valves defective in construction,	59	22
Pressure-gauges defective,	340	30
Boilers without pressure-gauges,	6	6
Unclassified defects,	900	2
Total,	11,523	764

Boiler Explosions.

MARCH, 1901.

(71.) — Mr. Low Payne was killed, on February 27th, by a boiler explosion which occurred some thirteen miles from Burton, W. Va. We have not learned further particulars. [This account was received too late for insertion in its proper place, among the February explosions.]

(72.) — On March 1st, John Kasson, a locomotive fireman employed on the Pennsylvania division of the New York Central railroad, was killed near Slate Run, Pa. A tube bursted in the boiler of his locomotive, and Kasson was hurled headforemost against a pile of rocks.

(73.) — On March 1st, a boiler exploded in the Texas & Pacific pumping station, at Texarkana, Ark. Fragments of the boiler were thrown two blocks in various directions, and considerable damage was done to surrounding property; but there were no personal injuries.

(74.) — A flue bursted, on March 1st, in the curled grass factory at North Judson, Ind. Nobody was injured.

(75.) — A slight boiler explosion occurred, on March 1st, on the Leared farm, near Findlay, Ohio. Three persons were in the boiler-house at the time, but none was injured.

(76.) — Three boilers out of a battery of six exploded, on March 2d, in the P. & R. C. & I. Company's Bast colliery, at Big Mine Run, near Ashland, Pa. Considerable damage was done to the boiler-house and the surrounding buildings, but nobody was injured.

(77.) — On March 2d, a boiler exploded in Jacob Lindemood's grist-mill, at Creuzet, Gallia county, Ohio. Brady Lindemood, Emmet Sheets, and Samuel Parker were instantly killed, and Bert Irion was injured so badly that he died a few hours later. George Chick, J. L. Dailey, and John Tryon were also seriously injured. The building was wrecked.

(78.) — A boiler exploded, on March 4th, at Colliery No. 12, Lansford, Pa. Daniel Shovelin and two other men whose names we have not learned, were badly scalded.

(79.) — An oil well boiler exploded, on March 5th, on the Given lease, on the Brady farm, in the Island Creek field, near Toronto, Ohio. The boiler-house was demolished, and the boiler was hurled 30 feet in the air; but nobody was injured.

(80.) — A heating boiler exploded, on March 6th, in Charles W. Reimers' greenhouse, at Crescent Hill, near Louisville, Ky. The total property loss was probably about $2,000.

(81.) — A boiler exploded, on March 6th, on the tug-boat *Nettie Tice*, belonging to the Hudson Towing Company, of Hoboken, N. J. James Curtin received injuries which may prove fatal, and Harry Free, John Mahler, and Thomas Wright were badly bruised. The explosion destroyed the whole superstructure of the boat.

(82.) — The State Normal College at Shepherdstown, W. Va., was totally destroyed, on March 9th, by an explosion which wrecked the building and then set fire to the ruins. The explosion is believed to have been a boiler explosion. The property loss is estimated at $30,000. Fortunately the accident occurred during a half holiday, and no students were in the building.

(83.) — On March 9th, the boiler of W. A. Downs' sawmill exploded at Montour, near Marshalltown, Iowa. L. G. Carter and Harry Smith were badly injured.

(84.) — On March 11th, a boiler exploded in the Doremus laundry, on West Madison street, Chicago, wrecking the entire block of buildings on the south side of Madison street, from Loomis street to Throop. Thirty-six of the employees of the laundry were in the place at the time. Katherine Kelly, Bessie Kucaba, Emma Sebreska, Minnie Olson, George Pihl, Frank Hanniman, Martha Jacobi, and an unidentified man were killed outright, and Theodore Van Alten died in the hospital next day. The number of injured is estimated at twenty-five, and at last accounts it was thought that some of these would die. It appears that the buildings were not very valuable, and that the damaged stores did not contain any great quantity of valuable stock. The property loss was therefore not so great as might reasonably be expected, when the disastrous character of the explosion is considered. It was thought to be about $15,000.

(85.) — W. O. Tatum's sawmill, at Norway, near Orangeburg, S. C., was destroyed by fire on March 12th, and during the fire the boiler exploded. All the machinery was ruined.

(86.) — A boiler exploded, on March 12th, in B. Russell's wood yard, Atlanta, Ga. Nobody was seriously hurt, and the damage was small.

(87.) — On March 12th, a boiler exploded in Albert Douty's sawmill, at Rebersburg, near Centre Mills, Centre county, Pa. Henry Wolfort, Warren Bierly, and Reuben Musser were badly injured. The mill was completely wrecked.

(88.) — The McKeesport Brewing Company's plant, valued at $100,000, was completely destroyed, on March 12th, by the explosion of a "cooker." The buildings were crushed like egg shells. William Fierkle and Matthew Marr were buried in the ruins and instantly killed. The accident occurred at five o'clock in the morning.

(89.) — The boiler of locomotive No. 633, on the Lehigh Valley railroad, exploded on March 13th, at Mud Run, near White Haven, Pa. Engineer Wilton Albert, Fireman Morgan Marsh, and Brakeman Robert McMillan were instantly killed.

(90.) — On March 14th, a boiler exploded in the Paxton Electric Company's works, at Paxton, Ill. Engineer Marion Jaynes was instantly killed, and the east end of the works was almost entirely destroyed. The property loss is said to have been $10,000.

(91.) — A boiler exploded, on March 15th, in J. M. Williamson's sawmill, some six miles north of Meridian, Miss. William Walker and his son were badly injured. The building in which the boiler stood was demolished, and the boiler was blown to atoms. One fragment of the boiler was found a mile away from the site of the mill.

(92.) — On March 16th, a boiler exploded in Hoover's sawmill, some six miles east of Murfreesboro, Ark. Thomas Snyder was killed, and several other persons were injured.

(93.) — A nest of six boilers exploded, on March 16th, at the Bear Ridge colliery, about two miles from Mahanoy City, Pa. The boiler house was completely demolished, and some of the debris was thrown nearly a mile. Nobody was injured. The colliery is operated by the Philadelphia & Reading Coal and Iron company.

(94.) — Four boilers exploded simultaneously, on March 16th, at the Eppinger & Russell Company's sawmill, at Olustee, Fla., about ten minutes after the one hundred or more men had quit work. One man was injured. The plant, which was one of the largest in the state, was entirely wrecked. The property loss is estimated at $20,000.

(95.) — On March 17th, a boiler exploded at the upper furnace of the Brier Hill Iron and Coal company's plant, at Youngstown, Ohio. Nobody was injured, and the damage to property was not great.

(96.) — A boiler exploded, on March 18th, in the creamery at Williamsburg, near Iowa City, Iowa. We have not learned particulars.

(97.) — A boiler exploded, on March 19th, in Seward & Thompson's mill, at Ridgely, near Denton, Md. Harry Dasher, John Turner, George Saulsbury, and Robert Stevenson were badly injured. George Vincent was also hurt, but not seriously.

(98.) — On March 19th, a slight boiler explosion occurred in a file factory near Newark, N. J. We have no further particulars.

(99.) — A hot-water boiler exploded, on March 20th, in the Albion House, at Albion, Neb. One person was injured, and the windows in the hotel were shattered.

(100.) — A small boiler exploded, on March 20th, on the De Roe rice farm, about fifteen miles south of Beaumont, Texas. Albert Snell and eight other men were injured. (One of the injured men, whose name was Noah Bellar, died on March 29th.)

(101.) — An explosion occurred, on March 21st, in the boiler room of the electric power house at Greenwood, Ind., badly wrecking the building, and fatally injuring Wilbur Johnson, the engineer. We understand that it was a heater of some sort that failed.

(102.) — A boiler exploded, on March 22d, in Hume Bros.' distillery, at Silver Creek, near Richmond, Ky. Nobody was hurt, and the property loss was small.

(103.) — A boiler exploded, on March 22d, at Leesville, Ind. We do not know further particulars.

(104.) — A boiler exploded at Pittsburg, Pa., on March 27th, on a pumping boat belonging to the Monongahela River Consolidated Coal & Coke company. The boat was wrecked, but nobody was injured.

(105.) — On March 30th, a boiler exploded in Daniel Steen's planing mill, at Waterford, Pa. Engineer William Steen was seriously injured, but it is thought that he will recover. The property loss was not large.

(106.) — A boiler exploded, on March 31st, in the cement works at Mosherville, near Jackson, Mich. Two men named Potts and Hanks were seriously injured.

THE FRENCH MENU.— He pulled himself up at the hotel table, tucked his napkin under his chin, picked up the bill of fare, and began to study it intently. Everything was in restaurant French, and he didn't like it. "Here, waiter," he said, "there's nothing on this I want." "Ain't there nothing you would like for dinner, sir?" "Have you got any sine qua non?" The waiter gasped. "No, sir," he replied. "Got any bona-fide?" "N-no, sir." "Got any semper eadem?" "No, sir, we haven't." "Got any jeu d'esprits?" "No, sir, not one." "Got any tempus fugit?" "I reckon not, sir." "Got any soirees dansants?" "No, sir." The waiter was edging off. "Got any sine die?" "We ain't, sir." "Got any pluribus unum?" The waiter's face showed some signs of intelligence. "Seems ter me I heerd of that, sir," and he rushed out to the kitchen, only to return empty-handed. "Maybe you've got some beef and cabbage, and a cup of coffee?" "Oh, yes, sir, we have," exclaimed the waiter, in a tone of the utmost relief; and he fairly flew out to the kitchen.— *Wasp.*

CONTRIBUTOR (reading aloud): — "'His eyes were riveted on her face.'" MAGAZINE EDITOR: — "'Riveted?' Here, cut that out! If he didn't belong to the union you'll have all the boilermakers in the United States down on us."— *The Boiler Maker.*

THE aggregate tonnage of American vessels is 5,164,839 tons, and vessels having a tonnage of 1,565,587 navigate the great lakes. The aggregate tonnage ten years ago, or in 1891, was 4,684,759. — *Scientific American.*

The Locomotive.

HARTFORD, JUNE 15, 1901.

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

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

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THE thirtieth annual *Report* of the Schlesischer Verein zur Ueberwachung von Dampfkesseln, of Breslau, Germany, is at hand.

THE New York and Franklin Air Compressor Companies, of 95 Liberty street, New York, have issued a joint catalogue (known as "Catalogue *B*") of the compressors and other devices that they manufacture and handle. It is very neatly gotten up.

WE desire to acknowledge the thirty-first annual *Report* of the Norddeutscher Verein zur Ueberwachung von Dampfkesseln, of Hamburg, Germany, together with several other interesting pamphlets from the same association, concerning its organization and methods.

IT is well known that we prepare plans and specifications for those of our patrons who may wish to install new boilers, and that we are quite willing, also, to look the new boilers over, previous to their acceptance, to make sure that they conform, so far as can be seen, to the aforesaid plans and specifications upon which they were supposed to be built. In reality we do much more than this; for our men have instructions, whenever they are going near a shop in which such a boiler is building, to visit the place and observe how the work is progressing, and whether, so far as can be seen, it is being done in conformity with our requirements. But it is absurd to suppose that we can certify, when the boiler is completed, that it is perfect in every respect. We cannot certify to things that are invisible and undiscoverable by inspection, without keeping a man in the boiler shop all the while that the boiler is building, so that he can keep an eye on everything that is done. This, we are confident, is not expected of us by anyone; and consequently it cannot be held, when we inspect a new boiler and pronounce it all right, that we are thereby relieving the boilermaker from all further responsibility for scamped work that looks right on the surface, nor for any other imperfection that is due to his negligence or carelessness, and which, from its nature, cannot be discovered by inspection. Our business is the insuring of steam boilers against explosion or rupture; and we do not undertake to insure the honesty of a boilermaker. The right way for an intending purchaser of a boiler to do, is to order his boiler of a first-class builder, and to pay him a good, fair price for it. This procedure will ensure good faith on the part of the builder, and a subsequent inspection by the Hartford Steam Boiler Inspection and Insurance Company will be an adequate provision against *mistakes* on his part.

How Cloths were Named.— About the year 1329 the woolen trade of England became located at Worsted, about fifteen miles from Norwich; and it was at this place that the manufacture of the twisted double thread of woolen, afterward called worsted, was first made, if not invented. Travelers by rail in Brittany often glide past Guingamp without remembering that it was here that that useful fabric, gingham, was produced. Muslin owes its name to Moussol, a fortified town in Asiatic Turkey. Tulle obtains its name from that of a city in the south of France. Linsey-woolsey was first made at Linsey, and was for a long time a very popular fabric. Kerseymere takes its name from the village of Kersey and the mere close by it, in the county of Suffolk. We have to thank Gaza, in Palestine, the gates of which Samson carried away, for gaze, or gauze. Gaza means "treasure"; and precious to the fair is the tissue which covers without concealing their charms. Voltaire, wishing to describe some intellectual but perhaps dressy woman, called her "an eagle in a cage of gauze." Damask derives its name from the city of Damascus; calico from Calicut, a town in India, formerly celebrated for its cotton cloth, and where calico was also printed; cambric from Cambrai, a town in Flanders, where it was first made; and tweed from a fabric worn by fishermen upon the river Tweed.— *Women's Home Journal.* (Quoted in *Fibre and Fabric.*)

[These derivations are conjectural, to some extent. The foregoing derivation for "gauze," for example, is admittedly based upon nothing but the similarity in sound between gauze and Gaze, coupled with the fact that fabrics sometimes *are* named from the places where they originated. The derivation of "linsey-woolsey" given above can hardly be justified at all. "Linsey" is undoubtedly a corruption of "linsel," the name by which this kind of a fabric was first known. Then "wool" was added, and by a sort of imitative tendency the final "sey" was then taken on.— this adding of an extra syllable without meaning being by no means uncommon in the formation of words of all sorts. The word "linsel" was undoubtedly derived from "linen," which is a good old word that cannot possibly be supposed to be derived from the town of Linsey. "Kersey" may be derived from the town of that name, but "kerseymere" is supposed to be a corruption of "cassimere." The writer of the article we have quoted might have extended his interesting list considerably. For example, "nankeen" is undoubtedly named from Nanking, China, where the fabric is made in large quantities, and from which place it appears to have been introduced into the western world. Batiste is named for its inventor, Baptiste, a French linen weaver of Cambrai. Jersey is so called from the Channel Island of that name. And many more cases of the kind might be given.— *Editor* The Locomotive.]

Some Examples of Bad Management.

An esteemed correspondent writes us as follows: "More than thirty years ago I was employed in a glue factory in Hudson City, N. J. I was then a boy of 13, and I made myself generally useful about the place. One day I called the attention of the foreman to the fact that there was no water in the gauge glass of the boiler, and he concluded from that that I would be a good one to look after the boiler. So I was put in charge of it. It was about 42 inches in diameter and 10 or 12 feet high, and it carried from 10 to 50 pounds of steam. It was blown off every three or six months, as might be convenient, and as soon as the water from the blow looked clean, it was shut off. I was the head man at the shovel for about two years, and during that time the boiler was never cleaned. How long it was run on that principle before and after my time I cannot tell. It seems to me, as I look back at it now, that nobody about the place knew more about the boiler than that they ought to pump water into it, and build a fire under it. At one time the boiler leaked very badly, and the owner of the factory got about two gallons of blood and put it in. 'That will stop it,' he said. After a few days the leak did stop, and the old boiler was as safe as ever. Every time I read of some curious boiler explosion, I think about my own first experience, and those two gallons of blood. In later years, when I was working for another firm building boilers, we were called to visit a factory in Newark, N. J., to see what was the matter with a boiler. The owner said they always had steam enough, but that the boiler 'steamed harder' every week. The boiler was only 2½ years old, and the owner's nephew was engineer. In opening the boiler we had to ram the rear handhole plate in with a piece of two-inch shafting, and it took two men more than half an hour to do it. We found that the boiler was filled with scale, from the bridge wall back, to the two upper rows of tubes. When we asked the engineer when the boiler had been cleaned, he said never, because no one had told him to clean it!"

Experiences similar to those here related are by no means rare; but we do not think that blood is often used in making repairs.

Wealth Made by Chemists.

The expert chemist is an important figure in the industrial world to-day. He can earn not only fame, but also a large income, and he saves manufacturers many millions of dollars every year. Of course, nine out of ten chemists stick to the old routine, but the tenth goes in for industrial chemistry, and either allies himself to some progressive and flourishing manufacturer, or independently conducts his industrial experiments and spends his time and brains in devising schemes for the utilization of by-products.

One doesn't talk much about waste products now. So little is wasted that it doesn't deserve mention. The Chicago joke that the packing houses utilize everything about the pigs save their squeals and are planning to make the squeals into whistles, has more point than most Chicago jokes.

Probably the great slaughter houses furnish the most familiar illustration of the modern thrift in the utilization of what was formerly considered waste ; and even the smaller abattoirs, while they haven't attained the scientific perfection of the Chicago packing houses, are reformed characters. It was only a few years ago that the abattoir was usually built upon the bank of a stream, and all refuse was washed into the stream. In course of time neighbors were inconsiderate enough to protest against the practice. Sanitary bees invaded innumerable bonnets, and a howl of protest went up against the abattoirs. It was necessary to dispose of the refuse in some fashion.

Chemists were called in. Methods for drying the refuse and extracting all the grease were developed. The grease went into the manufacture of soap. The residue was converted into fertilizer. After jelly had been made from the hoofs, the hoofs and horns were used for buttons, knife handles, etc. The health of the neighborhood, and the income of the slaughter men, went up.

The development of the tremendous aniline color industry is altogether due to chemical experiment with waste products. In the dry distillation of coal or wood for gas, the gas passes through a succession of washers, which take out its impurities. These impurities, including ammonia, carbolic acid, acetic acid, and various nitrogen compounds were formerly waste, but are now separated and used. In fact, nearly all of the acetic acid in the market is secured from the dry distillation of wood. Five per cent. of the coal used in gas manufacture is coal tar, and by experiment chemists found that this coal tar, always regarded as waste residue, contained substances useful in the making of dyes. Fully ten per cent. of the weight of the coal tar is available for this purpose, and upon the basis of this discovery the enormous coal tar color industry has grown. New plants have been put into many of the coke regions to collect the coal tar liberated in coke manufacture, and it will not be long before the open coke oven will be a thing of the past. Where coal is burned in an open oven no coal tar can be collected, and large profits are literally thrown away; but by burning the coal in closed retorts all the coal tar can be recovered and used.

This color industry, which chemists call the greatest of the modern chemical industries, has called for other chemical developments. It demands large quantities of sulphuric acid, of soda, etc., and chemists have sharpened their wits upon the problem of obtaining these products at a minimum expense. Until recently the greater part of the sulphur used in this country was imported from Sicily. Now, through chemical processes, the sulphur occurring with iron, gold, silver, and zinc is liberated and burned to sulphur dioxide, from which almost all of our sulphuric acid is made.

In connection with all of our mining development, chemistry has played an important part. Ores can be mined with profit, to-day, that would have been practically worthless a few years ago. In the old mining days only high grade ore was profitable, and only a certain percentage of the gold contained in the ore was freed.

The tailings thrown aside held a considerable quantity of gold, but could not be worked by the ordinary processes, and were therefore piled mountain high and disregarded until chemists discovered that the gold was soluble in potassium cyanide, and that by washing in a very weak solution of potassium cyanide, the tailing gold could be profitably separated from the refuse. The same process has led to the working of low grade ores, running $4 or $5 to the ton, which could not be profitably worked by the ordinary mining processes.

The silver contained in lead has also been freed and utilized. It was found by chemists that when the melted lead was mixed with zinc the silver formed an alloy with the zinc and floated to the surface. When this mass was taken from the lead and heated in a retort, the zinc, being volatile, was freed, and left a deposit so rich in silver that it was easily purified.

The applications of chemistry to mining processes are legion, but it is in other branches of industry that practical chemistry is now making its strides. The Standard Oil Company is a hardy exponent of the merits of industrial chemistry and has expert chemists constantly employed. As for that matter, so have all the great gas plants, coke plants, sugar refineries, starch factories, etc. The original waste of the oil business was enormous; now it is next to nothing. Of course, the primary aim is the production of kerosene; but crude oil contains, on the one side, oils lighter than kerosene, such as gasolene and naphtha, and, on the other side, products much heavier than kerosene, such as paraffin. At one time all of these by-products were waste; now every one of them is utilized. By first distillation, the lighter oils are freed and collected. Then the kerosene is distilled, leaving a product that is worked over into hard paraffin and soft paraffin or vaseline. A heavy oil, left after the collecting of the paraffin, is used for lubricating and fuel oil, much of it being made into car and axle grease. After all these processes a solid mass of carbon is left in the retorts, and this is used to a considerable extent in making carbon sticks for electric light. When one considers that until a few years ago every one of these products save kerosene was absolute waste, one can realize to some extent the place chemistry is taking in the industrial world.

The dairy business is one of the industries with which the chemist is busying himself, and the results so far have been most satisfactory, although a much broader field for the use of casein is prophesied. The large creameries, having turned out their cream and butter, were confronted by great quanities of skim milk for which there was apparently no use. Skim milk was a drug on the market, and in many cases was drained off into neighboring streams. The chemist stepped in and changed all that. The milk is curdled with alkali, and a dried product produced which is soluble in water. This casein has been used for paper sizing, kalsomining, etc., and successful experiments have been made with it in the manufacture of artificial foods. Moistened with water to a gelatinous consistency, put under a hydraulic press and then washed in acid, it forms a hard and insoluble substance, of which buttons and similar articles are made. Chemists say that the casein powder, which is like a fine tasteless flour, may be substituted for milk in cooking, and has a great future in this respect.

Chemistry applied to the sugar industry has been invaluable ; and, particularly in connection with the beet sugar manufacture, has recently effected a wonderful saving. The waste in the making of beet sugar was at first enormous, because the molasses was absolute waste. It contains products from the beet roots which give it a very bitter taste, and is also rich in an alkali which spoils its flavor. So, although more than one-half of the weight of the molasses was sugar, it was unavailable save for fermentation and alcohol. Experiment proved that dry lime, mixed with the molasses, combined with the sugar, forming a product insoluble in water. Washing the molasses would then separate this product from all the other elements. The lime and sugar product being heated with carbonic acid, the lime combined with the carbon, forming an insoluble product, and leaving the sugar free to be easily separated. By this process to-day 90 per cent. of the sugar is recovered from beet molasses, and there is practically no molasses in the beet sugar factories. In the manufacture of cane sugar the molasses is about as valuable as the amount of sugar contained in it would be, so there is no use for the process adopted in beet sugar making ; but there is less weight of sugar in the molasses than there was formerly. This fact, and the fact that the molasses is now made in vacuum pans and cannot be burned or thickened as it was in the old fashioned open pans, accounts for the fact that there is no more black molasses, and no more black gingerbread such as mother used to make.

The glucose manufacturers have called in chemists, and found a new source of profit. The corn grain has, in addition to its starch product, a tiny germ in which lies its life principle. This germ was formerly crushed with the starch and then separated and thrown aside as waste. Very lately it has been shown that this germ is rich in oil which can be utilized. The germ is now separated from the starch and crushed. The oil gathered finds a ready market, and within the last five years millions of dollars' worth of this oil has been exported to Europe, where all corn products are in great demand. After the oil is taken from the germ the gluten left in the cake is used for varnish, and the residue is used for cattle food.

The corn stalk also is ground and used for cattle food, but first the pith of the stalk is extracted and used for the lining of vessels, the theory being that if a fissure occurs in the framework of the vessel the pith lining, becoming wet, will swell and to some extent close the fissure.

The cottonseed oil industry has eliminated its waste almost entirely, although twenty years ago every part of the cottonseed save the oil was waste product. In the cottonseed oil factory, now, the seed is collected after coming through the cotton gin, and is first stripped of its lint, which is used in the manufacture of certain kinds of paper, felts, etc. Next the shell of the seed is removed and either ground for cattle food or used for fuel. In the latter case the ashes are collected for potash. The kernel of the seed is ground and pressed to extract the oil, and the residue is used for cattle food. The oil in process of refining gives off a waste which enters into soap making, and the making of oleomargarine.

Glycerine, used in such great quantities at present, was for years a waste product. All waste from fatty oils contains compounds of an acid with glycerine. The acid will combine with an alkali, leaving the glycerine in a watery solution, from which it is collected by evaporation and distillation. Immense quantities of this reclaimed waste product are used in the making of explosives.

When steel is melted in a Bessemer converter the phosphorus, which used to be a nuisance, is separated from the steel by the introduction of lime, with which the phosphorus combines readily. This phosphorus is then used as a fertilizer.

The slag from iron furnaces is converted into cement. The tin is taken from old tin cans by chemical process and is used over and over again.

Even the acids used for chemical purposes are not allowed to outlive their usefulness with the accomplishment of their purpose. The Standard Oil Company formerly wasted great quantities of sulphuric acid after it had been used to remove the impurities from the oil. The acid was drained off into the river. Now it is used in a fertilizer particularly adapted to soil where phosphate rock must be dissolved. Then again in certain great galvanizing works the iron was cleaned with sulphuric acid, which was then run into the nearest river. This method of disposing of the waste was forbidden, and chemists were consulted. The solution was made stronger so that it could be clarified and used repeatedly. Finally, when it could no longer be used for washing, it was evaporated, and the sulphate of iron extracted from it. This by-product proved so valuable that it is now the chief product of the works.

The list might be protracted indefinitely, and there seems to be in the industrial world to-day no product so utterly worthless that it may not find profitable incarnation in some form or other.—*New York Sun.*

A Fearful accident occurred on April 25th in the Griesheim Electro-Chemical works, on the River Main, near Frankfort, Germany. It consisted in a tremendous explosion, which destroyed everything in the vicinity. As the explosion occurred in the smokeless powder division of the plant, it would be natural to suppose that it was due to the accidental ignition of some of that substance. We are informed, however, that it was a boiler explosion, although this may have been followed by an explosion of powder also. Fifty or more persons were killed, and upwards of 140 were injured. We have tried to get full particulars of the explosion for publication in The Locomotive, but we are informed that an official investigation is in progress, and that nothing can be given out until this is completed. The ruins of the chemical works and of the surrounding buildings took fire, and the entire fire department of the city of Frankfort was engaged in fighting the flames for five hours before the work of rescuing the injured could be undertaken. The enormous benzine tanks in the vicinity of the destroyed plant were saved with great difficulty. Troops were called out to control the crowds, and the entire population of Griesheim was ordered out of the village for a time, until the fire could be subdued. The property loss must have been enormous, but we have seen no estimate of it.

The Locomotive.

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Concerning Pressed Steel Braces.

In the May issue of The Locomotive we printed an article entitled "A Common Defect in Bracing," in which we drew attention to the fact that it is by no means uncommon for boiler makers to provide adequate strength in the *body* of a brace, while leaving the blade, or part by which the brace is secured to the shell, altogether too weak across the line where the first rivet hole comes.

The article in question aroused a great deal of interest, if we may judge by the considerable correspondence that it has called out; and for this reason we desire to supplement it by a few more remarks on the same subject. In the previous article, we discussed only the solid type of brace, which is forged up out of round iron. The so-called "formed braces," which are stamped or pressed into shape out of sheet metal, are coming more and more into favor, in place of the forged kind, both because they are cheaper, and because they have no weld. We desire to call attention, however, to the fact that the formed braces are also liable to the same defect that we have already indicated in connection with the solid ones.

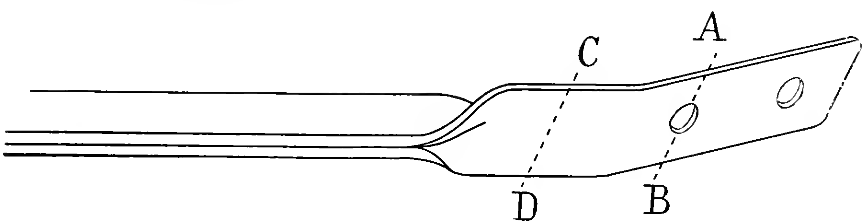

Fig. 1. — The Shell End of a Pressed Steel Brace.

Fig. 1, for example, represents the shell end of a formed brace, with two rivet holes to secure the brace to the shell. Such braces are almost invariably made strong enough along the section *CD*, but are often too weak along *AB*, owing to the removal of metal at this point, in making the rivet hole. It is common to find the brace $2\frac{3}{4}$ in. wide at *AB*, over all; and the usual thicknesses of material are $\frac{3}{8}''$, $\frac{7}{16}''$, and $\frac{1}{2}''$. Taking the $\frac{3}{8}''$ brace as an example, we see that the sectional area of the solid part of the blade (along *CD*) is $\frac{3}{8}'' \times 2\frac{3}{4}'' = 1.03$ sq. in. The error that we wish to call attention to consists in counting a brace of this sort as though it had a full square inch of sectional area, just because it has such an area *in the solid part*. For the weakest section of the brace is plainly that along the line *AB*, where the rivet hole is punched. Assuming that the rivet hole is $\frac{13}{16}''$ in diameter, or (expressed decimally) 0.8125'', it is evident that the effective section, across *AB*, has a width of only

$$2.75'' - 0.8125'' = 1.9375''.$$

The effective sectional area at this point is therefore

$$1.9375 \times \tfrac{3}{8} = 0.73 \text{ sq. in.},$$

in round numbers. Hence, although this particular brace has a sectional area of more than one square inch throughout almost the entire part of its length, it has less than three-quarters of a square inch of section across the line *AB*, and therefore it must be counted as having an *effective* sectional area of only 0.73 of a square inch; for a brace, like a chain or any other structure, cannot be stronger than its weakest part.

We do not draw attention to this matter for the sake of condemning the pressed steel brace, because we believe that these braces are very good things when they are properly designed and constructed. The point is, that we cannot allow one of these braces to count as having a square inch of sectional area unless it actually *does* have a square inch, in its weakest part. It is a matter of indifference to us how this square inch is obtained provided it is there. It may be secured by using thicker stock, so that the section along *AB*, even when reduced by the rivet hole, will still contain a square inch; or it may be secured in any other way that does not make the blade cover too much surface where it comes in contact with the shell. For example, the blade may be made extra wide, so that the *net* section across *AB* is as great as the full section in the body of the brace, the edges of the blade being turned up, as shown in Fig. 2, instead of lying flat, as in Fig. 3. This will give the necessary section at *AB*, without waste of metal, and without causing the blade to cover too great an area of the shell. (We believe this particular device is patented.) The main point to be observed, however, is, as we have said, that the calculated strength of a brace must not be based upon the full sectional area of the body when there is some other part that is weaker than this.

FIG. 2.

FIG. 3.

In tensile tests of braces, and in boiler explosions in which the braces give way, it is quite common for the metal to part across the line of the first rivet hole, which shows, in a practical way, that this section is usually the weakest one.

Inspector's Report.

MARCH, 1901.

During this month our inspectors made 11,109 inspection trips, visited 21,155 boilers, inspected 7,854 both internally and externally, and subjected 873 to hydrostatic pressure. The whole number of defects reported reached 16,405, of which 1,082 were considered dangerous; 79 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,182	74
Cases of incrustation and scale,	2,930	81
Cases of internal grooving,	185	11
Cases of internal corrosion,	763	42
Cases of external corrosion,	534	42
Broken and loose braces and stays,	175	61
Settings defective,	417	22
Furnaces out of shape,	466	20
Fractured plates,	340	54
Burned plates,	401	53
Blistered plates,	97	2

Nature of Defects.	Whole Number.	Dangerous.
Cases of defective riveting,	2,936	58
Defective heads,	85	12
Serious leakage around tube ends,	3,327	332
Serious leakage at seams,	466	26
Defective water-gauges,	269	33
Defective blow-offs,	155	42
Cases of deficiency of water,	23	6
Safety-valves overloaded,	129	38
Safety-valves defective in construction,	77	26
Pressure-gauges defective,	418	28
Boilers without pressure-gauges,	12	12
Unclassified defects,	1,018	7
Total,	16,405	1,082

Boiler Explosions.

April, 1901.

(107.)—On April 1st a boiler exploded in David Doremeyer's picket factory, in Cooper township, near Mt. Sterling, Ill. The proprietor, David Doremeyer, was fatally injured, and engineer Otha Gibson was severely hurt.

(108.)—A slight boiler explosion occurred, on April 1st, in Bibb Mill, No. 2, at Macon, Ga. Nobody was injured.

(109.)—Engineer James Purcell and driver Timothy Curtin were severely scalded, on April 1st, by the explosion of a portable upright boiler used for operating drills, in East Seventy-ninth street, New York. We do not understand that any considerable damage was done.

(110.)—On April 4th a boiler exploded at Kitterman, near Nevada, Mo. George and James Todd, brothers, were instantly killed, and their bodies were thrown through the roof of the boiler-house. Two other men are said to have been injured. The boiler-house itself was wrecked, and much of the machinery of the mill was destroyed, entailing a heavy loss.

(111.)—A boiler exploded, on April 6th, on the steamer *Redfield*, which plies between Catskill and New York, on the Hudson River. The explosion occurred while the *Redfield* was near Hyde Park, and she was towed into Rhinecliff by the *McManus*. We do not know of any personal injuries.

(112.)—On April 6th a boiler exploded in the Montgomery Door and Box Company's plant, at Buffalo, N. Y. Anthony Lapatana and Anthony Ambruster were killed, and George Sturm, John A. Zimmer, William Underhill, and Matthew Sherrin were seriously injured. The boiler house was wrecked. (According to some accounts, this was a dust explosion; but we have classified it among boiler explosions because it appears more likely that it was actually the explosion of a boiler. This interpretation is borne out by the fact that the boiler house was destroyed, and that the dome of the boiler was found to be ruptured.)

(113.)—A boiler exploded, on April 6th, in Charles Clark's grist mill at Lisbon, near Ogdensburg, N. Y. Several men were at work near by, but all escaped injury. The boiler was thrown about 150 feet in the air, landing on the top of a passing Ogdensburg & Lake Champlain freight train.

(114.)— A peculiar, compound explosion occurred on April 7th, at Spring City, on the Cincinnati Southern railroad, near Rockwood, Tenn. A double-header freight train, loaded with iron ore and southward bound, struck a cow and jumped the track. The boilers of both locomotives exploded. Fireman James Dugger was fatally scalded, and Robert Bradshaw, William Williams, Walter Elliot, engineer Miller, and one other man whose name we have not learned, were injured. One of the injured men may die.

(115.)— On April 8th a boiler exploded in the plate department of the Riverside Mill, at Benwood, near Wheeling, W. Va. Nobody was injured as the direct result of the explosion, but Mr. C. E. Davis, in running away, fell and was badly hurt by his fall.

(116.)— A boiler exploded, on April 9th, at Rebersburg, Center county, Pa. The mill was blown to atoms, and Henry Wohlfort, Wallace Bierley, and Reuben Messer were injured.

(117.)— A boiler exploded in the Great Western Elevator, at Hunter, N. D., on April 10th. A man named Stinso was injured. We do not know the extent of the property loss.

(118.)— On April 10th a boiler exploded in the Michigan Manufacturing and Lumber Company's plant, at Rose City, near West Branch, Mich. Fireman Oliver Allen was killed, and a young man named Arnold was seriously injured. The boiler house was completely demolished.

(119.)— A boiler exploded, on April 10th, in the Builders' Manufacturing Company's plant, at Norfolk, Va. W. S. Harrell and Turner Batler were killed, and the plant was completely wrecked. The property loss was estimated at $12,000.

(120.)—On April 11th a boiler exploded in Lewis M. Marr & Sons' clothes-pin factory, at West Paris, Maine. Engineer Herbert Emmons was fearfully injured, and died a few hours later. The entire main building was moved on its foundation, and the property loss is estimated at from $4,000 to $6,000.

(121.)— Two boilers used to pump oil wells on the Cameron and Smith leases, in South Strabane township, near Washington, Pa., exploded on April 12th. Fortunately nobody was injured. The shock of the explosion was felt at Washington, two miles distant.

(122.)— A boiler exploded, on April 13th, in James Harrison's sawmill, at Derby, near Tell City, Ind. James Hendershot and the proprietor, James Harrison, each received severe injuries, but at last accounts it was believed that they would recover.

(123.)— A boiler exploded, on or about April 13th, in a large lumber mill at Vintondale, Cambria county, Pa. We have not learned particulars, except that the mill was destroyed.

(124.)— On April 16th a boiler exploded in Brakeen Brothers' sawmill, at Mt. Olive, near Gulfport, Miss. Two men were severely injured. The mill was wrecked. The property loss was probably $10,000.

(125.)— On April 16th a boiler exploded in J. H. Riney's sassafras mill, at Gilbert, near Charlottesville, Va. The proprietor was fatally injured, and John Adams, David Sloan, and William Burton were seriously burned. The building and machinery were destroyed.

(126.)—A boiler exploded, on April 17th, at New Westminster, B. C., on the river steamer *Ramona*, while she was en route from New Westminster to Fort Langley, on the Fraser river. Mrs. H. M. Morrison, Mrs. Bailey, John Mack, and Henry Phipps were killed, Richard Power and James Maynard were fatally burned, and Victor Nowell and four Indians were also seriously injured. The *Ramona*, which was valued at $25,000, was completely wrecked.

(127.)—By the explosion, on April 18th, of the front engine of a double-header freight train on the Lake Erie & Western Railroad, at Cassville, fifteen miles south of Peru, Ind., engineer E. A. Redmond and fireman John Bender of the first engine were badly cut and scalded, and engineer Dodds and fireman Wallick of the second engine, Brakeman Otto Warder and Conductor Odem were seriously injured. Both locomotives were wrecked and fifteen cars were piled on top of them.

(128.)—On April 20th a boiler exploded in the Jersey Central Pumping Station, at Bethlehem, Pa. The building was blown away, but there was no loss of life. The destroyed property was valued at $5,000.

(129.)—A hot-water boiler exploded, on April 21st, in T. O. Ray's barber shop, at Plano, Texas. No serious damage was done, and no person was injured.

(130.)—On April 23d a boiler exploded at Cula, Monongalia county, W. Va. Henry Wilson was scalded to death.

(131.)—On April 26th a boiler exploded in Haynes & Whitaker's sugar of milk factory, at Antwerp, near Watertown, N. Y. Considerable damage was done, but we do not understand that anybody was injured.

(132.)—A boiler exploded, on April 26th, in the fat-rendering establishment of William Burtchall, near Philadelphia, Pa. Nobody was injured, and the property loss was small.

(133.)—On April 29th a boiler exploded at the works of the Seattle and King County Oil Company, near Seattle, Wash. The explosion caused the caving in of a shaft, which resulted in the death of Augustus Twombly.

The Society of German Engineers proposes to issue an English-German-French dictionary of technical terms; and, in order to make it as valuable as possible, the Society desires to secure the co-operation of numerous foreign correspondents, who would be likely to know most of the words that ought to be included. Several collaborators in each line of industry would be desirable. The work is a most worthy one, and we wish it every success. There is a need for just such a book; for, although there are a number of tri-lingual lexicons to be had already, with technical terms included, the progress of industry has been so great in recent times that most of them are practically obsolete. If we understand the plans of the present project correctly, the lexicon now projected is to be much more extensive than anything that has been heretofore attempted. Those who may be willing to co-operate in the work are requested to address the editor, as follows: Editor of the Technolexicon, Dorotheenstrasse 49, Berlin (N. W. 7), Germany.

The Locomotive.

HARTFORD, JULY 15, 1901.

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

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

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WE have received, from the publishers, a copy of *An Englishwoman's Love Letters*, with a request that we give it a review in THE LOCOMOTIVE. We have no regular love letter editor on our staff, and we therefore turned it over, first, to our expert on riveted joints, who is reputed to have had some experience in such matters. He says that the writer of the letters is badly designed; that she has a poor circulation and a cracked head, and that a few bricks are loose in her setting; and he swears he will take no responsibility for her, until she has been submitted to a hydrostatic test of at least a thousand pounds. His judgment has always been good on matters more directly in his line, but we were so sure that it was in error in this particular case that we took the book away from him and made a complete internal inspection of it ourselves. We quickly found that the language is so warm that our expert on combustion was the proper man to consult. He was away on his vacation, however, and we didn't want to call him back to make a calorimeter test during this hot weather. Our chemist shook his head sadly when we offered the job to him, and the only available man left on our staff was the automobile editor, who takes the place of the horse editor that we discharged when the horse went out of fashion. He says the author has wheels all right. He doesn't wish to condemn the book though, for he says that while it isn't in *his* line, he should judge that it would be hot stuff in somebody else's line. With this sentiment we heartily agree. It is our custom, in reading a work of fiction, to pick out the one passage in the whole book that seems to be most pat. We think we have found it, in this book, on page 203, where the author of the letters says to her hubby, "Oh, how tired loving you now makes me!" To which we would fervently respond, "Amen!" (Laird & Lee, Chicago.)

A Queer Little Planet.

It is well known to students of astronomy that between the orbits of Mars and Jupiter there is a host of little planets, which circulate around the sun in orbits of their own. These tiny members of the solar system are so small that they cannot be seen with the unaided eye, and no man knows how many there are of them. Some hundreds are known to-day, and others are being discovered all the time. The labor of calculating the motions of these objects is so great that some of them have actually been lost, because there were not astronomers enough who could afford to spend the time to keep track of them. It is not a very uncommon experience to find that an apparently new member of the family is really only a old one that had been lost — the identification being made by tracing the motion of the newly-discovered one backwards until it turns out to have been, on some particular date, in precisely the same position that one of the lost ones was known to have been in at that date.

Professor Watson, who discovered a number of these freak planets, *endowed* his little contingent; that is, he left money the income of which is to be used in keeping track of their wanderings, so that they may never be lost again.

The orbits of the "asteroids," as they are called, exhibit every variety of peculiarity that is consistent with elliptic motion, and we find some with great eccentricities, and others with enormous inclinations to the plane of the earth's orbit. The most remarkable member of the family, without doubt, is the little planet that was discovered a few years ago, and named "Eros." This particular asteroid has an orbit so eccentric that it actually comes nearer to us at times than the planet Mars. This circumstance alone is enough to make it an exceedingly important member of the solar system; because its smallness and comparative nearness will enable astronomers to measure its distance quite accurately; and when the distance of any one planet is known (in miles) the distances of all the others can be obtained by a very simple calculation. It turns out, however, that Eros has a great many other peculiarities of the most interesting kinds; and, while these others will probably not have the same importance that attaches to the planet's small mass and relatively close approach, they will nevertheless conspire to make the little wanderer one of the most interesting objects in the sky. The *Popular Science Monthly*, in a recent issue, tells of some of these things in the following words :

"The little planet Eros bids fair to hold the attention of astronomers for several years to come. Before the observations necessary for the determination of the sun's distance had been completed came the announcement, by Dr. Oppolzer, of the planet's variability. A variable planet, with a range of brightness such as Eros has shown, is, in itself, something new and striking; but this is only the beginning of the problem. Several hundred stars are known to vary their light periodically, and some advance has been made in the theory of their variability. Variable stars, however, do not become *invariable;* neither do invariable stars, after a time, become variable. But from a variable planet, having an extremely short period and large range of variation, Eros recently became invariable. In Europe, soon after the discovery of its variability, its range was said to be two magnitudes; that is, it shone with about six times as much light at maximum as it gave at minimum. Precise photometric measurements of the light of Eros, made by Professor Wendell, gave a range of variation of 1.1 magnitudes on March 12 of the present year, and of 0.4 magnitude on April 12. On May 6 and 7 no variation was perceptible, and if any variation existed, it was probably less than a tenth of a magnitude. Owing to poor weather and the planet's approach to the sun, later observations have been difficult; but a slight variation was apparent in June. These unique phenomena are probably the result of the changing direction of the axis of rotation of the planet, as related to the line of sight; for, although the direction of this axis in space is fixed, it will constantly change with reference to an observer on the earth. When (if ever) the axis points directly towards the earth, there can be no variation of light; and the maximum range will be found when the axis is perpendicular to the line of sight. Apparently this axis has been recently pointing towards the earth; and we may confidently expect that within a short time Eros will again show well marked changes, although the planet's position may not permit exact observations. On March 5th M. André communicated to the *Astronomische Nachrichten* a discussion in which he assumed that the variation in brightness is due to the fact that Eros is a double asteroid. M. André even gave approximate elements for a system which appeared to him to satisfy the conditions. Professor Pickering has recently pointed out that the variations in light can hardly be accounted for by two similar bodies alternately eclipsing each other, and has suggested that the known facts can be explained by supposing that Eros is an elongated, cigar-shaped body, or that one side of it is much darker than the other. The solution of the interesting problems that Eros presents may not be possible until the next opposition, which does not occur for about two years. Eros will be in conjunction with the sun in the spring of 1902, and in opposition in the summer of 1903. The distance of the planet will be great in 1903, since Eros will not be at perihelion; but this will not prevent precise determinations of the changes in light, with a telescope of sufficient power. The most favorable time for observation will be from March to August, 1903; but the planet will then be in the southern sky, and during the months mentioned its declination will be from 30° to 45° south of the equator, which will make its observation difficult or impossible at northern observatories."

We desire to acknowledge a copy of "*The A B C of the Telephone*," by James E. Homans, A.M. This book is a very complete treatise on the telephone, and on matters relating to it. It deals with the principles of electricity and of sound sufficiently to make the operation of the telephone intelligible; and it also gives a great variety of information concerning the practical construction of telephones and their accessories, including switchboards for both small and large installations. The work is profusely illustrated, and we cordially recommend it to any person who may wish to know the ins and outs of the telephone business. (Theo. Audel & Co., 63 Fifth avenue, New York. Price, $1.00.)

American Competition in England.

We have heard a good deal about American competition in England and elsewhere, and the tune that has been sung (by ourselves) has been a uniformly happy one, celebrating successes of all sorts. We have been in danger of thinking that everything is coming our way, even if we don't try our very best to get it. It might be a good plan, therefore, for some of us to read a few of the foreign comments upon our doings. It might help us not to get our heads swelled too much. The *Practical Engineer* of London, England, recently printed an article on American power station engines and locomotives, which we reprint below, not because it is pleasant reading, but because it shows that we have not given entire satisfaction to some, at least, of our English friends. We do not know whether the remarks of our contemporary are justified by the facts, or not; but we should be pleased to hear from any one who may be familiar with these facts, and who may be able to throw further light on the subject.

"The American engines brought over to Glasgow, the birthplace and home, almost, of the steam engine," says the *Practical Engineer*, "have at last got to work, and relieved the small auxiliary engines, which had to do duty for them for many weeks after the inauguration day of the station. These auxiliary engines have been kept at work so constantly that there was no time to get the governor right for them. However, it is not likely that they will be required to take over the whole work of the station again, because, even if the American engines should break down or need repairs, the Musgrave engines, which began working on June 24th, can be relied on to do their own work, and the work of the others as well. But it is satisfactory to learn, from the report published in a Manchester contemporary, that 'the little trouble at first experienced from warm pins . . . has entirely disappeared.' After that we may believe that the expert hurriedly called across the Atlantic to put these warm pins right will go comfortably back again, as his services will be no longer required. There is a little item between the committee and the company that constructed the engines. Mr. Paton, the chairman of the committee, was asked to state what the difference was; but he replied that he would prefer to say nothing further at this time. Whether the Glasgow engineers who are in charge of the station will have any more trouble with these engines or not, we cannot say; but at present engines of foreign construction do not carry, with them, a very good character. There are other American engines at power stations in this country, and these are known. It is never a pleasant matter to see the expression on the faces of the engineers of these stations when questions are asked as to the working of the American engines. What the chairman of the Midland Railway, and the superintendent engineer, said of American locomotives, are both known. In language not to be misunderstood, the engineer made several charges against them, and the chairman said, more mildly but quite as effectively, that he did not think there was a market for American locomotives in England. The directors and engineers of power stations are not so noted as those of the railway companies, but their opinions with regard to the American engines are quite as definite and conclusive. When they are asked if they will have any more, they refuse to even consider the request; and the engineers in charge say that they long for the day when they will see the last item of them on the scrap heap. It is said in their favor that they can be wonderfully quickly made. Some one once said, 'Quick writing makes hard reading.' So, in England, the experience is that rapid construction in engineering means hard working, to keep the thing in proper condition.

"But what is the matter with these American engines, of which power station engineers complain so much? Is it prejudice, or are there real troubles with them, wherever they may be fitted up? Have all the pæans sung by the journalists in the sensational papers of the great American progress shrunk to this little measure? Is all the competition of which we were warned come to this, that buyers will not look at the competition articles, and will not have them at any price? Surely there must be a cause. Mr. Garnett simply raved, at the Iron and Steel Institute, against English methods. He was very quietly told that the methods he spoke of had been in practice for thirty years. Was his real object to obtain from the discussion a description of our latest methods, so that they might copy them over there? He was also informed that the real American competitor is the tariff. Anyway, British engineers smile at the warnings of the half-penny papers, and invite the editors to try American machines just once.

"In the power stations these engines stand condemned. The first trouble experienced with them was in the cylinders. Oil had to be run into these, to allow them to work with any approach to satisfaction; and much oil in a cylinder spells ruin to the boiler, especially if it is an American boiler of the water tube type. At any rate, where half a gallon of oil a day sufficed for an English-built engine, two and a half gallons were required for the American ones. Even that great quantity of oil did not keep them working smoothly, for in a couple of months from starting the engines had to be stopped, and an emery wheel put in to remove the scores and ruts formed in the bottom of the cylinder by the piston. These periodical burnings out with the emery wheel went on, until at the end of twelve months the scores and ruts became too bad for the emery treatment, and the tool and boring bar at last had to be resorted to. Then there was trouble with the oil. The large quantity put in with the steam had to be got out of the water before it was pumped back into the boiler. One filter was tried after another, but none would do the work efficiently. At last, in one case, it was resolved to throw away the water and oil as they came from the condenser, and to pump town water from the mains into the boiler. This involved costly softening apparatus and materials, but the engineer was driven to use them. The cylinders were a very bad part of the engines, but the other parts were little better. We hear much of standardization, and of making everything to gauge; but engineers will find, later, that this is not the right road to success. A cry for standardization is a cry for profits, and the Americans never think of anything but the balance sheet. It would be better to return to the chisel and file, and to aim at getting everything to fit and to wear, rather than to have everything fall cheaply into its place. Future engineers will see to it that things are not made to compete, but to last long and to wear well.

"Each part of the American engines under review is made after the genius of the American 'mechanic'—that is, it was made in a hurry. The drill would be going through a bearing, and when well through it would be found out of true. It would then be quickly started at the other end, and a great hole left in the inside of the bearing, unseen. The bearing looked all right from the outside, but the shaft working in it rested only on two short surfaces at the ends. Such a job would have been examined in England, and ordered to be flung on the scrap heap. In America these things form part of the engine, are sent out of the country, and become a worry and vexation of spirit to the engineer in charge; and the common expression is, 'The home-made machine will see the American ones out of the station.' Of course, when engines are made in this way, when they are disgracefully machined, when the cross-head is not in line with the guides, and the surfaces are of bad, soft metal, and don't wear, they are, to say the least, not competition machines. In locomotives and power station engines the competition from America is over; their introduction and their success stand on the same footing as that other foreign design, the Belleville boiler."

We reproduce this article because it appears in a bright paper, which has, we believe, quite an influence in England. We have made a number of changes in the wording of the original, because in some places the sense was not entirely clear, and a few of the verbs did not agree with their subjects; but we are confident that we have not materially altered the writer's meaning at any point. We do not know what basis there may be for the editor's condemnation of the particular engines he had in mind when he wrote this article; but we do know that such engines as he describes are not turned out in America, even by fourth-rate machine shops. There is a junk shop down back of our office, where one can find engines of far better quality than this, which have been thrown out because, after long years of service, it was thought best to replace them with others of more modern design. We cannot imagine what kind of a scrap heap the *Practical Engineer's* engines came from.

Pulverized Fuel.

About ten years ago D. K. Clark referred to the use of powdered coal as "unique and interesting." It is now much more than that, and is worthy of the most careful attention of engineers in view of its apparently very promising possibilities. The idea dates back to 1831, when Henschel carried out experiments at Cassel, Prussia, in connection with brick kilns and heating furnaces. While progress has been made continually, it was not until recently that commercial success has been attained in practical operations, but its present employment in connection with the manufacture of cement in this country, and also in firing boilers both here and abroad, entitle it to a consideration which it has not yet attracted.

The burning of fuel in finely divided form permits of turning the fuel into gas and obtaining a perfect and prompt intermixture of the gas and air. This makes a perfect (and therefore smokeless) combustion possible, and there is good reason to believe that the results are almost as good with poor as with good grades of coal; but, of course, the better the coal, the less the quantity of it required. By passing the fuel into the furnace by means of a stream of air the elements of combustion are brought under perfect and convenient control, and one great advantage of the automatic stoker is attained, in that there is no opening of fire doors. That the combustion may take place under ideal conditions is evident from the fact that powdered coal has been burned with the proportion of 12 pounds of air per pound of coal, which is precisely the theoretical chemical requirement. We have also records of continuous tests showing 18 per cent. of carbonic acid gas from flue-gas analysis of a powdered-fuel boiler. With conditions such as these, or approaching them, increased evaporation may be expected, and is in fact obtained, over that from the same fuel burned on grates with a necessarily large excess of air. With powdered fuel there are no clinkers; the ash is apparently as fine as the powdered coal, and it may be removed through pipes.

Assurance is given that lignite will work satisfactorily when pulverized, although there are no authenticated records at hand confirming it. We have seen the fact demonstrated, that very poor coal works almost as well in this process as better coal, when the conditions are adjusted as they should be. There seems to be no difficulty in igniting the powdered fuel, and while it is convenient to retain the ordinary grates upon which to start a wood fire, as a preliminary to the dust firing, they are not absolutely necessary and might be removed; but where they are retained in the boiler, the change back to grate firing may be easily and quickly accomplished, if for any reason it becomes necessary. As to reliability, one experimenter informs us that he has operated a stationary boiler with powdered fuel, continuously, day and night, for four months, without any difficulty.

If we look for the disadvantages of the system, two come to the front, and both appear possible to overcome. First, there is the cost of grinding the coal; but this may be safely figured at 25 cents per ton or less, although several early experiments were terminated on account of the expense of this part of the process. With one type of grinder now in use, one horse-power is said to be sufficient to grind 100 pounds of coal per hour. The fineness of grinding differs among the different systems, and ranges from 200 mesh to impalpable powder. Great difficulty was formerly found in grinding moist coal, but this has apparently been overcome. Second, after the completion of the combustion the ash is left floating in the gases, and it must be given time to settle, or it will pass out of the stack as an annoying product. Careful examination of this matter appears to indicate that with the usual flame-way supplied by the ordinary cylindrical, return-tube boiler, a sufficient distance is provided in which the dust will settle before going into the tubes. Probably the change of direction of the gases at the back end of the boiler contributes to this result, because in a boiler of this kind there appears to be no more accumulation of dust in the tubes than in a grate-fired boiler, and there appears to be no evidence of dust about the stack. It is believed that there need be no difficulty from the ash in this type of boiler; but what the experience with locomotive or marine firing may be is yet to be learned. It has been tried in both of these services, but thus far its complete success has not been demonstrated in either.

The fundamental principles for the successful use of powdered coal appear to be: (1) a combustion chamber maintained at a high temperature, which requires a fire-brick arch to prevent the flame from impinging at once against the heating surfaces; (2) the powdered fuel must be thoroughly mixed with the entering air, so that the air will surround the particles of coal, and the fuel must be delivered in an uninterrupted stream; and (3) the particles of fuel must be maintained suspended in the gases until they are completely burned, and this requires a somewhat long flame-way, because the flame must not be chilled.

When the coal is finely divided, and delivered uniformly mixed with air, a solid radiating flame is produced, which at first is full of particles of solid fuel in incandescence. These particles rapidly disappear, leaving the larger portion of the flame composed merely of burning gases. One has only to follow this flame, as the writer has done, by means of peep-holes arranged in the brick-work of an ordinary boiler setting, to be impressed with the completeness and ideal character of the combustion. The flame is that of gas, rather than oil. The fuel appears to be gasified in an intensely hot atmosphere containing the right proportion of the supporter of combustion.

Different systems handle the pulverization differently. The Germans prefer to powder the coal in one place and deliver it to the feeding machine in bags, while in this country the neater and safer process of pulverizing the coal as it is used is generally followed. A large amount of finely-powdered coal may or may not be dangerous in storage, but there appears to be a decided advantage in carrying the dust directly from the pulverizer into the furnace, because this admits of the most perfect aeration, and this is essential. The power for grinding is applied in various ways, either by belt driving from a small steam engine or by connecting a steam turbine directly to the grinder. The grinding is usually in two stages, the first bringing the coal to about the size of split peas, and the second completing the process. The fine grinding appears to be accomplished best by attrition in a cylinder filled with rapidly revolving vanes, from which cylinder a blower takes the dust into the furnace through a tuyere, which is filled with partitions parallel to the current for the sake of obtaining a uniform mixture, and for spreading and concentrating the delivery as desired.— *American Engineer and Railroad Journal.* (Quoted in the *Journal* of the American Society of Naval Engineers.)

[In reprinting the foregoing extract, we do not wish to be understood as either recommending or opposing the use of pulverized coal as fuel. The matter is still in a more or less experimental state. The data which have been obtained thus far, some of which are appended to the original article from which this extract is taken, look promising; but we are not yet prepared to make any definite statement concerning the practicability of using pulverized coal in this way.— *Editor* THE LOCOMOTIVE.]

Superheated Steam.

It often occurs that a mechanical improvement attracts more or less wide attention for a time and then falls into disuse, even to the point of being almost forgotten, because of some apparently insurmountable obstacle, to be taken up again at a later date when the conditions governing its use appear to be more favorable. This seems to be especially true with the subject of superheated steam, by which we mean the practice of raising steam, immediately after its generation in the boiler, to a temperature considerably in excess of the saturation point, without greatly increasing its pressure, for the purpose of working it in a steam engine in this condition.

Considerable attention was given to this subject as far back as the year 1850, when we find numerous reports of engine tests which show most remarkable gains, ranging from 30 to 40 per cent. of the work done with a given amount of superheated steam over that done by the same weight of steam at a temperature corresponding to its pressure. These early experiments seem to have been practically confined to marine practice, possibly because this was the most active field for developing the steam engine at that time; and some idea of the thoroughness of the investigation is obtained from the accounts of long voyages, covering several thousand miles, of which records were kept of the amount of coal burned when the engines were worked with superheated steam, and of corresponding voyages using steam without superheating.

In the first volume of his *Researches*, Chief Engineer Isherwood discusses this matter quite carefully and draws the general conclusion that, while great economy is doubtless to be obtained by using superheated steam in engines, the extra bulk and weight of the apparatus required to produce the superheat, and the liability of the same to destruction, but more especially the bad effects of superheated steam on the interior working parts of the cylinders and valves of the engines, chiefly due to the destruction of the lubricating oils before they have had a chance to perform their work, constituted real difficulties which rendered the use of superheated steam at that time undesirable. In spite of this carefully considered condemnation, and Isherwood's apparent attempt to dismiss the subject as being the wrong line to pursue in steam engine development, the question of superheating seems to have continued to attract wide attention. The saving in the coal pile was too great to be ignored, and engine constructors and owners were tempted by the reduction in operating expenses to take the risk of inefficient lubrication and the other attendant difficulties, and so much progress was evidently made that we find in Isherwood's second volume of *Experimental Researches*, issued only two years later, even more attention devoted to superheating than before, and with quite different conclusions. In fact, superheating is here distinctly recommended, and the statement is made that an average gain in work done of about 33 per cent. may be counted upon. He recommends the steam to be superheated not more than 135 degrees Fahr., and suggests 100 degrees as an average which it is safe to assume, because of the inability of the oil to stand a higher temperature without destruction.

The primitive form of the engine, the inefficient insulating covering, and the low pressure used at that time were conditions which undoubtedly lent themselves to making the use of superheated steam exceedingly advantageous, and the difficulties of lubrication, packing of stuffing boxes, etc., must have been found to be very great in order to cause this practice to be discontinued for so long a time, as it undoubtedly was. At the same time the compounding of steam cylinders, the introduction of condensers, the improvement in valve gear and general construction, the increase of steam pressures, and other radical improvements, were so rapidly brought into general use that the amount of work done per unit of steam was raised to a higher point than ever before, in spite of the drawbacks of moist steam.

As the superheater was lost sight of, the improvements which were being adopted in other directions were of such a nature as to diminish its importance. Let us examine these improvements to the steam engine. Have they in any way interfered with it as a user of superheated steam? On the contrary, we find the steam engine of the present day much more suited to the use of superheated steam than formerly. We now have mineral oils which will stand high temperatures without disintegration; we have stuffing boxes packed with metallic packing; we have cylinders and steam pipes covered with a much more efficient insulating material; we have the wearing surfaces of cylinders and pistons machined to a nicety, and the interior surfaces often highly polished; we have improved forms of balanced and steam-tight valves, and these with our present searching after every device to make the engine more economical seem to open a field for the superheater to an almost unlimited degree.

In Europe we find much encouragement in this belief. We Americans have characteristically developed the line following the path of least resistance, practically ignoring the question which had seemed to be set aside. Europeans, however, particularly on the continent, also true to their characteristics, seem to have been plodding along in the direction which they knew to be meritorious, gradually working out the problems, and slowly overcoming the obstacles, until we now find them in a state very much in advance of ourselves. In this matter great credit is due to that able Alsatian engineer, G. A. Hirn, and to his successor, Emil Schwoerer, and also to the German engineer, W. Schmidt, for keeping the subject alive. We find them with records of several thousand successful installations of large and small plants, and European engineers educated up to a point where no economical steam plant is seriously contemplated without including the superheater. Most of the records of these tests show a saving in steam and fuel ranging from 6 to over 20 per cent.

What is the reason for this increased efficiency of steam when superheated? Rankine discusses the question in his work on the steam engine.

1. We raise the temperature at which the steam receives its heat, and so increase its efficiency without producing a dangerous pressure. According to the law of efficiency of thermo-dynamic engines, the heat transformable into mechanical energy bears the same ratio to the whole heat received by the fluid that the range of temperatures bears to the absolute temperature at which the heat is received, as follows:

$$\frac{T_1 - T_2}{T_1 + 461}$$

The more heat supplied per unit of volume of steam to the engine, the more work can be obtained from the engine; and the increase of pressure having a practical limit, this extra heat is to be obtained by superheating the steam.

2. The diminished density of the steam employed to do the work lessens the back pressure, or, as it is commonly expressed, improves the vacuum.

3. The prevention of condensation during expansion without the use of steam jackets, and in a much more effective manner. This is the most important advantage to be attached to the use of superheated steam. Steam jackets are wasteful and inefficient when applying heat to the engine [?]. Inefficient, because the contact is only with the steam immediately adjacent to the walls of the cylinder, with probably little effect being derived by the steam in contact with the piston and in the interior of the cylinder out of reach of the radiation from the walls; wasteful, because of the full effect of heating the exhaust steam after it has done its work in the cylinder during the waning stages of expansion and throughout the exhausting stroke. This is particularly true of engines which have a pause at the end of the stroke, which pause always finds the cylinder full of steam which has completed its work in the cylinder and is ready to be exhausted. Ample evidence of the truth of this statement is found in the high ratio of water condensed in the jackets of direct acting pumping engines, to the amount of steam used in the cylinders.

The use of superheated steam is bound to have an important effect on the question of jacketing cylinders. If the superheating is sufficient to carry the steam through the engine to the point of final exhaust without reaching the saturation limit, there is evidently no use for steam jackets. This, however, necessitates the careful covering of the cylinder walls and steam passages, to prevent as much radiation as possible; and the logical development of this question would seem to be to abandon the low pressure jacket first, and follow by giving up the intermediate, and finally the high pressure jackets, and substitute for these ample intermediate reheaters, between the cylinders, so proportioned that each cylinder would exhaust its steam at a point just sufficiently above the temperature due to the pressure, to insure the absence of any condensation.

The use of perfectly dry steam, and the elimination of condensed water, would appear to be a very practical advantage of superheating. Water is a disturbing element in steam engines and pipes at all times. It increases the friction of the wearing surfaces, interferes with the lubrication, and chokes up the discharge; it produces unequal strains in the metal, due to different temperatures, and often gives leaks at joints which remain perfectly tight under dry steam. Dripping at stuffing boxes is also avoided in this way.

It has always been difficult to determine the actual amount of moisture which is contained in steam; some light is thrown on the subject by the use of superheated steam. For instance, at a working pressure of 125 pounds, 1 per cent. moisture would represent about 20 degrees of superheat. We find under the best conditions of properly proportioned steam pipes, and well covered, a loss of $\frac{1}{5}$ to $\frac{1}{3}$ of a degree Fahr. of superheat per foot of steam pipe. It would not be out of reason to assume that with the ordinary large and indifferently covered steam pipe the loss would reach even as much as 1 degree Fahr. for every foot of pipe; consequently a pipe 100 feet long might lose 100 degrees of superheat, corresponding to 5 per cent. of moisture in the steam, provided the steam was dry on leaving the boiler. Even assuming $\frac{1}{2}$ degree loss per foot, we should have a condensation of $2\frac{1}{2}$ per cent. in a steam pipe of this length.

As the friction for superheated steam is much less than for saturated steam in passing, there is not so much loss in ports and passages, and the size of the pipes may be considerably reduced. The tendency in this country has been to use steam pipes which are much too large. Good practice with superheated steam recommends that the velocity should not be less than 100 feet per second, in passing from the boiler to the engine. Of course, this means ample steam receivers in proximity to the engine, and a very good plan would be to have these receivers fitted with reheating tubes containing steam which is being circulated through the superheater, or else a portion of the hot furnace gases, diverted from their course for this purpose, and returning again to the boiler flue by means of an induced draft.

As to the present effect of superheated steam on lubricating oils and stuffing-box packings, it may be said that the present practice provides, and, in fact already demands, oil and packing which will easily withstand these conditions. Minerals oils have supplanted the old vegetable oils and animal fats which were formerly used with machinery, and metallic steam packings have been universally adopted. Both of these were necessitated by the temperatures due to the steam pressures in the vicinity of 150 pounds to the square inch, the use of which is now common; hence we already have the way thoroughly paved for the introduction of superheated steam.

We have mentioned European practice in this direction. There we find no prominent central station designed without providing for superheated steam; engine builders make guarantees contingent upon it giving an advantage averaging about 12 per cent. in pounds of steam per horse power, based upon the steam being superheated. The range of temperature has resolved itself into recommending the use of steam at between 500 and 600 degrees Fahr. Good practice abroad may be said to lie in the vicinity of 570 degrees. Experimenters have observed that steam expands more rapidly during the first 20 degrees of superheating than when further raised in temperature; consequently the first effects are proportionately more beneficial.

The method of constructing the superheater naturally presents the most important aspect of the situation, after deciding that the results are beneficial and desirable. Dismissing the subject of superheating by means of wire drawing, as being inefficient and impracticable, the methods resolve themselves into a system of tubes or pipes, through which the steam is passed after leaving the boiler on its way to the engine; these pipes being subjected to hot furnace gases, either in connection with the steam boiler itself, or in a separate setting having a fire of its own. In large plants it is usual and even more desirable to set the superheater by itself; and it is placed alongside of the boiler as a continuation of the battery, with fronts and setting similar to the boilers, and fired in the regular manner as the boilers. — Ernest H. Foster. (Quoted in *Steam Engineering*.)

The Locomotive.

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On the Strength of Brace Pins.

An esteemed correspondent has sent us a sketch of the brace fastening shown in Figs. 1 and 2, all the dimensions being marked upon it, except the diameter of the pin; and he has requested us to calculate the size of the pin, in order that the pin may be equally as strong as the body of the brace. It is stated that both pin and brace are to be of open hearth steel, and it is requested that failure by both shearing and bending

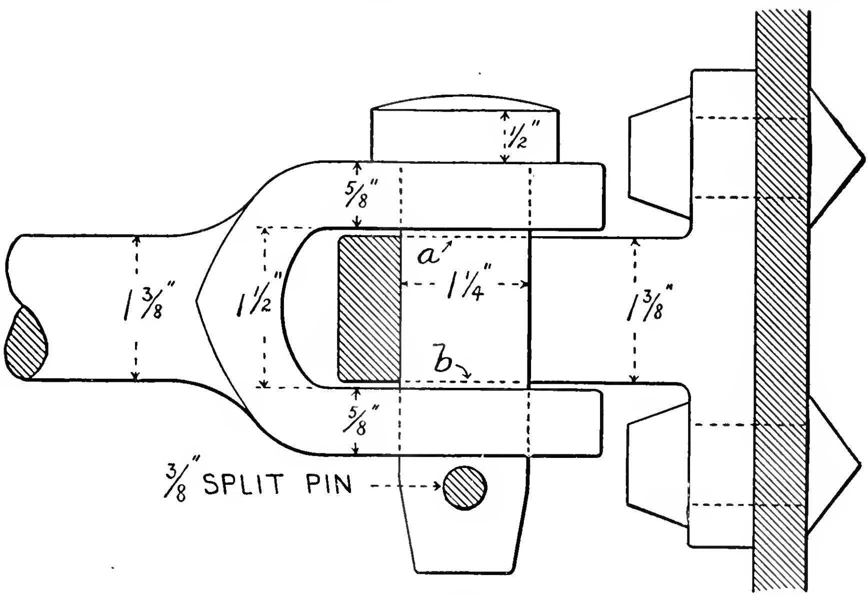


FIG. 1. — ILLUSTRATING THE JAWS, LUG, AND PIN.

be considered. We have thought that this problem might be of sufficient interest to be discussed in THE LOCOMOTIVE.

The way in which a brace pin gives out will depend upon the proportions of the pin, and of the parts which it unites. If the ear (or lug) that is attached to the boiler head is narrow, and the brace jaws are wide, so that there is considerable space between the two (as is indicated in Figs. 3 and 4), the pin may fail by bending; but if the lug and the jaws come close together, as in Fig. 1, failure can hardly take place by bending, but is usually due to the direct shear of the material of the pin. When the structure is so proportioned that the space between the lug and the jaws is intermediate between the limits here roughly suggested, failure may occur by a sort of compound shear and bend, such as is suggested by the form of Fig. 5, which is sketched from a pin which failed in this way, and which is now in the museum at the Home Office of the Hartford Steam Boiler Inspection and Insurance Company.

We will consider these different modes of failure separately, beginning with the simple shear of the pin, as this is the simplest to describe, and is, moreover, the way in which the pin may be expected to fail, if everything is properly proportioned and well made.

The pin in Fig. 1 cannot fail by shearing unless it gives way simultaneously at the

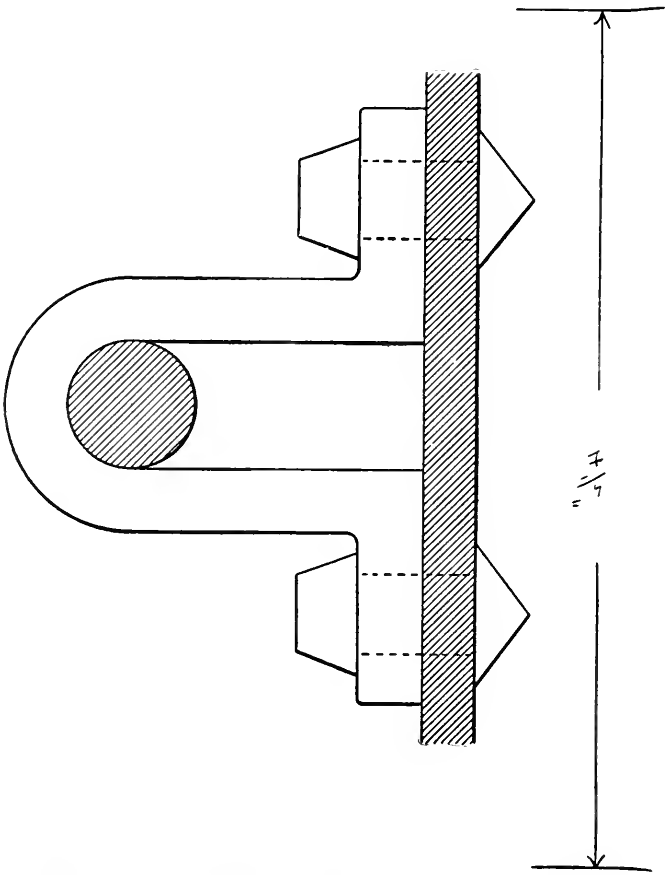
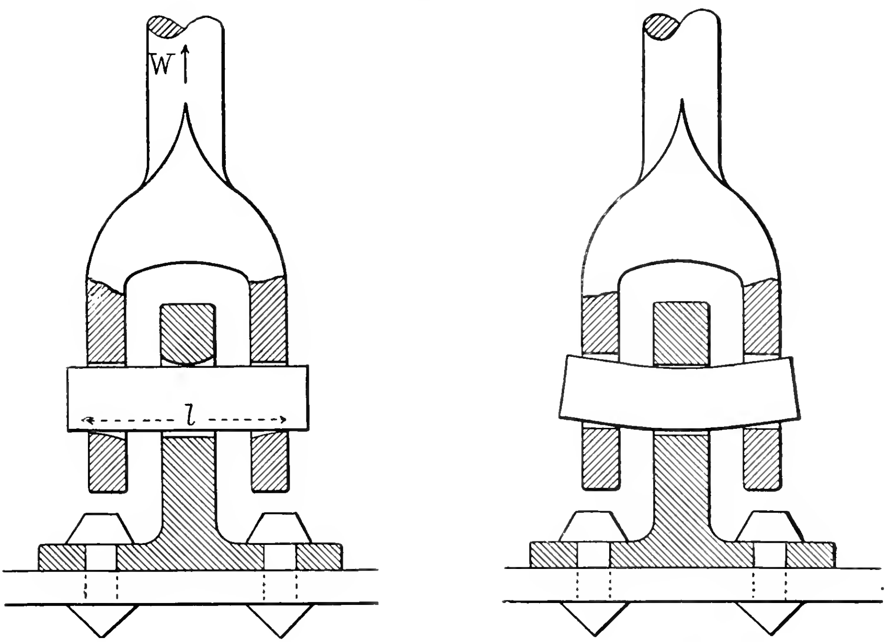


FIG. 2.—SIDE VIEW OF THE LUG SHOWN IN FIG. 1.

two sections that lie on either side of the lug, and between the lug and the jaws of the brace. (These sections are indicated in Fig. 1 by the letters *a* and *b*.) Now if the pin and the brace be made of practically the same material, we might safely take the shearing strength of the material of the pin to be equal to 85 per cent. of the tensile strength of the material of the body of the brace, if the pin were to shear at only *one* of the sections *a* and *b*. In other words, if the pin could fail by shearing at only *one* of the sections *a b*, we should have to give it a sectional area 1.18 times as great as the sectional area of the body of the brace. But, as we have already said, it cannot fail in this way, but must give out simultaneously at *both* of the sections named. If these sections were a considerable distance apart, we could consider the resistance of the pin to double shear (that is, to simultaneous shear in two different places) to be double its resistance to shear in one place only; and this would mean that it would suffice to make the sectional area of the pin 1.18÷2=0.59 times as great as the sectional area of the body of the brace. But it is known from experiment that the resistance of iron or steel to double shear is *not* twice as great as its resistance to single shear, when the sections across which the failure occurs are near enough together for the stresses in the vicinity of one of the sections to be felt to a considerable extent at the other one. This condition holds true in most of the brace pins that we find in stationary boilers; and it is found,



FIGS. 3 AND 4. — SHOWING POSSIBLE WAYS IN WHICH THE LOAD MAY BE THROWN ON THE PIN.

experimentally, that the resistance of a rivet or pin or bolt to double shear along two planes that are near together is only about 1.85 times as great as the resistance of the same pin or rivet or bolt to single shear. Hence, instead of dividing 1.18 by 2, we must divide it by 1.85; and upon doing so we find that it will be sufficient to allow 1.18÷1.85=0 64 sq. in. of sectional area to the pin, for every square inch of sectional area in the body of the brace. Now the diameters of two cylindrical bodies (like the pin and the brace body) are to each other as the square roots of the sectional areas of these bodies; and as the square root of 0.64 is 0.8, our final conclusion is, that a brace pin, arranged as shown in Fig. 1, will be strong enough *to resist shear alone*, if the diameter of the pin is not less than 0.8 of the diameter of the body of the brace. In the present case the body of the brace is $1\frac{3}{8}$ in. in diameter, or 1.375 in. Hence the diameter of the brace pin must not be less than 1.375×0.8=1.100 in., which is a trifle under $1\frac{1}{8}$ in.

Turning now to the possible failure of the pin by bending, we have to observe that the intensity of the bending stress on the pin (before the pin becomes deformed, at any rate,) will depend to a considerable extent upon how well the pin fits the lug and the brace-jaws, and upon what parts of the pin are in full contact with the brace-jaws and the lug. For example, it is possible that, owing to imperfect workmanship, the pin may bear as shown in Fig. 3, touching the lug only at its middle point, and touching the brace-jaws only at their outer edges. The bending stresses will be greater with the load falling upon the pin in this way than they would be with any other distribution of the load. We shall not go into the theory of the strains in a pin loaded like this, but it will be sufficient to say that they are determined by considering the pin as a beam, supported at both ends and loaded in the middle. If l is the length of the pin between the points shown in Fig. 3, and W is the total pull on the brace, and S is the tensile strength of the material of the pin, in pounds per square inch, and d is the diameter of a pin that would just be strained to the breaking point by the pull W on the body of the brace, then the theory of the beam shows that we have the relation

$$d = \sqrt[3]{\frac{8\ W l}{3.1416\ S}}$$

which gives d, when we know W, l, and S. If S stands for the safe working stress on the material of the pin, then the foregoing formula gives the diameter that the pin should have, in order to safely resist the bending stress that would be thrown upon it by the pull on the brace. It will be understood that this formula does not apply to a brace pin unless the pin is quite long, so that the distances between the points of application of the forces upon the pin are large in comparison with the diameter of the pin. In selecting the proper value for S to obtain the safe working diameter of the pin, we are confronted by the same difficulty that we meet with in calculating the strength of hooks. That is, if we assign to S a value, such as would be admissible for metal to be used in the shell of the boiler, we find that the foregoing formula gives a pin diameter that is materially larger than good practice has shown to be sufficient. For wrought-iron beams subjected to a dead load, we may safely take $S = 14{,}000$; and for a structure like a brace pin, which is very short in comparison with its thickness, we may take $S = 20{,}000$. With this latter value for S, the formula is easily reduced to

$$d = \frac{\sqrt[3]{W l}}{20},$$

where d and l are measured in inches, and W is the total load, in pounds, on the main body of the brace.

Referring now to Fig. 1, we see that if the workmanship of the structure there represented were imperfect, so that the lug and the fork bore upon the pin as represented in Fig. 3, then we should have $l = 2\frac{3}{4}$ inches. The diameter of the body of the brace being $1\frac{3}{8}$ inches, it is easily found that the safe working stress on this part of the brace is 11,140 pounds, allowing 7,500 pounds per square inch of section, which is all that is allowed, in conservative practice, even on braces made of open hearth steel. We have then to substitute this value for W in our formula, and we have

$$d = \frac{\sqrt[3]{11{,}140 \times 2\frac{3}{4}}}{20} = \frac{\sqrt[3]{30{,}635}}{20} = \frac{31.29}{20} = 1.56 \text{ in.}$$

When the workmanship on such a structure as is shown in Fig. 1 is good, our "bending formula" will give a pin diameter which is somewhat larger than good practice requires; because we have assumed, in deducing the formula, that the pin rests against the brace-jaws at the outer edges of the jaws. When the holes in the jaws are straight, however, and fair with the hole in the lug, there is a tendency on the part of the brace pin to yield a little, and take the form shown in Fig. 4; and this action will bring the bearing points of the jaws nearer together, and will, at the same time, tend to make the lug touch the pin at its two outer edges only. The load being thrown upon the pin in this new manner, it is not difficult to show that the bending stress on the pin is materially less than it is when the load falls upon it as shown in Fig. 3. These various uncertainties can hardly be avoided, in computing the strength of a brace pin; but if the pin diameter be calculated in accordance with the formula we have given, we shall certainly obtain a result that is large enough for safety. If the design and workmanship of the pin and its fastenings are good, some reduction in the diameter given by the bending formula may be allowed. *How much* reduction it will be safe to make, must be left to the judgment of the individual designer or inspector, who is familiar with the facts in each special case. But it will not do, under any circumstances, to allow the brace pin to be smaller in diameter than our previous rule for calculating its resistance to shearing would indicate. We may, therefore, say, that the way to compute the diameter of a brace pin is to find the diameter (1) on the supposition that the pin fails by shearing, and then (2) on the supposition that it fails by bending; and we must take for the diameter of the pin a value which is at least as great as the diameter indicated by the rule for finding its shearing resistance, but which may be somewhat smaller than the rule for finding its resistance to bending stresses would call for, provided the design and workmanship of the pin and its fastenings are satisfactory in all respects. In the special problem submitted for our consideration, and which is illustrated in Figs. 1 and 2, we should say that a pin $1\frac{1}{4}$ in. in diameter would be ample.

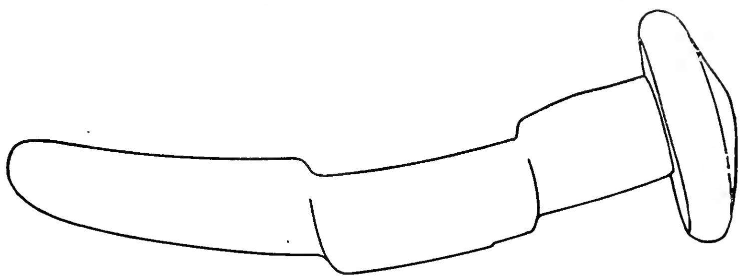


FIG. 5. — A BRACE PIN WHICH FAILED PARTLY BY SHEARING, AND PARTLY BY BENDING.

Boiler Explosions.

MAY, 1901.

(134.) — On April 29th a boiler exploded in C. L. Reaves' machine shop, at Muskogee, I. T. John Harlow was killed, and Charles Nasey was fatally injured. The explosion tore one end of the shop out, and the shock was felt all over the city. [Received too late for insertion in the regular April list. — EDITOR.]

(135.) — A boiler exploded, on May 1st, at Stanfordville, near Poughkeepsie, N. Y., in the saw-mill and blacksmith shop of George and Charles Beilke. Some signs of leakage had been noted, and the owners were examining the boiler when the explosion occurred. Charles Beilke was injured very seriously, but his brother George escaped with minor injuries only. The boiler went out through the roof of the building.

(136.)—A boiler exploded, on May 4th, in A. W. Dickerson's mill, at Bannister, some three miles east of Ashley, Mich. Fireman Moore was thrown about one hundred feet from the mill, and received injuries from which he may die. Frederick Fuller was terribly scalded and bruised about the head, and six other men were injured in a lesser degree. The mill was demolished.

(137.)—On May 6th a boiler exploded in the Czar Hart distillery, in Wharton township, Fayette county, Pa., near the West Virginia line. Ezra J. Thomas (the owner of the plant) and Frank Fearer were killed, Fearer's body being torn to pieces. Frank Thomas (a son of the owner) and William Dennis were badly injured. The four men who were killed and injured were the only ones about the plant at the time. The boiler house and the distillery and its contents were completely wrecked.

(138.)—On May 9th a slight boiler explosion occurred at the Edgar Thompson furnaces, at Braddock, Pa. Peter Noga, Andrew Jugan, and James Noone were seriously scalded, and several other men received lesser burns.

(139.)—A boiler exploded, on May 10th, in Solomon Raley's saw-mill, some three miles southeast of Arlington, near Stroud, Oklahoma. Oscar L. McAnally was killed, and Solomon Raley was seriously injured. Frank Raley also received minor injuries. The mill was demolished, and numerous trees in the vicinity were also torn down.

(140.)—On May 10th a boiler exploded in McDuffie & Wells' planing mill at Trio, S. C., about twenty-six miles from Georgetown, on the Georgetown & Western Railroad. R. L. Brunson and Thomas Scott were instantly killed, and Ellerbe McDuffie was fatally injured. Thomas Wells and two other men whose names we have not learned were also injured badly, but probably not fatally. (Mr. McDuffie died two days after the accident.) The property loss was about $5,000.

(141.)—The boiler of locomotive No. 16, of the Huntingdon & Broad Top Railroad, exploded, on May 10th, at Mount Dallas, near Huntingdon, Pa. Conductor Charles A. Hollingshead, Engineer A. S. Berkstresser, Fireman Stanton Edwards, and Brakeman Clinton Richey were instantly killed. The bodies of Conductor Hollingshead and Engineer Berkstresser were thrown 400 yards across a river. The entire fire-box and cab of the locomotive were carried away.

(142.)—On May 10th a boiler exploded at the Highland hoist of the Homestake Mining Company, at Lead, S. D. Engineer Edward Brelsford was almost instantly killed, and Mandy Klingler and John Cowlin were severely injured but will recover. Several other men were also more or less injured. The total loss to the Homestake Company, directly and indirectly, is estimated at from $200,000 to $300,000.

(143.)—A boiler exploded, on May 14th, on the tow-boat *Owensboro*, at Calhoun, Ky. Fire followed the explosion, and the boat was burned to the water's edge. Firemen Crenshaw and Brinkman, and two roustabouts whose names we have not learned, were killed. The property loss was about $6,000. The *Owensboro* belonged to the Green River Coal Transportation Company, of Evansville, Ind.

(144.)—A small boiler exploded, on May 13th, in Cross & Allen's chocolate factory at Philadelphia, Pa. William Pennell was badly injured, but it is said that he will recover.

(145.)—On May 14th a boiler exploded in Tedder Bros.' saw-mill, at Live Oak, some nine miles from Luraville, Fla. One man, whose name we do not know, was injured.

(146.)—The boiler of a Lehigh Valley locomotive exploded, on May 15th, at Bloomsbury, N. J. The locomotive was being used as a pusher at the time of the explosion. The front portion of the boiler was blown off, crushing the caboose of the train. Flagman George Hoodmacher and Brakeman John Meehan were fearfully scalded, so that Hoodmacher died a day or two later. W. A. Clemmer, fireman of the pusher, received minor injuries.

(147.)—On May 16th a boiler exploded, in J. H. McMillan's saw-mill, at Elizabeth Bay, near Little Current, Algoma, Ont. Frederick Eaton, Thomas Bowser, and Thomas Gaffney were killed.

(148.)—A slight boiler explosion occurred on May 16th, in the East Street School building, at Chicopee, Mass. Nobody was injured, and the damage was small.

(149.)—A flue failed, on May 17th, in the boiler of the Canajoharie Creamery, at Canajoharie, N. Y. Irene Maxim, a little girl who was standing near the boiler, was badly burned, and may not recover. Her father, Frank Maxim, was also slightly burned. No serious damage was done to property.

(150.)—A boiler exploded, on May 17th, in the Deadwyler-Byers saw-mills, at Thelma, Clinch county, Ga. We have not learned further particulars.

(151.)—A boiler used for heating water in the Palace barber shop at Plano, Texas. exploded on May 19th, doing considerable damage to the barber shop and to Hood's restaurant, adjoining it. Fortunately nobody was injured.

(152.)—A boiler exploded, on May 20th, in the plant of the I. A. Dye Lumber Company, at Janssen, Ark. Nobody was injured, but the building in which the boiler stood was wrecked, and the machinery was damaged.

(153.)—A boiler belonging to Mr. Teis Zimmer exploded at Emden, near Peoria, Ill., on May 21st. Nobody was injured.

(154.)—On May 21st a 48-inch boiler exploded in the basement of the Mandeville block, at Lodi, Wis. Nobody was injured. The boiler passed up through two floors.

(155.)—On May 21st a boiler exploded at the Edward Cain oil well, on Middle Island Creek, some seven miles from West Union, W. Va. Mr. L. R. Dingham was seriously injured, and may not recover.

(156.)—A boiler exploded, on May 22d, at Card & Prosser's Klondike coal mine, situated in the southwestern suburbs of Lisbon, Ohio. Jefferson Davis was scalded so badly that he died a day or two later. William Rigam, Hiley Lamborn, and Henry Lamborn were also severely injured, though it is believed that they will recover. One fragment of the boiler demolished one end of the brick boiler-house, while another passed through a similar brick wall and then destroyed a large section of a trestle that was used for cars that were being hauled from the mine.

(157.)—On May 24th a boiler exploded in Hector McCaskill's shingle mill at Big Oak, Moore county, N. C. Joel Cagle was instantly killed, and three other men were injured.

(158.)—On May 24th a flue failed in a boiler at the Union Stockyards, Chicago, Ill. John Allen and Philip Othoff were seriously scalded and burned.

The Locomotive.

HARTFORD, AUGUST 15, 1901.

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

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On Bodies Smaller than the Atoms.

For many years past we have been taught that all matter consists of molecules, which are exceedingly small, and yet not too small for us to be able to get some ideas about their actual diameters. We cannot pin a molecule down, and measure it with a micrometer caliper, it is true, but, nevertheless, we can get some general idea of its magnitude by methods that are known to those who have followed the development of modern physics.

We have also been taught that the molecules of substances are made up of still smaller particles called atoms; and, while the number of atoms in some of the more complicated organic substances may be large, we have been led to believe that the elementary bodies, such as copper, iron, lead, sulphur, iodine, and the like, are very simply constituted, their molecules each consisting of from two to six or eight or perhaps a dozen atoms. Some substances, such as mercury vapor, have even been thought (for good reasons) to be so simple in constitution that their molecules each contain but *one* atom — the words "atom" and "molecule" being synonymous in these cases. We have also been taught that the constituent atoms of the various elementary substances are essentially different from one another, so that there is no possibility of transmuting silver into platinum, nor quartz into diamonds; and we have furthermore been told that the "atoms" that have figured so prominently in the chemical and physical philosophies of the last century are the *smallest* bodies that exist in nature.

The atomic theory of Dalton, to which we have been referring, was promulgated and placed on what appeared to be a sure foundation, very early in the nineteenth century; and yet the twentieth century has hardly begun when Professor James J. Thomson, a man of undoubted learning and ability, announces that the molecules of all bodies consist, wholly or in part, of particles which he calls "corpuscles," which are so exceedingly small that no less than a thousand of them would be required to make a single atom of hydrogen. And the atom of hydrogen was previously supposed to be the smallest mass of matter in existence! More than this, he announces that the constituent "corpuscles" of all the elementary bodies are exactly alike, so far as he has been able to test the matter of their similarity.

This scientific bombshell was thrown in among us so recently that it is not yet possible to decide whether it is time to throw our previous notions overboard, or whether there may not be some other possible, but as yet unthought-of, explanation of the professor's experiments. The "corpuscular" theory is the outcome of the experiments that have been made on the "cathode rays," that are seen in X-ray vacuum tubes, such as were described in The Locomotive when the X-rays were first discovered. Physicists sought to discover the nature of the cathode rays, and after many experiments had been devised and tried with this object in view, it was concluded that the cathode rays consist of minute particles of matter flying about like tiny comets. Professor Thomson does not question this conclusion at all; but he believes that we cannot admit that the particles in question are either molecules or dissociated atoms, as was universally supposed until a few months ago. He devised and carried out some very ingenious experiments which indicated that the particles composing the cathode rays are either only one one-thousandth as big as hydrogen atoms, or else that they are charged with a thousand times as much electricity as we have heretofore supposed a hydrogen atom could hold. (This much of his theory is pretty soundly established.) He next proceeded to devise a method for distinguishing which of these two alternatives is correct. His method of discriminating between the two is not quite as convincing as the rest of his argument; but his conclusion is, as we have indicated, that we must admit the existence of particles only one one-thousandth as big as a hydrogen molecule.

If further experiments bear out Professor Thomson's conclusions, we shall certainly have to recast all our ideas of molecular physics; and no man can yet see where the new notions may lead us to.

If anyone should ask "what good" all this is, we can only answer that it certainly does not promise to make sheep fatter, nor to reduce the price of potatoes. But any enlightenment that we can get on the constitution of the universe is surely welcome, and the strict utilitarian will do well to remember that Faraday's apparently trifling and "useless" experiments with wires and magnets have now, half a century later, made the trolley-car possible.

Economy in Marine Engineering.

A lecture delivered before the students of Sibley College, Cornell University, by W. M. McFarland, upon the progress of economy in marine engineering, has recently been published in the *Sibley Journal of Engineering*, and as a number of interesting and valuable points in the history of steam engineering were brought out by the lecturer, we have made copious extracts from his remarks.

Starting with the *Clermont*, the first really successful steamer, and taking up in order the *Savannah*, *Great Eastern*, and other noted craft, the speaker said that it was impossible to obtain any reliable figures about the steam consumption of such early vessels. One book, printed in 1825, makes the statement that the coal per horse power at that period on steamers was ten pounds, but the method of computing the horse power is not stated, and, from the general method used in the book, it is doubtful if this figure is at all accurate. When we consider the conditions under which machinery was operated, however, ten pounds per horse power does not seem incredible. The steam pressure carried was very low, frequently not more than five to ten pounds above the atmosphere, the engines were very slow for driving the paddle wheels, the cylinders were unjacketed, and the steam was used almost entirely without expansion.

The first steam war vessel of our navy, the *Fulton*, built in 1837, had for her chief engineer Charles H. Haswell, the author of "Haswell's Pocket Book," and an extract from her steam log for a portion of January, 1838, shows that the maximum steam pressure was eleven pounds, the vacuum twenty-four inches, and the maximum revolutions per minute, eighteen.

As already stated, the early steamers were all driven by paddle wheels, and although a small launch was driven by a screw propeller as early as 1804, the propeller did not attract serious attention for driving until about 1840. The screw propeller naturally requires a much higher engine speed than the paddle wheel, but at first it was not considered practicable to drive the screw shaft from the engine direct, so that the higher speed necessary was secured by gearing. Even during the Civil War a great many of the vessels which took part used paddle wheels. Most of them built during that period were propellers, and this has been the practice in the Navy for ocean navigation ever since.

In reviewing the literature of the early days of steam navigation, after ocean steamers had become fairly well established, it is very interesting to note the evident aim at greater economy in the use of fuel, and there was no lack of suggestion of methods for accomplishing this result. It is surprising to note, however, that what to us nowadays seems the obvious way of determining the value of these methods, namely, actual experiment, seemed to have little chance. The authors do not seem to have been able to refer to any attempt to secure greater economy by higher pressures and increased expansion, although this was a favorite subject of discussion. It is only fair to remember, however, that metallurgical operations were by no means so well developed as in our day, and the workmanship on the machinery was also quite inferior. The difficulty of procuring thick boiler plates which would be thoroughly reliable offered an effectual bar to high steam pressures, and the inferior workmanship prevented high rotational speed, two features which, we now know very thoroughly, are necessary to give economy.

With reference to the question of expansion, not only the early writers but those as late as 1860 believed that the only limit to expansion was the practical consideration of not reducing the mean forward pressure so low that the back pressure would be too large a percentage of it, thereby requiring a very large engine. Most of them seem to have been entirely unaware of the effects of cylinder condensation in reducing the theoretical benefit to be derived from expansion. These older writers also seemed to have been familiar with the indicator mainly as an interesting scientific instrument, of which comparatively little use was made.

The first reliable data with respect to the cost of power that I have been able to find are given in a work which at one time had considerable vogue, called "Engineering Precedents," by Chief Engineer Isherwood, of the U. S. Navy, published in 1858. In 1863 we come to the first volume of his "Experimental Researches." These include records of the performance of a class of naval screw steamers built about 1854 to 1856. The *Merrimac* was one of them. These vessels were about four thousand six hundred tons displacement, three hundred feet long, fifty feet beam, and twenty-one feet draft. The engines were of about thirteen hundred horse power working with a steam pressure of thirteen and one-half pounds above the atmosphere, and making about forty-five revolutions per minute. A record of the maximum performance in smooth water showed a coal consumption of 4.37 pounds of coal per horse power hour. Under ordinary steaming conditions at sea, when a certain amount of heat was lost due to "blowing off" to reduce the density of the water in the boilers, as the condensers were of the jet variety and using anthracite coal with eighteen per cent. refuse, the coal consumption was six pounds per horse power hour.

This same work contains the record in extenso of the famous *Michigan* experiments, conducted by a board of naval engineers, of which Isherwood was president, on the economy of using steam with different degrees of expansion. The *Michigan* was built in 1854, so that the machinery was of an older type than that of the frigates just discussed. It is, however, very well designed for the period in which it was built, and it is in use to-day, the only change being in the boilers, which have been renewed twice in the fifty-seven years since the vessel was commissioned. The first renewal occurred in

1859 — about a year before the experiments — and the boilers then placed on board remained in use until 1892, or about thirty-three years. The steam pressure carried was about twenty pounds above the atmosphere, and the greatest economy was found to be when the steam was cut off at four-ninths of the stroke, which, allowing for clearance, meant an expansion ratio of about two. This was quite contrary to what the advocates of extreme expansion had claimed, for, according to calculation based on Boyle's law alone, the greatest degree of expansion should have given the highest economy. [On this point the theory of nearly all text-books on steam engines, up to within a few years, has gone wrong. As good an authority as Rankine neglected to take account of the effect of condensation in the engine cylinder. If the condensation be neglected, theory shows that the shorter the cut-off and the greater the expansion of the steam in an engine cylinder the more economical the engine. At present steam pressures, about one-third cut-off gives the best results with simple non-condensing engines, there being less condensation in the cylinder and consequent waste of steam when running under these conditions that when the cut-off is very early in the stroke. In the case of the *Michigan*, where the steam pressure was only twenty pounds per square inch, it was found, as stated above, that the most economical point of cut-off was at nearly half-stroke. The steam lost through condensation upon the cylinder walls when cutting off at this point was less than half the condensation when cutting off at about one-tenth stroke. — EDITOR.]

It would seem that the results of these experiments should have been absolutely convincing as to the limiting ratios of expansion with low steam pressures and slow-moving engines, but such was not the fact, and during the Civil War and thus right after the publication of the experiments there was a heated controversy on this question of expansion between Mr. Isherwood and a famous patent lawyer of New York named Dickerson. Mr. Isherwood was accused by Dickerson of willful waste of government funds by designing engines with very little expansion, and, indeed, after the war was over these charges were investigated by a Congressional committee, which, after taking testimony from many eminent engineers, found, in accordance with the facts, that Mr. Isherwood had been entirely right. However, during the war, Dickerson was given permission to put machinery of his own design on two vessels, *Pensacola* and *Algonquin*. The machinery of the *Pensacola* was an absolute failure, and had to be removed to make the vessel of any service. After the war was over a competitive trial was made of the *Algonquin* and a vessel called the *Winooski* with Isherwood's machinery. This resulted in a marked victory for the latter. The trial was conducted by civilian experts, whose report concluded: "In every point guaranteed by the contractor for the *Algonquin* machinery he has failed, and we are of the opinion that it is totally unfit for the naval service."

During the Civil War the depredations of Confederate privateers, notably the *Alabama*, had driven American merchantmen off the ocean, and towards the end of the war it was decided by the Navy Department to build a class of vessels which would be faster than any others afloat, either in naval or merchant service. The most famous of these vessels was the *Wampanoag*, whose machinery throughout was the design of Chief Engineer Isherwood, who also laid out the lines of the hull. This vessel was not completed until after the conclusion of the war, but in February, 1868, she was given a full power trial at sea from Sandy Hook to near Cape Hatteras. The performance was the most wonderful record for a steamer in the history of marine engineering up to that time, and in some ways it is still the most remarkable that has ever occurred. The average speed for the whole trip was 16.7 knots; for twenty-four consecutive hours 17 knots, and the maximum speed for any one hour 17.75 knots. This was a speed greater by at least four knots than that of any other vessel then afloat, and it is to be noted, moreover, that the performance was at sea in the winter and under rather adverse conditions. Indeed, the trial was terminated much earlier than had been intended on account of a severe gale. The steam pressure carried was thirty-two pounds above the atmosphere, and the coal consumption was 3.15 pounds per horse power hour. We should doubtless be not far wrong in assuming that the figures just given represent about the best economy in simple engines in regular performance at sea.

During the period when Mr. Isherwood was engineer-in-chief of the navy he conducted numerous experiments looking to increased economy, among which were some including superheated steam, and, although these promised an increase of economy, there were practical objections, on account of the speedy deterioration of the superheating apparatus, which prevented the adoption of this device.

During the '60's British marine engine builders had been developing the compound engine, and by the early '70's it had become universal; steam pressures had risen to sixty pounds and rotational speeds had increased. The engineer-in-chief who had succeeded Mr. Isherwood, Mr. J. W. King, after a visit to Europe in 1871, reported to the Navy Department on the general adoption of compound engines in merchant steamers, and also their experimental adoption in the British Navy, and he recommended that all new machinery for our naval vessels should be of the compound type. In a later report printed in 1877, after he had spent more than a year in Europe, he winds up a discussion of the compound engine by saying: "In the face of these facts, further discussion on the subject of adopting the compound engine for the vessels of our own navy is as useless as would be a discussion of the relative merits of the screw propeller and paddle-wheel for ships of war."

At that time about fifteen vessels in our own navy had been provided with compound engines, and these remarks of Mr. King were not for the purpose of stimulating engineers to progress, but to combat a most violent opposition on the part of many of the deck officers in the navy who feared that the high pressures used with the compound engine would lead to disastrous boiler explosions. As showing the intense opposition to increased steam pressure, an ordnance expert in the United States Navy said that the boilers filled with this high pressure steam were equivalent to a magazine containing so much gunpowder. At this time many naval officers still regarded the steam engine as a disagreeable necessity on board ship, and encouraged in every way the use of sail power when at sea.

The adoption of the compound engine was not nearly so rapid as that of the next great step in marine engineering progress, and there were many who fought hard for the retention of the simple engine. This was helped to a certain extent by the influence of such great names as that of Professor Rankine, who proved mathematically that as far as expansion itself was concerned there was no advantage in using two cylinders of different diameters instead of having the expansion occur in a single cylinder. I believe no one would now maintain this view, for we understand much more about the effects of condensation and of the desirability of limiting the range of temperature in a single cylinder. It is possibly true that with unusual care in design and by using superheated steam, steam jackets, etc., a single cylinder engine could be made to give as great economy as an ordinary compound engine, but, under exactly the same conditions of working, a compound engine would show a marked economy.

Some very interesting experiments were conducted by Messrs. Loring and Emery on some revenue cutter vessels which were alike in every respect except the engines;

one vessel was fitted with compound engines, another with high pressure condensing engines, and the third with low pressure condensing engines. The ratio of expansion in the compound engine was a little over 6, in the high pressure engine, 3.5, and in the low pressure about 3. The water per indicated horse power per hour was, for the compound engine, 18.38, high pressure engine, 23.9, and for the low pressure engine, 26.9. The steam pressure for the compound and high pressure tests was sixty-seven pounds, and for the low pressure thirty-two pounds.

What may be called the compound period in marine engineering extended up to about 1883, and during the twenty years that it lasted the efforts of many talented engineers were devoted to improvement, with the result that there was very decided progress. Even here, however, the lesson which it would seem Mr. Isherwood had taught in the *Michigan* experiments, that expansion cannot advantageously be carried beyond a moderate amount, had to be learned again. Many of the compound engines were fitted with ingenious adjustable cut-offs to enable the steam to be used with a very high degree of expansion. As steam pressures increased, the ratios of the cylinders became greater, and it was found that in most cases sufficient expansion could be obtained by the use of the link motion without any additional cut-offs. As a result in the later compound engines with steam pressures of one hundred and twenty pounds, and having a cylinder ratio of four and one-half, all independent cut-offs were abandoned. The splendid steamers of the Guion Line, which were the pioneers in fast trans-Atlantic service, and the later Cunarders, furnished fine examples of the best compound engines.

While steam jacketing had been used to some extent with simple engines, its use only became general after the compound engine had been well established. Experiments showed very clearly the decided gain in economy from the use of the jackets and they were also very beneficial in warming up for preventing sudden strains due to variation of temperature. Doubtless in many cases where there was not careful attention paid to draining, the full benefit to be derived from their use was not obtained; but when good automatic traps were fitted so that the jackets were really filled with steam and not with water, their action was very beneficial.

Reference was made earlier in the lecture to the loss from blowing off. This began in the days of jet condensers, because the condensation by direct mixture made the feed practically salt water. There was unfortunately a curious misunderstanding of the formation of boiler scale, so that even after condensing engines became universal, blowing off was still resorted to. When it was finally found that blowing off did not prevent the formation of scale, this practice was stopped and the density was allowed to become as great as five times that of ordinary sea water instead of about twice. In more recent days, since the invention of the evaporator, nothing but fresh water is fed into the boilers. I may remark that the evaporator is merely a small boiler using steam instead of heated gases for evaporating the salt water. As there must inevitably be a deposition of scale, the evaporator is so constructed that it has a nest of tubes which can readily be withdrawn and the scale removed from the tubes. As the loss by blowing off was often as high as ten per cent., it will be seen that there was a distinct gain in economy when this practice was abandoned.

The great increase of steam pressures and the improvement in materials led progressive engineers to see that the next step was along the same lines, and as the temperature ranges with the cylinders of the compound engine had become as great as they previously were in the simple engine, the next step was obviously expansion by three cylinders instead of two, which meant the triple expansion engine. The credit for this is due to Dr. A. C. Kirk, the engineering head of Napier & Sons in Glasgow. There was no such fight against the triple expansion engine as there had been against the compound, and in a very few years all new engines were of this type, with pressures at first of one hundred and fifty to one hundred and sixty pounds. With ordinary boilers of thoroughly good design, the coal expenditure in regular working at sea was probably about two pounds per horse power hour or slightly less.

The late Mr. Thomas Mudd, a very progressive engineer, who was the head of a works in England which built machinery for cargo vessels, developed a type of machinery of about eight hundred horse power which attained probably the greatest economy that any marine triple expansion engine reached. One of his vessels, the *Iona*, was given a very careful test by a committee of the Institute of Mechanical Engineers in Great Britain, where a horse power was obtained for about 15 pounds of steam and 1.46 pounds of coal per horse power hour. As will be seen, the steam consumption was very low, and the unusually low coal consumption was brought about by a remarkably economical boiler, which had a ratio of heating to grate surface of 75 and used assisted draft.

An extension of the multiple expansion principle has given us the quadruple expansion engine, where there are four separate expansions. A number of the very large trans-Atlantic steamers, including our own *St. Louis* and *St. Paul*, have engines of this kind, with two high pressure and two low pressure cylinders, and a single first and second intermediate cylinder. In view of previous experience the steam pressure, of course, was raised to about two hundred pounds.

Mr. Mudd, shortly before he died, built a five-cylinder quadruple expansion engine which secured a coal expenditure of about 1.2 pounds of coal per horse power hour. Since his death his firm have recently built machinery for a vessel called *Inchdune*, which has secured the phenomenal result of a horse power hour for .97 of a pound of coal. The engines are quadruple expansion with five cylinders, carrying a steam pressure of two hundred and sixty-seven pounds per square inch, and with the steam superheated to a temperature of about 500 degrees Fahrenheit. The cylinders are carefully jacketed and the feed water is also heated to a temperature of about 370 degrees before entering the boiler.— *Steam Engineering*.

The Causes of Yellow Fever and Cancer. — What can be accomplished by properly-directed medical research is proved by two advances of extraordinary importance made recently by American students. These are the discovery of the probable causes of yellow fever and of cancer. In the July issue of the *Popular Science Monthly* Surgeon-General Sternberg describes the experiments made under his direction by a board of army surgeons in Havana. In heroic self-sacrifice and triumphant achievement these experiments have surely an absorbing interest, surpassing any fiction. Although the yellow fever parasite has not been seen, its existence seems as certain as that of the malaria parasite. We now know that yellow fever is not directly contagious, but is transmitted by a special kind of mosquito, and, probably, only in this way. If we exterminate certain kinds of mosquitoes, or prevent them from biting those diseased, or from biting those who are well, two of the most dreadful diseases — yellow fever and malaria — will be exterminated. The cost in money and life of the Spanish-American War has been more than repaid to society by the services of the medical army officers. Science is often said to be cosmopolitan, but men of science owe allegiance to their country, and there is every reason to rejoice that it is also to an American that we owe the discovery of the probable cause of cancer. Dr. Harvey R. Gaylord, working in the New York State Pathological Laboratory, at Buffalo, has been able to cultivate the organisms that cause cancer, and to produce cancer by injecting them into healthy animals. These organisms are not bacteria or yeast cells, but protozoa. There has long been a difference of opinion as to whether cancer is due to alterations in nutrition or to a parasite. Now that the latter has been proved, cancer must be regarded as a preventable disease, and it remains to discover the method of its propagation. It must be remembered, of course, that Dr. Gaylord's discovery, like all others, rests on a long line of careful researches, carried on in many countries. There are innumerable names connected with the development of the germ theory of disease, but the forerunners of Gaylord, who especially deserve mention in connection with cancer, are Scheuerlin, Kubasoff, Russell, Sanfelice, and Plimmer. — *Popular Science Monthly.*

A correspondent of *Steam Engineering* tells a story of a city smoke inspector, who stopped at a certain steam plant in Boston, to see if the smoke ordinance was being violated. "He was invited to take a seat until the chief could go with him to the roof, and word was quietly passed around to fire heavily, and then not to fire again until further orders. This was done, and the inspector was conducted, in a leisurely fashion, to the roof. By the time they reached it, only a thin thread of smoke was coming from the chimney. Of course the inspector had to light one of the chief's cigars, and as the scenery was quite pretty and the air breezy and cool, he was too comfortable to be in a hurry about going down. The chief, of course, could not take the initiative. Suddenly a coal passer stuck his head through the hatchway, saying, 'The steam is going down like blazes, sor, and Mike wants to know can he fire up, now.' What the chief replied is not on record."

Laid Down His Life for His Friend.

William Phelps of Richmond, Kentucky, died a hero. His heroism was displayed without hope of reward, in the face of almost certain death and amid surroundings bereft of all the enthusiasm, the cheers of comrades and the excitement of battle that lead to great deeds when the flag is to the fore and an enemy is to be overcome. This man deliberately made way for a comrade when the two were imprisoned in a boiler into which steam had been accidentally turned. There was room for but one to escape and Phelps said, "You go first Jim, you are married." "Jim" went first and William died in horrible agony, but with a smile, and with the words "It was Jim's right to go first; he is married."

William Phelps was a negro. He was a laboring man, and presumably had not received greater advantages than thousands of his fellows in the South. He was strong and full of the love of life implanted in all of us. Opportunity came to him to go first and escape comparatively unhurt. Deliberately he chose the path of absolute self-sacrifice, and thousands who read his story will think of the text, "Greater love hath no man than this, that he lay down his life for his friend." When we read of bad negroes who are ostracised not only by the whites but by many of their own kind, who, maddened by drink or brutalized by despair, commit crimes against humanity that deserve and almost always receive condign punishment, let us hesitate before we impute instinctive brutality to the race, remembering rather that there is no man in current history who showed a whiter soul than did William Phelps of Richmond, Kentucky, when he said, "You go first, Jim." — *Unknown Contemporary.*

[The accident here referred to occurred some time ago in the Cerealine mills at Indianapolis, Ind. We are glad to print the foregoing tribute to the dead negro, and we regret that we are unable to identify the paper in which it first appeared, so as to give that paper fuller credit for it. — *Editor* The Locomotive.]

Between 1895 and 1900 the production of Portland cement increased from one to seven million barrels per year.

The Locomotive.

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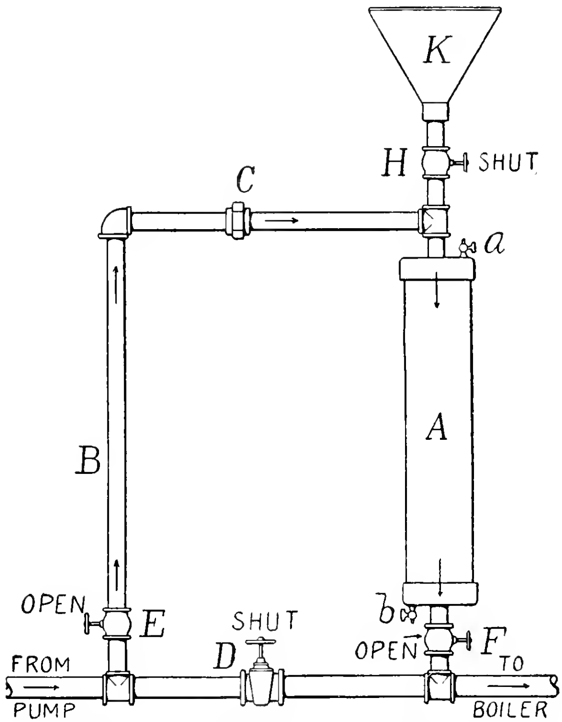
Introducing Solvents into Boilers.

We are often asked, by engineers and others, how to introduce scale solvents, such as soda ash, into a boiler. We took up this question at some length, in the issues of THE LOCOMOTIVE for July and August, 1888, when we showed two very convenient arrangements for pumping the dissolved solvent into the boiler, and also a method of



ARRANGEMENT OF PIPING FOR INTRODUCING SOLVENTS.

introducing it by means of an injector. These different methods ordinarily work very well in practice, but we have occasionally had complaints to the effect that the soda ash, when passed through the pump, eats out the packing thereof. We think this would hardly be likely to occur with a new packing, but with an old one, which had become impregnated with oil or grease, the soda ash might easily give some such trouble as has been reported.

To assist those who have had difficulties of this sort, we present, herewith, another plan for introducing the dissolved solvent, by means of which it is forced into the boiler without passing through the pump at all. The present arrangement calls for more piping than the ones previously shown, and its only advantage is, that it saves the pump.

Referring to the illustration, *A* is a section of big pipe,— say 6 inches in diameter and 30 inches long,— which is to serve as a reservoir. This connects with the feed pipe running from the pump to the boiler, by means of the pipes *B*, *C*, and *F*, which are so arranged that they connect with the feed pipe on opposite sides of the stop valve *D*. Over the reservoir is a funnel, *K*, by means of which the reservoir, *A*, can be filled through the valve *H*. The reservoir, *A*, is provided with pet-cocks, *a* and *b*, at the top and bottom, so that it may be readily filled and emptied. A union is provided at *C*, to facilitate the assembling of the piping. (A right-and-left elbow, of course, may be used instead, if it is preferred.)

The device is used as follows: The reservoir *A* being empty, valves *E* and *F*, and pet-cock *b*, are first closed, and valve *H* and pet-cock *a* are opened. The soda ash solution is then poured into *K*, until the reservoir *A* is filled. The valve *H* and the pet-cock *a* are then closed, as well as the valve *D*, in the main pipe. Valves *E* and *F* are then opened, and the pump is started. The device is then in the condition shown in the engraving, and the water from the pump passes around through *B*, *C*, and *A*, as shown by the arrows, sweeping the contents of *A* out into the boiler.

When the pump has been run long enough to thoroughly remove all soda ash from *A*, valve *D* may be opened, and valves *E* and *F* closed. The reservoir *A* is then emptied by opening pet-cock *b* and either pet-cock *a* or valve *H*, and the device is again ready for operation.

Boiler Explosions.

JUNE, 1901.

(159.)— On May 24th the boiler of locomotive No. 492, of the Santa Fé railroad, exploded near Paleman, Mo. Fireman John Hatfield received injuries from which he died shortly afterwards. Engineer Andrew Smith was only slightly injured. The train was running at full speed at the time, but the passengers were not injured, and would not have known of the accident except for the noise and the stopping of the train.

(160.) — A boiler exploded on May 26th, at the coal dock of the Union railroad, at Duquesne, Pa. Engineer John Turner and Fireman Jefferson Harris were painfully scalded, and four other men were struck by flying bricks.

(161.)— On May 27th a boiler exploded in the Cass City brick and tile works, at Cass City, Mich. Engineer Anglus Leach was scalded and otherwise hurt, and died within a few minutes. Perry Withey, George Warner, and H. Baxter were also injured.

(162.)— A boiler exploded at Boonville, Mo., on May 28th, on the Rocheport Ferry & Transfer Company's boat *Lurline*, plying between Boonville and Rocheport. Nobody was injured, but the boat was destroyed.

(163.)— On May 28th the boiler of a steam shovel exploded at the Waukesha Stone company's quarries, near Waukesha, Wis. Nobody but the night watchman was about at the time, and he, fortunately, was not near the boiler at the time, and so escaped injury. The explosion did considerable damage.

(164.) — A 48-inch boiler exploded on May 30th, in the Eureka Planing Mill, at Meridian, Miss. The roof of the boiler-house took fire, and the boiler exploded during the fire, just after the arrival of the fire department. Nobody was hurt, but the boiler-house was demolished, and fragments of the burning roof were thrown in all directions.

(165.) — The boiler of Frank S. Swartz's sawmill, at Caldwell, ten miles west of Waterville, Pa., exploded on May 31st. Engineer George Helms was killed, and Henry Kryder and Andrew Conway were injured. The mill was completely wrecked. [This explosion and the foregoing ones were unavoidably omitted from the regular list for May, which was printed in our issue for August.]

(166.) — On June 1st a boiler exploded at Ansted, W. Va., while used in drilling a well. Several small boys were standing near the boiler at the time, and Harry Furguson, Carl Doolittle, and Harry Pack were scalded so badly that they died within a few hours. Engineer Rife was also injured to some extent.

(167.) — The towboat *George S. Ross* was destroyed on June 1st, by the explosion of her boilers, at Tarentum, near Pittsburg, Pa. Captain George A. Kelly was killed, and Engineer Humphrey Mount, Wilson Beatty, Guy Wolf, and Charles Kelly (a nephew of Capt. Kelly) were seriously injured. The boilers of the *Ross* had been inspected only a short time before, and were believed to be in good condition. The upper part of the boat was completely ruined, and she will have to be entirely rebuilt if she is ever used again. The *Ross* belonged to the Pittsburg Plate Glass Company, and was valued at $50,000. One fragment of the wreckage partially destroyed the residence of Mr. Charles Selmer, 500 feet away from the scene of the explosion.

(168.) — An experimental boiler, built by Mr. William Weisel, of Ohio, Bureau county, Ill., exploded on June 3d. The building in which the boiler stood was considerably damaged, but fortunately nobody was injured.

(169.) — On June 5th the boiler of a locomotive exploded on the Nashville branch of the Atlantic Coast Line, near Rocky Mount, one mile below Nashville, N. C. Engineer Frederick Brown was instantly killed, and the fireman was fatally scalded. A switchman also received painful injuries. The boiler of the locomotive was thrown up an embankment, and the train was partially wrecked.

(170.) — A boiler exploded on June 6th, in the Standard Electric Power company's plant, at Dallas, Tex. Nobody was injured, but part of the city was thrown into darkness, and the entire trolley service was paralyzed.

(171.) — The boiler of a traction engine exploded on June 7th, in the warehouse of the Banting Machine & Supply company, Toledo, Ohio. Henry Langerman was injured so badly that he died a short time later. Engineer Charles Richfield was also badly hurt, and E. O. Rule was injured to a lesser extent. The explosion blew out the front of the building in which it occurred, and the property loss is estimated at $35,-000.

(172.) — On June 8th a hot water boiler exploded in the clubhouse on the Baseball club grounds, at Washington, D. C. John Harris was slightly injured.

(173.) — A slight boiler explosion occurred on June 8th, in Christopher Ifland's sawmill, at East Litchfield, Conn.

(174.) — On June 8th a boiler exploded in the electric light plant at West, Tex.

We have not learned full particulars, but as the plant was running again, two days later, the damage was probably small.

(175.) — A boiler is said to have exploded on June 10th, in the wrecking establishment of T. P. Whitelaw, San Francisco, Cal., during the course of a fire.

(176.) — A boiler exploded on June 11th, twenty miles southwest of Huntington, W. Va., at Inez, where the Triple State Natural Gas and Oil company was putting down a test well. Frank Walter was fatally scalded, and several other men were also injured to a lesser extent.

(177.) — On June 13th the boiler of Union Pacific locomotive No. 1,831 exploded between Clark's and Haden's, Neb. Fireman David R. Jenkins was killed instantly, and Engineer Charles Fulmer was injured so badly that he died before he could be removed to the caboose. Brakeman David R. Fleming was also seriously but not fatally injured. The locomotive was blown to atoms.

(178.) — A boiler exploded on June 13th, during the course of a fire in the Royal Match Factory, in Clifton township, near Passaic, N. J.

(179.) — A boiler exploded on June 13th, in the Big Dick mill at Joplin, Mo. The mill, which belonged to the International Zinc company, was completely wrecked. Debris was scattered for 200 yards in every direction, and the explosion was heard twenty miles away. Six men were in the boiler room at the time, but none of them was injured. Those who visited the ruins said that the escape of these men was astounding.

(180.) — On June 13th a boiler exploded in Strange & Harden's sawmill, about four miles west of Whitney, on the Alabama Great Southern railroad, near Asheville, Ala. Charles Harden was instantly killed, and the mill was demolished.

(181.) — On June 13th a boiler exploded in Baker & Few's sawmill, some five miles south of McEwen, Tenn. Johh Tripp, Oliver Priest, Albert Gunn, and a boy named Holland were injured, and the mill was totally wrecked.

(182.)— On June 13th a boiler exploded in the cotton factory at Halifax, N. S. The mill was considerably damaged, but as the explosion occurred during the noon hour, while the operatives were at dinner, nobody was injured.

(183.) — A boiler exploded on June 15th, in Philip Stadhem's cooper shop, Philadelphia, Pa. Engineer John Murgatroyd was fearfully burned and scalded, but at last accounts it was believed that he would recover. Some local Solon explains the explosion in the following rather novel fashion : "The excessive dampness in the air this morning, it is said, affected the draft in the boiler, and in consequence the fire flowed back, causing the steam tank to blow up." This is a brand-new one on us!

(184.) — A boiler exploded on June 17th, at the Colorado Fuel & Iron company's mine, at Starkville, near Trinidad, Col. Night Engineer William Pollard and Fireman Martinez Assamonti were killed, and Bernard Cervilli was scalded so badly that he will probably die.

(185.) — On June 19th a boiler exploded in the water works at Champaign, Ill. The explosion occurred shortly after five o'clock in the morning, and nobody was injured. The damage was small, being confined chiefly to the boiler. The roof of the boiler-house was raised several feet, but it fell back nicely into place again.

(186.)—A boiler exploded on June 20th, on the farm of Joshua Strange, nine miles east of Marion, Ind. Ernest Strange was fatally injured, and John Sherron was badly hurt, though he will recover.

(187.) — On June 20th the boiler of a big mogul freight engine on the Chicago & Alton railroad exploded at Blue Cut, some fifteen miles east of Kansas City, Mo. Engineer George Gerew was killed, and Fireman Willis Crowley was fatally injured. None of the passengers was injured. The tracks were torn up for a distance of 100 feet.

(188.) — On June 29th a boiler exploded in Simon Bartlett's sawmill, on George's Creek, ten miles from Louisa, Ky. Oscar Miller, who was running the mill, was badly scalded, and his two children, who were playing near the boiler, were scalded so badly that one of them died during the following night, and the other probably cannot live.

Inspector's Report.

April, 1901.

During this month our inspectors made 10,570 inspection trips, visited 20,105 boilers, inspected 8,756 both internally and externally, and subjected 959 to hydrostatic pressure. The whole number of defects reported reached 15,890, of which 1,063 were considered dangerous; 144 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,183	50
Cases of incrustation and scale,	3,136	74
Cases of internal grooving,	199	26
Cases of internal corrosion,	865	67
Cases of external corrosion,	760	49
Broken and loose braces and stays,	298	75
Settings defective,	393	32
Furnaces out of shape,	409	27
Fractured plates,	357	69
Burned plates,	375	40
Blistered plates,	137	4
Cases of defective riveting,	3,150	20
Defective heads,	87	20
Serious leakage around tube ends,	2,251	258
Serious leakage at seams,	395	32
Defective water-gauges,	227	42
Defective blow-offs,	207	57
Cases of deficiency of water,	88	14
Safety-valves overloaded,	81	35
Safety-valves defective in construction,	84	30
Pressure-gauges defective,	418	38
Boilers without pressure-gauges,	4	4
Unclassified defects,	786	0
Total,	15,890	1,063

The Locomotive.

HARTFORD, SEPTEMBER 15, 1901.

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

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IN our issue for October, 1899, we printed an article on the November meteors, which were expected by astronomers on the morning of November 16, 1899. When this particular shower passed us in 1833, there was an extraordinarily brilliant display in the heavens, and we quoted some of the things that were said about it by those who were fortunate enough to see it. Brilliant showers from the same family were seen in 1866, 1867, and 1868, and there was excellent reason to believe that on the date above referred to, there would be another display of comparable magnificence. Any of our readers who watched for them will remember that although there were a few stragglers coursing across the sky, they were hardly worth mentioning, and were very disappointing. Considerable discussion followed among astronomers, and it was concluded that Jupiter had probably swerved the shower out of the orbit it had followed for so many years, and that we might never again be treated to so glorious a display. But we should like to call attention once more to the uncertain character of these particular calculations, and to say that there is a *possibility* that the celestial storm has only been delayed, and that it may appear on the morning of the 14th, 15th, 16th, or 17th of the coming month of November. The most favorable time is from three o'clock, A. M., until sunrise.

Belleville versus Cylindrical Boilers.

Vice-Admiral Compton-Domville, the president of the committee appointed by the English Admiralty to investigate the efficiency and reliability of the Belleville boilers in comparison with the cylindrical boilers, has issued his report concerning the trial run that was undertaken from Portsmouth to Gibraltar and back by the two sister ships *Hyacinth* and *Minerva* at full speed. The former vessel is fitted with the Belleville boilers, while those of the latter are of the Scotch cylindrical type.

Representatives of the boiler committee embarked on board these two vessels at Devonport on July 6 last. Both vessels started from that port for Gibraltar at 3 o'clock in the afternoon of the same day and commenced working up to 7,000 horse power. It was intended that the ships should maintain 7,000 horse power till all the coal, except the 82 tons in the reserve bunkers, was exhausted. Three-quarters of an hour from the start the revolutions of the *Hyacinth* were 152 per minute and the horse power 6,994, and her trial started from this time. The *Minerva's* trial commenced a quarter of an hour later. The latter vessel soon showed that she was the faster ship, and steadily drew away from the *Hyacinth*. By midnight on the 7th she was about four and a half miles ahead.

It had been arranged that the water in the reserve tanks of both ships should be used as the only make-up feed-water until it was reduced to 20 tons, in order that the amount of make-up feed used per day might be accurately determined. When the reserve had been reduced to 20 tons, this water was to be kept intact in the tanks ready for use in case of emergency, and all make-up required was to be obtained from the evaporators. Special reserve tanks had been fitted on the *Hyacinth* to hold about 100 tons; this, added to the original tank stowage, gave a total reserve tank stowage of about 140 tons. The total reserve tank stowage on the *Minerva* was about 170 tons.

When the amount was reduced to 35 tons on the *Hyacinth*, the staff engineer asked to be allowed to start the evaporators, on account of the difficulty of getting the water out of the tanks by the special pump fitted for these trials. Two Weir's evaporators working with exhaust steam were started for the purpose.

At 1:15 A.M. on July 11, the staff engineer of the *Hyacinth* reported the engines would have to be eased on account of the large loss of water, and the trial was abandoned from 1 A.M. All the evaporators were working at this time, and in addition to the water from the reserve tanks, 25 tons of drinking water had been used for boiler make-up. The *Hyacinth* steamed into Gibraltar at slow speed, arriving there on the 11th, in the evening.

The *Minerva* continued steaming at 7,000 horse power till 11 P.M. on the 12th, at which time there were still 39 tons of coal in the bunkers, not including the reserve, and 20 tons of water remained in the reserve tanks.

The average horse power of the *Hyacinth* was 7,047 for 103¾ hours, with a coal consumption of 1.97 pounds, and the distance run was about 1,810 miles at an average speed of 17.6 knots. The *Minerva's* horse power was 7,007 for 147 hours, with a coal consumption of 2.06 pounds, and the distance run was about 2,640 miles at an average speed of 17.96 knots.

On the night of the 10th flaming occurred at the after funnel of the *Hyacinth*, but no such flaming occurred on the *Minerva*. When the boilers of the latter vessel were examined upon arrival at Gibraltar the openings in the Admiralty ferrules were seriously choked, the sizes of the openings in some cases being reduced to about one-third of the original.

The boilers and engines on both vessels worked well on the way out, with the exception of the breaking of the eccentric-strap bolt of the starboard intermediate engine of the *Minerva*, which delayed her for about two hours. A number of leaks developed in the *Hyacinth's* boilers, which became worse when the vessel was eased up when entering a fog, on which occasion the steam pressure became sufficiently high to lift the safety-valves. The loss of water was at first attributed to leaky feed-suction pipes, but during the stay at Gibraltar these pipes, the feed, and the hot well tanks, and the boilers and boiler blow-outs, were water-pressure tested, and no leaks, beyond those already known to exist in the boilers, were discovered. The leaky joints were remade by the ship's staff while at Gibraltar, and on the 16th the ship was taken out for a run at about 7,000 horse power, to test the amount of feed-water being lost. This was found to be at the rate of 55 tons a day, according to the record of the six hours' run. The boilers of both ships were thoroughly cleaned out at Gibraltar, so that the race home might be determined under the most advantageous conditions.

Both ships lay at anchor — the *Hyacinth* with two boilers alight for auxiliary purposes, and the *Minerva* with one alight. The homeward run was commenced at 4:27 by a previously unknown signal, on the 20th. Directly the signal was given the fires were lighted in the boilers not at work and the ships were headed for Portsmouth. Both ships started punctually at 4:30 — three minutes after the signal. The *Hyacinth's* engines were worked slowly in accordance with orders from the deck, steam being supplied by the two boilers which were alight. At 4:52 the after group of boilers was connected up; at 5:05 the forward group; and at 5:09 the middle group was connected up, the steam pressure being 22 pounds. At 5:20 — less than one hour from weighing anchor — the *Hyacinth* was proceeding at 150 revolutions per minute, the horse power being nearly 7,000.

When the *Minerva* set sail the boilers were also worked slowly. The second boiler was connected up at 4:55; the third at 5:02; the fourth at 5:07; the fifth and sixth at 5:10; the seventh at 5:12; the eighth at 5:15. The engines were working up to full power at 5:16, but had to be eased several times during the next three hours, owing to the eccentric straps warming up.

At 5:15 on the 18th the *Hyacinth* was about six miles ahead of the *Minerva*. Both ships, however, ran into a fog, and the *Minerva* caught up to the *Hyacinth*, and at 9:30 A.M., on emerging from the fog, the *Minerva* was still ahead. Both ships then worked up to the maximum, but throughout the day the *Minerva* gained one-third of a knot per hour on the *Hyacinth*. At 7 P.M. another fog was encountered, and the ships went slowly through the night, keeping close to each other.

At 9 A.M. on the 19th they were again level, but during the day the *Minerva* again gradually drew ahead, traveling a quarter of a knot per hour faster. At 7 P.M. the *Hyacinth* again eased, owing to a fog, and went slowly till 5 A.M., the *Minerva* being out of sight ahead. The *Hyacinth* then steamed at over 9,000 horse power till 6:10 on the 20th, when the fires of 10 boilers were drawn on account of a burst steam tube. At 9:50 P.M. the trial finished, the ship then being off St. Catherine's, and she arrived at Spithead at 11:30 P.M. The *Minerva* had anchored at Spithead 1 h. 45 m. previously. The coal consumed in the *Hyacinth* on the way home was 550 tons; on the *Minerva* it was 451 tons. The *Hyacinth* used her evaporators all the way; the *Minerva* utilized hers but very little.

The maximum power developed by the *Minerva* was 8,700 horse power, while that developed on the *Hyacinth* was nearly 10,000 for at least two hours, during which time the *Hyacinth* did not perceptibly gain upon the *Minerva*. The *Hyacinth's* average power while running clear of fog was about 9,400 horse power, and the *Minerva's* about 8,400 horse power. From the results of the outward run it appears that the radius of action of each of these vessels at 7,000 horse power, as far as the coal is concerned, should roughly be: *Hyacinth*, 2,930 miles; *Minerva* 3,000 miles. No difficulty was experienced in either ship during any part of either the outward or homeward runs to maintain a sufficient supply of coal to the fires.

Following the report of the president of the committee is one by Rear-Admiral W. H. Hay, Controller of the Navy, relating to the condition of the boilers after their unusual exertions. He draws the attention of the Admiralty to the following points in this trial.

(1) The very serious loss of water in the *Hyacinth*, as pointed out by the president of the committee. This was due to leaky joints. A certain number were located at Gibraltar, and on examination at Portsmouth other leaks were discovered and reported.

(2) The state of the *Minerva's* tubes at the end of each run. On arrival at Gibraltar the cup ferrules were discovered to be partially choked, and the ship could not have gone any further at that power (7,000). As it was, she was using up to 1.7 inches of air pressure, instead of ½ inch, to maintain the necessary combustion for this power. On arrival at Portsmouth practically the same thing occurred.

(3) The *Hyacinth* developed an average of 1,000 more indicated horse power than

the *Minerva* on the run home. This should have given the former a substantial increase in speed, whereas there was a slight decrease. This extra indicated horse power must have been absorbed either in the engines, or on the main shaft's bearings, or in the hull. It is possible that the shape of the hull may have had something to do in the matter, but former trials do not bear this out. For example, when the *Highflyer* (same class) was tried against the *Minerva* last year, the former maintained a higher power and speed, except at 10 knots, when she had to exert more indicated horse power to obtain the speed.

The Controller of the Navy, in his conclusion, significantly remarks that this last feature of the Belleville boilers requires investigation. Although these trials were not conducted under the most satisfactory conditions, yet they conclusively established the relative merits and disadvantages of the two types of boilers, and the cylindrical boiler has issued from the ordeal with the greatest success. It has been proved to be far more economical, in every respect, than the water-tube boiler. — *Scientific American.*

Shop Foremen.

Some years ago John Richards delivered a series of lectures before the students of Leland Stanford Junior University, at Palo Alto, California, his subject being, "Works Administration." These lectures contain much that is interesting and valuable to others besides students; in fact, much that can be made better use of by shopmen than by students. The following is what he had to say in one of these lectures on "Shop Foremen":

In the first lecture the ideal foreman was mentioned as a mythical person, and is so if he be expected to perform the duties commonly ascribed to this position; but at this day a good many of the duties once performed by a foreman have disappeared. The draftsmen have taken his place. I can remember very well when a foreman gave out all kinds of instructions for the work in the smaller machine shops in this country. The drawings, if any at all, for use in the machine shop consisted of general elevations in two planes, abundantly tinted in colors, but with no dimensions marked. These were supplied to the foreman, who laid out the work, and every little thing had to come under his notice.

He was responsible for the work, for the performance of the workmen, and for the proprietors also, because the supplies, discipline, and everything throughout were under his charge. He alone was responsible in an executive sense, and the man on whom all depended. He got the credit of success, and bore all the odium of mistakes and failures.

With detail drawings came new conditions. The foreman interpreted the drawings when they were obscure, but responsibility was shifted to the drafting room, and to specifications; but the foreman found still quite enough to do in other ways, and remained an authority for many things that cannot enter into drawings; but under the present system in machine works the general foreman's executive duties have gone over to a manager and special foreman, or leading workmen set over departments.

I think useful suggestions may arise out of some personal experience in respect to foremen. I had the misfortune to rise to this function at eighteen years of age; not over a great charge, but one of some responsibility, and from then on for twenty years or more I was associated with the methods of a general foreman, and could not help noticing various " hitches " that arose in that system.

Then occurred some experience in Europe, where the methods of organization were different, and not applicable, as I supposed, in this country; but in 1884, when a business founded in San Francisco had grown up to employ a hundred men, this matter of a foreman began to resolve itself into a problem of much difficulty.

The work made was machine tools, steam engines, hydraulic apparatus, and mill gearing or general work, it might be called, consisting of shafts, pulleys, special work and repairing; so there were four separate classes of work carried on, besides the shop departments of wood work, pattern making, and forging. Several foremen, all of them fairly competent men, were tried, but it was found beyond their powers to manage the different departments. A man conversant with steam engines did not understand hydraulic work, and one who could manage the hydraulic department could not deal with machine tools or steam machinery.

Finally the shop was divided up into sections under five workmen, selected from each branch of the work because of their skill, and these men were paid extra for acting as the heads of their departments, and being responsible. The shop machine tools were set off to these departments, as far as possible, and such tools as could not be segregated were operated first for one department and then for another, being for the time under the charge of the foreman in that division. The men were all young and ambitious, and for many years this went on without a clash, except on the first day, when one of the workmen came into the office to find out whom he was working for. He was informed that this could not be determined in the office, but his right to ascertain was fully conceded, and as there might be some difficulty under our system he was advised to go at once to some other shop where there was but one foreman. This was the first and last case of the kind. An arrangement of this sort exists in the case of contract work, or other systems of an analogous nature, both in this country and in Europe — indeed.

In a very large works there is commonly a staff, as at the Union Iron Works, in San Francisco. There is a manager over all, then a works superintendent of the fitting or machine department, a marine superintendent, a ship builder, a chief draftsman for the engineering department, and other chief draftsmen for the shipbuilding department, an electrician, and so on. The division of duties is not often the result of a concerted plan, but follows generally as a matter of evolution in each works, because the division of duties is very different in various kinds and branches of work. The general foreman of former times has disappeared.

The terms discipline and responsibility have been used several times, and in these the key to management in a large works of any kind is to be found. In a former lecture it was attempted to show that the efficient performance of duty depended upon responsibility, and the more the subject is investigated the more will this become apparent. The same rule applies to discipline, which is sometimes a very difficult matter to deal with in a works. I doubt if this can be made apparent by words alone, but it will become very tangible in the future, as you will find; because an aggregation of persons, all striving to better their condition and improve their skill and position, are necessarily in competition one with another. Jealousies arise, and to manage so as to maintain harmony among a body of workmen and the staff of a works where there are no defined rules of law to guide, sometimes surpasses human powers. This is an ethical study, and if we should pursue it we should be led far away from the subject under discussion; but to make it more clear, and to gain suggestions, I will go outside of the industrial field for some new illustrations.

About thirty years ago Doctor Holbrook established a normal school at Lebanon, Ohio, to prepare teachers for the schools of that state, and the Doctor, being quite a student of sociology, hit upon a happy expedient for avoiding the cares of discipline.

The students, who were mainly adults, were assembled at the beginning of each term and informed that the Doctor and his aids had quite enough to do in giving instruction, and that the school must govern itself. He recommended the adoption of formulated rules, so far as these would apply, the rules to be voted for or signed by the students. This has since been done at the beginning of each new term, and, so far as I know, the scheme has been a complete success.

The other extreme, that of authority in maintaining discipline, exists at sea, where a commander is clothed with absolute authority over the crew of his vessel. When he reaches a port, he is amenable to the laws of his country; but while at sea he is unrestrained in the exercise of any reasonable, or even unreasonable, function. By tradition, superstition, and necessity, the system is successful; but it is not one from which suggestions can be drawn for the management of a works.

One other example may be cited, showing that the natural tendency of people is towards order and discipline. In London there is a large number of places of amusement, called music halls, most of which are quite respectable, and all of which are extensive. The admission fee is small, and the risk of disorder is great, even in that city, where order is very rigidly enforced. It was discovered that the best way to maintain order in these public halls is to make the audience itself responsible. A chairman, representing the audience, sits in front of the stage, facing the people; he announces the plays, criticises the performance, and apparently controls everything on behalf of the audience, to which he appeals in case of a dispute. The theory of the scheme is correct; the teachers in the colleges and schools, or those who have to conduct a works, should not be taxed with the maintenance of discipline and order among their pupils or workmen.

In industrial establishments, rules relating to discipline should appeal to the self-respect and responsibility of those to whom the rules are directed. Posted notices of a paternal or arbitrary form commonly do no good, and frequently work a good deal of harm. When such posted rules are required, it is easy to put them in the form of an agreement or request, and to say that the owners or management deem such rules expedient for the welfare and interest of all concerned.

It must be remembered that at this day, in the higher class of skilled industries, workmen occupy a position quite different from that which they held in former times, and sometimes they outrank, whether measured by education or by a fair social standard, those who employ and manage them; but even if this were not the case there would still be much truth in the old French adage that "Courtesy costs nothing, and buys a great deal." — *American Machinist.*

Are the Atoms Real Things?

In his presidential address, delivered before the recent Glasgow meeting of the British Association for the Advancement of Science, Professor A. W. Rucker dwelt upon the interesting and important question as to whether our conceptions of the ultimate constitution of nature really correspond to the actual facts of the case, or whether we are to regard them merely as convenient images, that serve to assist our thoughts, while they perhaps do not correspond even remotely to the actual things that they stand for. His address, although it is interesting throughout, is far too long to be reproduced in its entirety in our pages; but we make a few extracts from it, which may serve to show its general tenor.

The three chief conceptions (he says) which for many years have dominated physical as distinct from biological science, have been the theories of the existence of atoms, of the mechanical nature of heat, and of the existence of the ether. Of late, doubts have arisen as to whether the atomic theory, with which the mechanical theory of heat is closely bound up, and the theory of the existence of an ether have not served their purpose, and whether the time has not come to reconsider them. The question at issue is whether the hypotheses which are at the base of the scientific theories now most generally accepted are to be regarded as accurate descriptions of the constitution of the universe around us, or merely as convenient fictions. *Convenient* fictions, be it observed; for even if they are fictions they are not useless. From the practical point of view it is a matter of secondary importance whether our theories and assumptions are correct or not, provided they guide us to results that are in accord with facts. A person who thought that a river was really a streak of blue paint might learn as much about its direction from a map as one who knew it as it is. It is thus conceivable that we might be able, not indeed to construct, but to imagine, something more than a mere map or diagram,—something which might even be called a working model,—of inanimate objects, which was nevertheless very unlike the realities of nature. Of course, the agreement between the action of the model and the behavior of the things it was designed to represent would probably be imperfect, unless the one were a facsimile of the other; but it is conceivable that the correlation of natural phenomena could be imitated, with a large measure of success, by means of an imaginary machine, which shared with a map or diagram the characteristic that it was in many ways unlike the things it represented, but might be compared to a model in that the behavior of the things represented could be predicted from that of the corresponding parts of the machine. We might even go a step further; for if the laws of the working of the model could be expressed by mathematical formulæ, then when the formulæ were obtained, the model might be discarded, on the ground that it was probably unlike the thing that it was made to imitate, and that its usefulness was gone when we had constructed our mathematical theory. By doing this, we should have abandoned the hope of a physical explanation of the properties of inanimate nature, but we should have secured a mathematical description of her operations.

But if this is to be the end of the study of nature, it is evident that the construction of the model is not an essential part of the process. The model is used merely as an aid to thinking; and if the relations of phenomena can be investigated without it, so much the better. The highest form of theory, it may be said, is that which has given up the attempt to form clear mental pictures of the constitution of matter, but which expresses the laws of nature by language which leads to results that are true, whatever be our view as to the real nature of the objects with which we deal. From this point of view the atomic theory (which corresponds to the model) becomes not so much false as unnecessary; and it may even be regarded as an attempt to give an unnatural precision to ideas which are, and must be, vague.

There are, indeed, numerous cases in which successful mathematical theories of physical and chemical phenomena have been established, without making any hypothesis about the existence of atoms. For example, a great school of chemists, building upon the thermodynamics of Willard Gibbs and the intuition of van Hoff, have shown with wonderful skill that, if a sufficient number of the data of experiment are assumed, it is possible, by the aid of thermodynamics, to trace the form of the relations between many physical and chemical phenomena, without the help of the atomic theory. But this method deals only with matter as our coarse senses know it; it does not pretend to penetrate beneath the surface. It is therefore with the greatest respect for its authors, and with a full recognition of the enormous power of the weapons employed, that I venture to assert that the exposition of such a system of tactics cannot be regarded as the last word of science in the struggle for the truth. Whether we grapple with them, or whether we shirk them; however much or however little we can accomplish without answering them, the questions still force themselves upon us: Is matter what it seems to be? Is interplanetary space full or empty? Can we argue back from the direct impressions of our senses to things which we cannot directly perceive; from the phenomena displayed by matter, to the constitution of matter itself?

When we consider the structure of matter in minute detail, there are those who cry halt at the point at which we divide it into molecules, and their first objection seems to be that molecules and atoms cannot be directly perceived,—cannot be seen or handled,—and are mere conceptions which have their uses, but cannot be regarded as realities.

It is easiest to reply to this objection by an illustration. The rings of Saturn appear to be continuous masses, separated by circular rifts. This is the phenomenon which is observed through a telescope. By no known means can we ever approach or handle the rings; yet everybody who understands the evidence now believes that they are not what they appear to be, but consist of minute moonlets, closely packed indeed, but separate from one another. For in the first place Maxwell proved mathematically that if one of the rings were a continuous solid or fluid mass it would be unstable, and would necessarily break into fragments. In the next place, if it were possible for the ring to revolve like a solid body, the inmost parts would move slowest; while a satellite, on the other hand, moves faster the nearer it is to a planet. Now spectroscopic observations show, not only that the inner portions of the ring move the more rapidly, but that the actual velocities of the outer and inner edges are in close accord with the theoretical philosophies of satellites at like distances from the planets. This and a hundred similar cases prove that it is possible to obtain convincing evidence of the constitution of bodies whose separate parts we cannot directly distinguish; and I take it that a physicist who believes in the reality of atoms thinks that he has as good reason for dividing an apparently continuous body into molecules as he has for dividing the apparently continuous Saturnian rings into satellites. If he is wrong, it is not the fact that molecules and satellites alike cannot be handled, and cannot be seen as individuals, that constitutes the difference between the two cases. It may be urged that the atoms and the ether are alleged to have properties different from those of matter in bulk, of which alone our senses take their ex-cognizance, and that therefore it is impossible to prove their existence by evidence of the same cogency as that which may prove the existence of a newly-discovered variety of matter or of a portion of matter too small or too distant to be seen. This is an important point, and yet it cannot be any great objection to the atomic theory that it claims that the atoms have properties different from those of masses of matter large enough to be directly perceived. If they are mere fragments of ordinary matter, they cannot be used as aids in explaining those qualities of matter which they themselves share. We cannot explain things by things themselves. If it be true that the properties of matter are the product of an underlying machinery, that machinery cannot itself have the properties which it produces, and must, to that extent at all events, differ from matter in bulk as it is directly presented to the senses.

The arguments upon which the simpler and more fundamental notions of the atomic theory are based, are very convincing. Matter in bulk appears to be continuous, and such substances as water or air appear to the ordinary observer to be perfectly uniform in all their properties and qualities, in all their parts; but the hasty conclusion that these bodies are really uniform is, nevertheless, unthinkable. In the first place, the phenomena of diffusion afford conclusive proof that matter when apparently quiescent is in fact in a state of internal commotion. Gases and many liquids, when placed in communication, interpenetrate or diffuse into each other; and air, in contact with a surface of water, gradually becomes laden with water vapor. Similar phenomena are exhibited even by metals at ordinary temperatures. Thus Sir W. Roberts-Austin found that if pieces of lead and gold are left in contact for four years at a temperature of 64° Fahr., appreciable quantities of the gold could be detected in the lead at a depth of more than a fifth of an inch. Again, no clear mental picture can be formed of the phenomena of heat, unless we suppose that heat is a mode of motion: and if heat be motion, there can be no doubt that it is the fundamental particles of matter which are moving. Combining, then, the phenomena of diffusion and heat, it is not too much to say that no hypotheses which make them intelligible have ever been framed, other than those which are at the basis of the atomic theory.

If it be granted that the evidence that matter is coarse-grained and is formed of separate atoms and molecules is too strong to be resisted, it may still be contended that we can know little or nothing of the sizes and properties of the molecules. It must be admitted that although the fundamental postulates are always the same, different aspects of the theory, which have not in all cases been successfully combined, have to be developed when it is applied to different problems; but in spite of this, there is little doubt that we do have some fairly accurate knowledge of molecular motions and magnitudes. The physicist, if he keeps to his business, asserts nothing more than that he who declines to admit that matter consists of separate moving parts must regard many of the simplest phenomena as irreconcilable and unintelligible, in spite of the fact that means of reconciling them are known to everybody:— in spite of the fact that the reconciling theory gives a general correlation of an enormous number of phenomena in every branch of science.

On these grounds the physicist may believe that, though he cannot handle or see them, the atoms and molecules are as real as the ice crystals in a cirrus cloud which he cannot reach; as real as the unseen members of a meteoric swarm whose death-glow is lost in the sunshine, or which sweeps past us, unentangled, in the night.

If the confidence that his methods are weapons with which he can fight his way to the truth were taken from the scientific explorer, the paralysis which overcomes those who believe that they are engaged in a hopeless task would fall upon him. "Science," said Helmholtz, "Science, whose very object it is to comprehend Nature, must start with the assumption that Nature is comprehensible." And again: "The first principle of the investigator of Nature is to assume that Nature is intelligible to us, since otherwise it would be foolish to attempt the investigation at all." These axioms do not assume that all the secrets of the universe will ultimately be laid bare, but that a search for them is hopeless if we undertake the quest with the conviction that it will be in vain.

A man peering into a darkened room, and describing what he thinks he sees, may be right as to the general outline of the objects he discerns, while wrong as to their nature and their precise forms. In his description fact and fancy may be blended, and it may be difficult to say where the one ends and the other begins; but even the fancies will not be worthless if they are based on a fragment of truth. He who saw "men as trees walking" had at least a perception of the fundamental fact that something was in motion around him.

And so, concludes Professor Rucker, at the beginning of the twentieth century we are not forced to abandon the claim that we have actually penetrated under the surface of nature, and yet we must admit, at the same time, that with all our searching we have not torn the veil of mystery from the world around us. It may be granted that we have not yet framed a consistent image, either of the nature of the atoms or of the ether in which they exist; but I have tried to show that in spite of the tentative nature of some of our theories, and in spite of many outstanding difficulties, the atomic theory unifies so many facts and simplifies so much that is complicated that we have a right to insist — at all events till an equally intelligible rival hypothesis is produced — that the main structure of our theory is true; that atoms are not merely helps to puzzled mathematicians, but physical realities.

Needed a Plumber.

From the middle-west a story has just blown in, concerning a well-known paper manufacturer, who is so genial and jolly that he tells it on himself. Some time ago he began to feel badly. Then he felt worse, and finally he reached that stage where, in reading patent medicine "ads," he imagined he had all the symptoms described in all of them. The next step was to go to a doctor, who advised him to go to Hot Springs for a month.

The patient followed the advice. When he arrived at the Springs, one evening, the hotels were so crowded that as a mere temporary arrangement he was given an eight by ten room, being promised better accommodations next day. He went to bed, but the heat was so intense that he could not sleep. The air was stifling, and perspiration rolled from all his pores, until, by the aid of a lively imagination, he worked himself into such a state of mind that he believed that he was nearing the point where it would be necessary to indicate what disposition his heirs should make of his belongings. At this point he sent for a physician, to whom he told his long tale of woe, laying particular stress on the fact that he was in a very desperate condition, one of the symptons being that he was drenched in perspiration.

The doctor listened and then said: "You don't need a doctor; you need a plumber, — to turn off the steam to that radiator at the head of your bed." It is recorded that "Larry" recovered. — *Paper Trade Journal.*

Telephoning to the Hospice. — Mr. John W. Gates, of the U. S. Steel Corporation, tells a story about a friend of his who went into the Alps last summer. He began the ascent to the hospice of St. Bernard, and when about an hour's climb from the pass he was stopped by a dense fog. He waited gleefully, expecting to be rescued by the dogs, and so be able to come back to us with a thrilling story. The dogs did not come, however, and presently the fog partly lifted, so that he could resume his climb. When he arrived at the hospice, where he was warmly welcomed by the brothers, his first question was, "Why did you not send out the dogs in so dangerous a fog?" He nearly dropped from his chair when one of the brothers replied that he had not telephoned them. "Telephoned you!" he ejaculated. "Yes," was the answer; "you see, shelters have been built all along the climb, and each shelter has been provided with a telephone. If a fog comes up, all one has to do is to go to the nearest shelter and telephone. We immediately send a man and dog to that shelter. The dog carries bread, cheese, and wine. As we know at just what shelter the climber is, no time is lost in looking for him." Mr. Gates says his friend was so disgusted at having his romantic notions knocked in the head that he left Switzerland at once.—*Electrical World.*

The Locomotive.

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A Pennsylvania Boiler Explosion.

A small boiler exploded, last month, at Erie, Pa., in a factory in which brass goods and plumbers' supplies were made. The results of the explosion, so far as property is concerned, are shown in the accompanying photo-engravings. In addition to the severe property damage, six persons were injured, and most or all would have been killed had

FIG. 1. — GENERAL VIEW OF THE RUINS.

it not been for the fact that the débris, in falling, formed "pockets" in which the injured persons were protected to a certain extent.

The wrecked buildings consisted of a three-story brass foundry, a three-story annex to the Liebel Hotel, a warehouse belonging to a hardware store, and the café of the hotel. All of these were totally demolished, and the damage to property will undoubtedly amount to about $30,000. The injured persons were all employés of the Liebel House.

The story of the explosion, as gathered from the employés, was as follows: The foreman, Mr. Hitchcock, states that he went into the fireroom about five o'clock P. M., and remarked to the fireman that he had plenty of water; it showed about 3 inches from the top of the glass. He states that he had the fireman open the cocks on the bottom of the glass and column, and they showed water. The factory shut down at six o'clock, and the fireman asserts that about five minutes before six he closed the draft doors, opened the fire doors, and covered the thin fire with fine coal. At six o'clock the pressure had been run down to about 60 pounds, the usual working pressure being from 75 to 85 pounds, and the safety-valve being set at 95 pounds. The fireman left a few minutes after six o'clock.

The night watchman went to work at about quarter of six, and at quarter past six, when the men had gone home, he went to the boiler room and found the water level in the glass about 3 inches from the top. He opened the cock under the glass and ran the water out, and it returned quickly to the normal level. The fire was banked so that no bright coals were showing, the ash-pit doors were closed and the fire doors opened. After this he went around to see if all the doors were locked. The explosion occurred at ten minutes of seven, at which time the watchman was in the machine room, on the first floor of the building.

It appears, from the testimony of these men, that there was plenty of water in the boiler, and that the explosion took place on a falling steam pressure; for, as has been said, the regular working pressure was 75 or 85 pounds, and the gauge showed only 60 pounds when the fireman left, after banking the fires. It does not appear reasonable to suppose that the pressure ran up, from any cause, during the short interval that elapsed between the departure of the fireman and the explosion, fifty minutes later. We are forced to believe, on the contrary, that some kind of weakness was developing, progressively, in the boiler, so that it was only a matter of time before the failure would take place, whether the pressure was maintained at the usual point, or reduced. This view was borne out by a subsequent examination of the torn sheets of the boiler, for it was found that a groove had developed along two of the longitudinal joints for a considerable distance, weakening one of them so much that rupture followed. A similar groove was found to extend along another longitudinal joint for a distance of 56 inches, although it had not cut deeply enough in this place to cause the plate to give way. The boiler was only 44 inches in diameter, and was so difficult of access that the grooving could hardly have been detected before the explosion took place.

Boiler Explosions.

JULY, 1901.

(189.) — On July 5th a boiler exploded in the creamery at Whigville, near Attica, Ind. The front of the building was blown out, and the principal portion of the boiler was thrown several rods into a creek. A small boy who was playing outside was struck by a fragment of wreckage and bruised. The employes were outside loading milk at the time, and so escaped injury. The creamery was operated by the Gibsonville Altruist community, which has its headquarters at Whigville.

(190.) — A boiler exploded on July 8th in the C. & C. laundry at New Albany, Ind.

Joseph M. Bosier, John Bosier, Edward Vasar, and John Holt were scalded. Vasar's condition is serious, but it is believed that he will recover.

(191.) — A boiler exploded on July 8th in Russell's creamery at Barker's Corners, about five miles north of Janesville, Wis. Nobody was injured, although the roof of the building was blown off and the machinery was badly damaged. William Boetchker, who operated the creamery, lived in a part of the building almost directly over the boiler room; but, fortunately, nobody was in his rooms at the time.

(192.) — A boiler exploded on July 10th in Spottsylvania county, Va., and Mrs. L. B. Mills was badly scalded. We have not learned further particulars.

Fig. 2. — Detail View of Ruins.

(193.) — A threshing machine boiler exploded on July 10th at Muse's Fork, Westmoreland county, Va. Engineer T. O. Atwell and fireman Ryland Sanford were seriously injured. Some of the fragments of the boiler were thrown 300 yards.

(194.) — Henry Altzatder was severely scalded on July 11th by the failure of a tube on a locomotive belonging to the Pennsylvania railroad, near Menlo Park, N. J.

(195.) — On July 11th a boiler exploded in the Catholic University at Georgetown, D. C. Fireman Frank Popp was severely burned over the entire body; and while his recovery is expected, at last reports he was still in a very critical condition.

(196.) — A boiler exploded on July 12th in the Sample Lumber Company's mill at Hollins, some fifty miles east of Birmingham, Ala. Fireman James Lane was killed, and

Supt. J. Laumer was seriously injured. The exploding boiler was blown through the roof of the building, and a considerable portion of the building itself fell in.

(197.) — A boiler exploded on July 13th on the steamer *Montour*, as she was getting up steam, at Sunbury, Pa., for an excursion on the Susquehanna river. Pilot George Frymire was killed and his body was blown into the river, from which it was recovered next day. A number of boys were fishing near by, and several serious casualties occurred among them. Allen K. Fetzer and his brother, Arthur M. Fetzer, were killed, and Charles Keller and Frank Keller were fatally injured. William Pullen, Harry Adams, and several others were also injured to a lesser extent. The *Montour* was a modern boat, and was elegantly fitted up. She was seriously damaged, but we have seen no estimate of the property loss.

(198.) — On July 17th a boiler exploded in Dunn & Holcomb's sawmill at Magee Run, Warren county, Pa., two miles up river from Tidioute. The mill was completely demolished, and fireman John Williams was badly scalded. The boiler was thrown fifteen rods, wrecking a log train and demolishing several cars.

(199.) — On July 20th a threshing machine boiler exploded on George McKinley's farm at Hunter, O. T. We did not learn of any personal injuries.

(200.) — A boiler exploded on July 20th in the elevator at Velma, near Taylorville, Ill. Matthias Tex and Eugene White were injured.

(201.) — A tube bursted on July 22d on the steamer *Julia*, in Jamaica Bay, near New York city. The four hundred passengers were badly frightened, but nobody was hurt. The *Julia*, which was disabled by the accident, was taken in tow by the *Sunshine*.

(202.) — On July 22d the torpedo boat *Stringham* went out from Newport, R. I., for a speed run over the measured mile course. When she was just outside the breakwater, a tube gave out in her after boiler, and the boat returned to the torpedo station. Six men were scalded by the accident. The cause of the trouble is not clear, as it is said that the pressure on the boiler was light, compared with the load for which it was designed.

(203.) — A boiler exploded on July 22d in Betzman & Kerth's creamery at London, near Cambridge, Wis. The building was considerably damaged.

(204.) — On July 22d a boiler exploded in Lyons, Swift & Co.'s lumber mill at Bon Secour, Baldwin county, Ala. Engineer S. S. Hatt was killed, and fireman Robert Hayden was injured. The property loss amounts to several thousand dollars.

(205.) — The boiler of a threshing machine exploded on July 22d on Clinton Boyd's farm, some three miles north of Ashland, Ohio. Jay Jackson, John Wertman, John Kissell, and George Beymer were severely injured.

(206.) — A boiler exploded on July 23d, near Abilene, Kans. Otto Krutze was scalded so badly that he is not expected to recover, and two other men were also burned, though not so seriously.

(207.) — Herbert Schiffer was fatally scalded on July 23d by the explosion of a threshing machine boiler at Ridgedale, Iowa. He died a few hours after the accident.

(208.) — On July 23d a boiler exploded at Arthur Robertson's oil wells at Tilsonburg, Ont. The boiler was thrown 100 feet, and three men who were working around it at the time had narrow escapes from instant death.

(209.) — On July 24th a traction engine boiler exploded at Clarksburg, near Chillicothe, Ohio. Albert Johnson was badly scalded.

(210.) — On July 25th a feed-pipe nipple failed on a boiler in the Poyet Manufacturing Co.'s confectionery establishment at Tenth avenue and Thirty-fifth street, New York city. The fires were thrown out into the room, and firemen Joseph Dooley and Charles Forsetti were fearfully burned. Both men were taken to Bellevue hospital, where Dooley died later in the day, and Forsetti died on the day following. There was a panic among the 400 girls and 100 men employed about the place, and some of the girls fainted; but none of them were injured.

(211.) — On July 26th a threshing machine boiler exploded at Anderson Valley, twenty miles southwest of Ukiah, Cal. William Rose was struck on the head by a heavy casting and instantly killed. David Leard was also injured so badly that he died a short time afterwards. Several others of the crew were injured to a lesser extent.

(212.) — A threshing machine boiler exploded on July 27th at Seger, fifteen miles south of Weatherford, O. T. John W. Peters, Alfred White, and Caleb Jones were killed, and Dr. Jewett and Augustus Fergeson were fatally injured. Arnold Douglass and John S. Troughton, Jr., were also injured, though to a lesser extent.

(213.) — Engineer Arthur Bigler was seriously scalded on July 27th by the explosion of a threshing machine boiler on Charles Chappelear's farm, seven miles southwest of Neoga, near Mattoon, Ill. Fire followed the explosion, and a great deal of property loss resulted.

(214.) — On July 28th a boiler exploded in the Winyah Lumber Company's plant at Georgetown, Ga. Three persons were killed, and seven others were injured. The plant was almost entirely wrecked.

(215.) — A boiler exploded on July 28th in the Robert Portner Brewing Company's plant at Alexandria, Va. Engineer Lewis Hart was badly burned about the arms and face, but will recover. It is said that the exploded boiler was carrying only 40 pounds of steam at the time of the accident. The property loss is said to have been about $5,000.

(216.) — On July 29th a boiler exploded in Simon Bartlett's sawmill on George's Creek, ten miles from Louisa, Ky. Oscar Miller was badly scalded, and his two children, who were playing near the boiler, were scalded so badly that one died during the night and the other can hardly recover.

(217.) — The boiler of a mine locomotive exploded on July 29th at the Pancoast colliery, on the Winton branch of the Lackawanna railroad, near Scranton, Pa. Engineer James Burnett was instantly killed, and fireman Cronk and brakeman Reuben Jones were badly scalded and cut. It is thought that Jones will die. The locomotive was totally wrecked. The boiler was lifted from the trucks and thrown thirty feet, and several cars that were attached to the locomotive were wrecked.

(218.) — Fire broke out on July 31st in the engine room at Zeller, McClelland & Co.'s mine, on the McBeth farm, near Brazil, Ind. While engineer Frank Bard was fighting the blaze, the boiler exploded with great force, demolishing the engine and boiler rooms, and the blacksmith shop, fifty feet away. Fortunately, Bard escaped injury. According to a subsequent report by Factory Inspector D. H. McAbee, there was likelihood of the fire involving the mine itself; and as there was nobody hurt, he considers that the explosion was fortunate, because it effectually extinguished the blaze.

The Locomotive.

HARTFORD, OCTOBER 15, 1901.

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

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

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IN our issue for August, under the heading "Laid down his Life for his Friend," we told what we supposed was a true story of the death of William Phelps, of Richmond, Ky. Phelps was a negro laborer, and he was inside a boiler with another man, when somebody accidentally turned steam in upon them from an adjacent boiler. The story went that Phelps could have made his escape, but that he voluntarily remained behind, so that his companion, who was married, could go first. The accident occurred in the Cerealine Mills, at Indianapolis, Ind., and we printed the account of it because we thought it was but just to the negro to spread the knowledge of his self-sacrifice. We are now credibly informed that while Phelps was indeed killed, the self-sacrifice part of the story is not true. Our informant adds that this feature "emanated from the brain of a sensational newspaper reporter." We are sorry to have to make this correction, but we do so in the interests of accuracy.

Early Hot Water Heating in Greenland.

When we investigate the early history of any invention, unless it is one which has been made possible only by recent discoveries, we are likely to unearth some surprising facts. One would hardly suppose, for example, that the heating of dwellings and churches by hot water originated in Greenland, yet such is the fact, if we may rely on the data given by a recent number of *Cassier's Magazine*, from which we quote below.

"An interesting example of the antiquity of the system of heating by means of hot water is cited by Mr. Frederick Tudor in a diminutive treatise on 'Heating for Health, or How to Heat a House,' which he prepared about ten years ago. Mr. Tudor tells that the announcement of the discovery of Greenland by Davis, in 1587, brought to light the fact that the territory had been discovered and colonized by the Norwegians, centuries before. The first European to land upon its shores was probably Leif, in the year 984, whose glowing accounts of its attractions led to the founding of a colony a year or two later. This flourished until, in the fourteenth century, it contained 190 villages, divided into twelve parishes with one bishop's see. Christianity had been introduced in the twelfth century, and a considerable intercourse was maintained with the mother country, Norway. The transfer of the latter to the crown of Denmark in 1387, its attachment to Sweden dating only from 1814, was the cause, probably, of neglect of the arctic colony, and eventually intercourse ceased altogether, and the country and its people were forgotten. Doubtless there were occasional winters of great severity, and the inhabitants, languishing under the attacks of disease superadded to their hardships, perished without being able to make known their distressing condition.

"Davis found no trace of any previous occupation of Greenland, nor in later years were the Eskimos able to give any definite information concerning them, although historians had discovered proof that Greenland had once been a flourishing colony, and were unremitting in their efforts to prevail upon the Danish government to make a search for the lost colony. It was not until 1723, however, that an expedition was undertaken with this object. It was in August of that year that Egede, in command of the expedition, and while seeking for traces of the lost colonists, came upon a group of remarkable ruins at a place called Kakortok, in southwest Greenland. This has since been identified as Alba, which is spoken of by the ancient German author Dithmar Blefken, who tells us that in 1516 he met a Dominican monk in Iceland, who told him about the state of Greenland, and besides, 'several other things about St. Thomas' cloister, particularly that there was a fountain of hot water which was conveyed by pipes into all their apartments, so that not only their sitting rooms but also their sleeping chambers were warmed by it, and that in the same water meat might be boiled as soon as in a pot over the fire.' This is also vouched for by Cæsar Longinus, in his 'Extracts of All Journeys and Voyages.' These old ruins, the earliest traces of Europeans in the Western hemisphere, were revisited as recently as 1888 by the artist Bradford, who also found the hot water spring, which is of volcanic origin. This Mr. Tudor considers to be the first authentic example of the use of hot water for warming dwellings, though it was probably only a clever adaptation by the builders of the monastery of a method of conveying heat which must have been previously known to them. Mr. Tudor himself says that it is not improbable that the men who could build those magnificent cathedrals without mortgages were both able to appreciate the merits of hot-water heating and to make efficient use of it by the aid of appropriate apparatus. As to the utilization, as described above, of the natural hot-water springs, it is not uninteresting to add here that piping such waters to houses has been practiced in more than one instance in recent years. In one old German town there is an installation of this kind going back beyond memory or record."

The Future Power Problem.

During the nineteenth century, for the first time in the history of the world, men have made extensive use of sources of energy other than their own bodies. The human animal began to differentiate himself from others by the acquisition of such accomplishments as throwing a stone or wielding a club, and after many centuries of evolution he at last reached a state not materially different from that in which a few tribes of savages are still found. Although immeasurably superior to other animals in the way in which he used his available energy, in common with them his supply was limited, during this long period, to that which his own muscles were capable of furnishing.

The inevitable domination of the strong over the weak must have set in at an early date, and the establishment, at that time, of human slavery, painful and unpleasant as it may have been to the slaves themselves, must nevertheless be regarded as a blessing to the race as a whole, because it enabled those who, by reason of physical, intellectual, or moral superiority, were masters, to direct a power vastly greater than that of their own bodies; and thus men, acting in obedience to authority, easily accomplished what man, individually, would hardly have ventured even to attempt. There are still in existence many evidences of the successful execution, at this early period, of engineering operations of great magnitude and importance, in which human muscle was the only available, or at least the principal, source of energy, and the practical ownership of this supply of power was necessary to the success of work by which the whole race was lifted a little out of the domain of brute force.

The utilization of the muscular power of other men must have suggested, at a very early time, the possibility of controlling and directing the more powerful muscles of the lower animals. No small amount of intelligence, skill, and cunning is necessary to the accomplishment of this end, and the training of the horse and ox for power purposes marked a distinct advance in the direction of modern civilization.

A horse will do the work of six or seven men; his food is coarser and cheaper than that required by man; his years of useful activity are fewer, but he reaches maturity sooner, and when once thoroughly "broken," he is more easily controlled and directed than a man. Owing to these qualities the horse, as a source of power, will long continue to be important, notwithstanding his relatively low efficiency when considered simply as a machine. Absolutely, the output of real "horse-power" is probably greater today than ever before, but relatively it has long been small, and is constantly and rapidly growing smaller.

At the beginning of the nineteenth century the work of the world was very largely, indeed, almost entirely, done by muscle, as it had been from the beginning of human industry. At the end of that century the contribution of human muscle to the total power supply is relatively very small. It is difficult to estimate its quantity, but it is certainly not more than ten per cent. of the whole, and is much more likely to be less than five per cent. The ease and accuracy with which muscular energy may be directed give it a value often many thousands of times greater than that of its equivalent in mere work, as measured by ordinary resistances overcome, and nothing can ever take its place, for it is the only energy immediately controlled by human intellect. "Made by hand" is usually and properly accepted as a certificate of superior excellence, for the most perfect machines are still inferior to human muscle directed by intelligence. Indeed, they must always be subordinate to that by which they are themselves created.

The shifting of a large share of the burden of work from the shoulders of men to the horse and the ox was a thing of prime importance, but, mechanically and economically, it is of much less moment than the introduction of the so-called physical forces into the workshop. For a long time, and until a comparatively recent period, the energy thus made available was either that due to gravitational attraction or to the motion of a mass of matter. The latter is exemplified in the work done by air in motion, or wind power, while water power is due to gravitational energy, although both forms ultimately involve heat.

As the first, and for a long time the only non-muscular sources of power, water and wind have played a most important part in the history of civilization. By the power of the wind geographical discovery and exploration became possible; nearly all parts of the world became known to Europeans, and much of it was colonized by them; both international commerce and international war were enormously facilitated; by an interchange of products, material and intellectual, increased production was encouraged; a wide dissemination of religions took place; and, indeed, it was only through the utilization of wind power that man got a lasting hold upon the inhabitable earth. It is hardly to be imagined that human muscle alone could ever have brought this about.

It is only as applied to the propelling of ships at sea that wind power has been, up to this time, of any special consequence. Its use in connection with stationary machinery is a thing of modern times, and its importance will be considered later, but the remarkable simplicity of the means necessary to its employment in driving ships makes it almost certain that this type of non-muscular energy was the earliest of which man availed himself.

The recognition and development of the power of falling water implies no small degree of engineering instinct and technical skill, yet it occurred in an antiquity so remote that we shall never be able to do honor to the first great hydraulic engineer, the inventor of the water-wheel. With the introduction of water power began, although at first in a very small way, the use of machinery as a substitute for manual skill. As long as the workman furnished all of the power demanded by his handicraft, the machinery he employed was limited, often to his own fingers and hands, supplemented by a few tools of the simplest kind.

Curiously, the word "manufacturing" literally means "making by hand," which is just what it does not mean in its modern acceptation, and in this modern sense manufacturing,—"making things by machinery,"—practically began with the introduction of water power, by which machinery could be run. Instead of pounding the corn or turning the millstone, men occupied themselves with the far more agreeable task of seeing that the mill was supplied with material; instead of making the wheels go round, they watched them go, and saw that they went properly. This was the first great step towards emancipation from the slavery of that unintelligent toil in which man differs from the beasts of the field only by being inferior to them.

Up to the beginning of the nineteenth century no other sources of power than these three,—muscle, air in motion, and water,—were extensively employed. The only opportunity for great expansion in the world's output of work was in the greater use of water and wind. But while the total energy embodied in these two elements was enormous, its utilization was subject to such serious limitations as to time, place, rate of supply, and others, that power development was slow, coming, when it came at all, as a result, and not as a cause, of the steady enlargement of human enterprise. Wind power was used only as a last resort where nothing else was available. Water power could be used only where it existed, and for this reason it sometimes directed the course of exploration and colonization; but agricultural resources and possibilities were always considered as vastly more important. For these reasons those arts and industries dependent upon the use of machinery or upon rapidity or cheapness of transportation made comparatively little progress during several centuries preceding the nineteenth, being, in the nature and quality of their products, not very different from what they were at the beginning of the sixteenth, and, indeed, a thousand years had brought no remarkable extension in their operations nor innovation in their methods.

The great revolution in industrial processes and operations which constitutes the glory of the nineteenth century began with the recognition of the value of heat energy and the possibility of transforming it into useful forms of power. More than a thousand years ago this transformation was attempted, with little real success, however, and with less understanding of the nature and meaning of the operation. It was only when this was revealed by the genius of Watt and Rumford that the new era actually set in. They, first of all, distinctly comprehended the interrelation of heat and mechanical energy,—their equivalence and capacity for transformation. They showed that any source of heat was a source of power, and the combustion of fuel began at once to supersede or supplement the use of muscle, water, or wind in the work of the world.

The new power possessed so many advantages over the old, especially in availability and constancy, that its development was rapid, even in the beginning. The limitations to the current supply of combustible material in the form of wood would soon have checked this development, but, happily, an enormous, apparently inexhaustible stock of fuel in the convenient form of coal was at hand, and with continued improvement in the construction and efficiency of the engine by means of which the transformation of heat into power is accomplished, the combustion of fuel and the transmutation of the heat produced into various forms of mechanical energy has gone on for a hundred years, increasing in magnitude at a rate which is almost bewildering, creating conditions of which few persons grasp the full significance, and affecting the whole human race in its relation to its environment more profoundly than any other event in its history.

The nature of the changes thus wrought is well known among intelligent persons, but their extent is so little appreciated that it will be useful to consider, briefly, that phase of the subject, and especially to endeavor to present it in such a way as to emphasize the purely power aspect of the question.

Everybody has a more or less correct idea of the enormous development of steam navigation and railway systems and of the cheapening of transportation brought about by it; of the phenomenal growth and widespread distribution of manufacturing establishments; of the generation and use of electricity as a convenient means of transmitting energy; and of many other things characteristic of the industrial revolution through which we are passing. It is instructive, however, to reduce it all to the daily combustion of a certain, rapidly increasing number of pounds of coal, for these may be easily converted into their muscle equivalent. And since by far the greater part of the coal output goes directly or indirectly into the production of power, no attempt will be made to separate from the whole that which is used purely for heating purposes, and indeed, the very general consideration of the subject to which this discussion must be restricted does not require such separation. Furthermore, for convenience in understanding numerical relations, it may be assumed that the combustion of one pound of coal under the favorable conditions of modern practice produces available energy equal to the work of one horse for one hour, and that a horse-power is equal to the power of seven men.

The total quantity of coal taken in any given year from the mines of the whole world cannot be very accurately ascertained, but from the best available information it may be assumed to have been about 700,000,000 tons of 2,000 pounds each for the year 1900, the last of the nineteenth century. Using the relations assumed above, it is found that this represents in energy the equivalent of 9,800,000,000,000 hours of work for one man, and allowing ten hours to each day and three hundred working days to the year, this is found to be equal to the work of 3,000 millions of men during one year. This is about double the entire population of the globe, and it follows that the utilization of the energy of combustion is equivalent to an increase of the working capacity of this population to the extent of an addition of two able-bodied men for every man, woman, and child; and practically it amounts to much more than this, for these imaginary additional 3,000 millions stalwart laborers make no demands upon the food products of the world; they need no clothing, no matter what the zone of their employment; and in faithfulness, loyalty, general docility, and ease of management they are beyond compare.

A very large share of the population of the earth still does not take advantage of non-muscular uses of power, and the transformation is confined to civilized nations. Its full significance can be better understood by studying its influence upon one of these, and especially upon the United States,— itself a creation of the nineteenth century. The output of the coal mines of the United States has increased with unparalleled rapidity during the past twenty-five years, and for the year 1900 it may be assumed to be about 250 millions of tons. Converting this into human labor, as above, it is found to be equivalent to the work of 1,200 millions of men for one year. This is about sixteen times the entire population of the country, and it means, therefore, that the energy thus put at disposal is equal to that of sixteen laborers for every inhabitant. Thus, in the average, every man, woman, and child has sixteen able-bodied slaves working for him ten hours a day and three hundred days in a year.

In a somewhat less degree the same is true of the whole English-speaking population of the globe. The mines of Great Britain and the United States furnish about three-quarters of the entire annual output of coal, and both nations jointly control three-quarters of the power of the world, for which reason alone they are easily the controlling factors in the disposition of its affairs.

Perhaps the most serious aspect of the power problem at present is the rapidly increasing annual draft upon available sources of supply. It may be said of the world's energy account that up to the beginning of the nineteenth century its expenditures were equal to its annual product; there was no surplus or deficit. With the new era, however, began the draft upon the enormous accumulations of a remote age, the current supply being no longer adequate. In the very nature of things this reserve of stored power is limited, and must, sooner or later, be exhausted. In the United States and Great Britain there has been a surprising increase in the quantity of coal taken from the mines during the past quarter of a century, and this increase has been much greater in the former country than in the latter, corresponding to its more rapidly developing industrial interests. In the United States the coal output of 1900 was very nearly seven times that of 1870; in Great Britain it has only about doubled in that time, and is now a little less than that of the United States. All other coal producing countries bear similar testimony to the wonderful increase in the use of power.

The amazing growth of steam power at sea is seen in contrasting such vessels as the Cunard liner *Britannia* of 1840, whose engines were then famous for their 750 horse-power, with the *Deutschland* of current type, whose energy capacity is nearly fifty times as great. Such a ship as this gives some idea of the full meaning of the use of heat energy instead of muscle; for if the 33,000 horse-power of its engines were converted into man-power, remembering that in continuous effort, like that assumed, men cannot work more than eight hours out of the twenty-four, about 700,000 men would be required to drive the vessel as it is now driven by coal combustion. The *Britannia* consumed nearly five pounds of coal for every horse-power-hour; the *Deutschland* consumes only one-third or one-fourth as much, but her power demands are so much greater that her coal consumption is, perhaps, fifteen times that of the earlier ship. Besides, there are many of her type, in 1900, for one *Britannia* in 1840. The transportation of goods by rail affords an illustration of the expanse of power consumption equally startling, and the same is true of manufacturing and other industrial operations.

Up to the present time, with comparatively insignificant exceptions, all of these drafts upon the energy reserve of the world have been cashed at one bank, and that is the coal bank. The combustion of fuel, in one form or another, has kept the wheels turning. Against a large and ever-growing demand for fuel there is a fixed and limited supply. How soon the accumulated stock will be exhausted (never again to be restored) it is impossible to say; but it is not likely that any very extensive supplies of coal, oil, or gas, not now known to exist, will ever be accessible. However this may be, the practical elimination of fuel as a source of energy in the not very distant future must be regarded as a certainty, and for some years thoughtful persons have been looking about for a possible substitute.

The introduction of new sources of power will come gradually, and no one can now tell by what agent or prime motor the work of the world will be done one hundred or two hundred years hence. Fortunately, it is easy to find stores of energy vastly greater in amount than that upon which the nineteenth century fed, and grew, and flourished. Their availability must determine their usefulness, and their development is already the subject of much experimental research.

The application of electricity to the transmission and to the storage of energy has quite altered the power problem, and it has been especially important in bringing about a revival of interest in those long known sources, — the earliest of the non-muscular, — water power and wind power. When it becomes possible to store energy cheaply and to hold it without loss, wind power will assume a high rank. The total quantity of it is enormous; in a sense it is "current supply," and not a draft upon a limited stock; it is more generally distributed than water power, compared to which it possesses many advantages.

Just now much attention is given to the development of water power, from which hitherto existing restrictions as to use in the immediate neighborhood of the waterfall have been removed in large measure by electric transmission. There is every reason to believe that in the near future economical transmission through hundreds of miles of wire will be possible, and in this way water power may shortly become, as, indeed, it already is in some degree, an active competitor of fuel.

But even if this be accomplished, it is tolerably certain that the total energy of falling water will be inadequate to the demands which must be met. The most famous water power of the world is Niagara Falls, over which about 18,000,000 cubic feet of water pass every minute, the equivalent horse-power being about 5,000,000. Remembering that this goes on day and night, it is easy to see that this is equal to about 80,000,000 of men working ten hours each day, a number greater than the entire population of the United States. Of course, it is very unlikely that any very large proportion of this power will ever be actually made available; at present about two per cent. of it is being used, but if it were all consumed it would be equal to only about one-twelfth of the present power supply from the coal mines of the United States alone. Almost invariably water power is subject to meteorological conditions to such an extent that it is, in a way, even more unsteady and unreliable than wind, and some system of storage, more perfect than any now in use, will be absolutely essential to the development of its highest efficiency.

It is almost certain, therefore, that it will be necessary to turn to storehouses of energy not hitherto made use of, or, if at all, only in a very limited and tentative way. One of the first of these to be thought of, because oftenest talked about and already tried in a small way, is the heat received directly from the sun. Many inventors have been sanguine of success along this line, but thus far little has been accomplished. The amount of radiant energy reaching the earth from the sun is enormously large, approximating a million times the present product of fuel combustion, and it may be expected to continue without sensible change for a practically indefinite period. But in availability it ranks very low, being especially affected by geographical localization and meteorological conditions. It is greatly diffused, and even with ideally perfect collectors only a very small part of the total amount could ever be converted into work. Under present conditions it is not worth considering as a possible source of power.

Much more promising is the great tidal movement of the ocean, a species of water power, although originating in a source very different from that of the ordinary waterfall. For hundreds of years occasional use of tidal power has been made, but with the prospect of the exhaustion of fuel supplies, the possibility of electric power transmission, and especially in view of the rapidly growing demand, its use in a large way must, before long, be seriously considered.

It is interesting to note that while the energy of ordinary water power is due ultimately to the heat of the sun, by which water is continually carried from a lower to a higher level, that of the tidal wave is dependent upon the rotation of the earth upon its axis. The earth may be regarded, mechanically, as a huge fly-wheel of enormous mass, its mean density being not materially less than that of iron, which, in some way or other, has been set spinning about its axis and is thus a storehouse of energy, the amount of which is practically inconceivable. The effect of drawing upon this supply would be to lessen the speed of rotation if there were no compensating influences; that is, to increase the length of the day. Of the immensity of this source of power it is almost impossible to form an adequate conception. If it could be tapped successfully it might be drawn upon indefinitely, and every demand might be satisfied without serious disturbance of the solar system.

Great, also, beyond our power of calculation, is the stored energy of the interior heat of the earth, and some not entirely unsuccessful attempts to utilize this have already been made. From a short distance below the surface the temperature increases downwards at an average rate which indicates that at a depth of fifty miles it is not less than 5,000° Fahr., and there is abundant reason for believing that the earth is an intensely hot body with only a thin layer of poorly conducting, cold surface matter. These are the essential conditions of a heat engine of enormous capacity, and as in many parts of the world comparatively high temperatures are found very near the surface, while in all parts considerable ranges are possible within reasonable differences of level, the interior heat of the earth is worthy of most serious consideration as a possible and reasonable source of power. Its importance will be greatly enhanced when we are able to transform heat energy directly into electricity on a large scale and with economy, avoiding the great waste which necessarily accompanies the use of the steam-engine; and this must soon come about.

The power by which, for the most part, the work of the world will be done during the next few centuries must come, it is believed, from one or more of the sources here considered. They are none of them fanciful; all are, even in the present state of science and art, within reach, and in capacity they are sufficient to satisfy any conceivable future demand. The abandonment of fuel as the chief source of energy is sure to come; its use is accompanied by many well recognized and harmful disadvantages, and it is not improbable that the time will come when men will look upon the era of coal much as we now look upon the Stone Age of our ancestors. — T. C. Mendenhall, in *Cassier's Magazine.*

A Venerable Engine. — The *Illustrated Guide*, published in connection with the exposition at Glasgow, Scotland, says that there is at the Farme colliery, Rutherglen, near Glasgow, situated about a quarter of a mile from Dalmarnock Bridge, and within ten minutes' walk of Rutherglen Station, an "atmospheric" or Newcomen engine, which has been at work drawing coal since it was erected in 1809. The cylinder was never bored and is open at the top, and the piston is packed from time to time with hemp, which, with a little water at the top, keeps it sufficiently tight, and it gets an occasional scrape to keep it in order. It takes about 35 seconds to lift coal from the bottom of the pit to the top. A man works the handle which admits steam to raise the piston, and, alternately, water to condense the steam under the piston, so that the weight of the atmosphere may press the piston down. With the exception of one or two spur wheels, which were broken by accident, no part of the engine has been renewed. It is the oldest engine at work in Scotland, and the only "atmospheric" engine now at work in Great Britain. The boiler used was not made for this engine, but for another one in the district about the same date. It is of the "haystack" type. The engine cylinder is $32\frac{1}{4}$ inches in diameter, and the stroke is 66 inches. The engine is run at about 27 revolutions per minute. An indicator card taken in June, 1901, shows a mean pressure of 7.35 pounds. About 27 horse power are developed.

The *Scientific American Supplement*, from which we quote the foregoing extract, is mistaken in its suggestion that the engine referred to is the oldest one in Scotland, or the only "atmospheric" engine now at work in Great Britain, although it was quite justified in taking the Glasgow *Illustrated Guide* as an authority in the matter. The following quotation from *The Engineer*, originally printed in 1898, gives particulars concerning an engine that is even older, and which, we are informed, is still running. "Probably one of the best examples of historical engines is the 'Earlston,' an old Newcomen pumping engine still occasionally worked at the Caprington colliery, two miles from Kilmarnock, near Glasgow. The history of this engine is uneventful. It was set up at Caprington in 1806, and has been used almost continuously ever since, at the same place, practically without any renewals or alterations. Some time ago it was proposed to remove it, but as it was found still serviceable, giving little trouble, and capable of useful work on an emergency, it was left in position. On one occasion, when the workings in the mine were flooded to a depth of 30 ft., it was set to work, night and day, and pumped out the water in six weeks.

"The engine, with the boiler beneath it, stands in an isolated house, with half of the beam projecting. It is single-acting, single-cylinder, and the piston is drawn down by the vacuum formed below it. The diameter of the cylinder is 30 in.; stroke, 5 ft. 3 in.; diameter of the pump, 9 in.; stroke, 5 ft. 3 in., or the same as that of the motor piston, as the beam is of equal length on both sides of the main bearings. The jack-head and service pumps are both $5\frac{7}{8}$ in. in diameter and 2 ft. $7\frac{1}{2}$ in. stroke. The lift of the main pump is 170 ft., and both engine and pump work at twelve strokes per minute. The steam pressure in the boiler is about $\frac{1}{2}$ lb. above atmosphere, and the vacuum in the cylinder, from diagrams recently taken, is $8\frac{1}{2}$ lbs. The engine indicates 9.65 horse power, and the pump 8.32 horse power. The only structural change made in the engine since it was first set up was the substitution, about fifty years ago, of a cast-iron beam with radius bar and parallel motion for the original old wooden beam with 'cradles' at the ends. The engine has, however, worn out several boilers since it was first started. The top of the cylinder is open, and to prevent the passing of air below the piston, a jet of water from the pump plays constantly above the piston. If too much water accumulates, it is led off through a hole and pipe, at a suitable level, to the hot well. The valve gear is of the type usual in these old Newcomen engines, with tappet rods worked from the beam, tappet levers and catches; one tappet arrangement is for the injection water, and another for the steam inlet. An indicator cock was fixed on the engine by Mr. Hugh Dunn, the manager, in October, 1897."

This engine is situated about 18 or 20 miles, in a straight line, from the one described above.

A CORRESPONDENT of *Marine Engineering* tells of an experience he had with an obstinate blow-off pipe, in the following words: "A number of years ago, while employed as assistant engineer on an old ship running fruit to New York, the following mishap occurred. The machinery of the ship consisted of an old single engine forty two inches square, with all pumps attached, and a boiler of the firebox return tubular type. As we had neither evaporator nor tanks, and our steam pressure was low, we used salt water. We had heavy weather all the trip, and were about off Hatteras, bound to New York. I had just gone on watch, and finding the density of the water in the boiler too great, started to blow off a little. On attempting to close the blow-cock, it stuck fast and could not be shut ; and as there was no valve on the ship's side, we were in a bad fix — a gale of wind blowing, the sea running high, the blow-cock wide open, and the water blowing out faster than it could be fed in. To stop the engine meant to fall off into the trough of the sea and be swamped, and it was only a question of time when she would stop herself, if that blow-off was not closed. Realizing the necessity of prompt action, I looked around and my eyes fell on the coal hammer and a heavy sledge. Calling the fireman to hold his hammer to one side of the blow-off pipe, which was copper, I took the sledge and began to flatten the pipe. Fortunately, the brazing held, and we succeeded in hammering the pipe out flat, thereby stopping the water. An old rivet was afterwards found wedged in the blow-cock, and preventing it from closing."

We do not pretend to know much about the perils of falling into the trough of the sea, although we have always heard it said that it is not a proper thing to do, if one can help it. But we do know something about the perils of hammering a blow-off pipe when the boiler to which it is attached is under pressure; and unless the trough was a pretty bad one, we think we had rather take chances with it than with the hammer.

Inspector's Report.

May, 1901.

During this month our inspectors made 11,717 inspection trips, visited 23,063 boilers, inspected 9,901 both internally and externally, and subjected 1,089 to hydrostatic pressure. The whole number of defects reported reached 16,925, of which 1,308 were considered dangerous ; 134 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,488	90
Cases of incrustation and scale,	3,773	105
Cases of internal grooving,	412	16
Cases of internal corrosion,	1,067	44
Cases of external corrosion,	763	59
Broken and loose braces and stays,	209	94
Settings defective,	553	66
Furnaces out of shape,	589	28
Fractured plates,	389	74
Burned plates,	419	49
Blistered plates,	140	3
Cases of defective riveting,	1,604	129
Defective heads,	84	11
Serious leakage around tube ends,	2,679	232
Serious leakage at seams,	522	28
Defective water-gauges,	289	71
Defective blow-offs,	238	70
Cases of deficiency of water,	60	11
Safety-valves overloaded,	146	54
Safety-valves defective in construction,	93	28
Pressure-gauges defective,	522	36
Boilers without pressure-gauges,	10	10
Unclassified defects,	876	0
Total,	16,925	1,308

The Locomotive.

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Our "Chamber of Horrors."

The Hartford Steam Boiler Inspection and Insurance Company, having been in the business of insuring boilers for the past thirty-five years, and being also the largest, by far, of all the companies in the world that give their attention solely to this particular class of work, has had abundant opportunity for the collection of specimens of all kinds,

The "Chamber of Horrors."

illustrating the ills to which boilers are prone. The way in which these opportunities have been improved may be inferred by an examination of the photo-engraving accompanying this article, which represents the Hartford Company's museum, at its home office in Hartford, Conn. We exhibited a collection of specimens of this sort at the Centennial Exposition in 1876, and have made similar exhibits at other expositions since that time, showing some of the strange and interesting things that are discovered by our inspectors. It would have been easy for us to accumulate a mass of such material sufficient to fill a good-sized building; but we have always had in mind the illustrative value of our specimens, rather than their number, and we consider that our present collection is of correspondingly greater interest and importance.

The room in which these treasures are stored might very properly be called a museum: but since many of the specimens in the collection illustrate errors of construction, and dangerous defects that developed during the ordinary operation of the boilers from which they were taken, we have formed the habit of referring to the room in question as our "chamber of horrors": and that is the reason we adopted the foregoing title for the present article. The melancholy aptness of this title is also emphasized by the fact that not a few of the specimens in the collection are from boilers that have exploded and caused great loss of life and property. The two large pieces of plate that are seen in the engraving leaning against the right-hand side of the double glass door, for example, possess a peculiarly sad interest to us, because the boiler from which they were taken exploded and killed one of our inspectors who was present in the plant at the time, to make an external inspection of this very boiler.

The collection comprises almost every kind of defect that can be represented by means of specimens that are small enough to be stored conveniently in a museum of this sort. We have, for example, a striking collection of feed pipes and blow-off pipes, showing the ways in which these deteriorate in service. We have blow pipes that are filled with deposit until they were badly burned by the hot furnace gases, and we have feed pipes that have also been filled by deposit until it would be impossible to force any considerable quantity of water through them, under any pressure whatever. We have many specimens of brass blow-off pipes, too, that are burned and burst. There are also in the collection numerous sections from shell plates, showing beautiful bulges and blisters; some fine specimens of plates that have been corroded, in use, to an almost incredible degree; many tubes that have been pitted or corroded or otherwise damaged, until unfit for use; some excellent examples of burst water tubes from sectional boilers, and of similar tubes filled with scale matter so as to be useless and dangerous; and fittings that have been broken by water-hammer action in undrained steam pipes. It would be impossible to enumerate all the different kinds of defects that are illustrated by the collection, but it may be said that there is hardly any kind of trouble that can arise in connection with boilers that is not represented, in some manner, by one or more of the specimens that may be seen in this "chamber of horrors."

The fragments of plates and tubes and other constructive elements that have been referred to above do not by any means exhaust our exhibit, for we have also a fine collection of samples of deposit and sediment of all kinds. These include scale in which the predominant substances are sulphate of lime, carbonate of lime, magnesia, salt, and other minerals that are introduced into the boiler in the dissolved state, and also huge aggregates or conglomerates that were formed by the consolidation of loose flakes of one sort and another, and are now cemented together into one solid mass. Some of these conglomerate scales are so amazingly solid and massive that it is hard to believe that a boiler could run for five minutes with such deposits within it. Those who have not given special attention to this subject would be surprised at the great variety of forms exhibited by specimens of boiler scale, even when the chemical composition of the samples compared is substantially the same. Some of the specimens in our museum are solid and stony, and hard enough to take a good polish, while others, of nearly the same chemical nature, have fantastic forms, reminding one of coral growths, with hollow spaces in the interior. Chemists know that the form in which a precipitate is thrown down in the laboratory is often strongly influenced by conditions that are apparently trifling, and which may even elude observation altogether. It is undoubtedly the same way with different forms of boiler scale that have nearly the same composition. The precise shape in which they are thrown down appears to depend largely upon conditions that can often be hardly guessed at.

In addition to the specimens that have given our "chamber of horrors" its distinctive name, we have, also, a considerable number of exhibits illustrative of the quality of materials. Some of these are test pieces that have served for the determination of the tensile or shearing strength of the materials that they represent, or for the experimental verification of the calculated efficiency of some new form of riveted joint. Others serve to illustrate the capacity of materials of various kinds to pass severe tests of one sort and another. Thus we have specimens of boiler plate that have been bent back flat upon themselves and hammered, to show that the particular brands of steel or iron from which they are made will pass such a test successfully; and we have tubes that have been belled, flanged, flattened, or crushed endwise, to show the resisting power of the material of which they are composed; and we have rivets and other structural materials that have been subjected to tests of similar severity, for a like purpose.

Many of the specimens of defective boiler parts that have been illustrated in The Locomotive in the past are now lodged in this "chamber of horrors," where they may be seen by anyone who is interested; for the "chamber" is open to the inspection of visitors to our office at any time.

Inspector's Report.

June, 1901.

During this month our inspectors made 11,320 inspection trips, visited 21,037 boilers, inspected 9,729 both internally and externally, and subjected 1,159 to hydrostatic pressure. The whole number of defects reported reached 15,804, of which 985 were considered dangerous; 78 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment.	1,270	47
Cases of incrustation and scale,	3,191	55
Cases of internal grooving,	232	8
Cases of internal corrosion,	1,046	35
Cases of external corrosion,	849	43
Broken and loose braces and stays,	192	82
Settings defective,	421	34
Furnaces out of shape,	520	22
Fractured plates,	310	43
Burned plates,	351	30
Blistered plates,	118	5
Cases of defective riveting,	2,068	81
Defective heads,	88	10
Serious leakage around tube ends,	2,510	215
Serious leakage at seams,	412	51

Nature of Defects.	Whole Number.	Dangerous.
Defective water-gauges,	363	67
Defective blow-offs,	164	48
Cases of deficiency of water,	31	6
Safety-valves overloaded,	82	19
Safety-valves defective in construction,	74	30
Pressure-gauges defective,	502	20
Boilers without pressure-gauges,	34	34
Unclassified defects,	976	0
Total,	15,804	985

Boiler Explosions.

AUGUST, 1901.

(219.) — On August 1st a boiler exploded in the Marion apartment house, on St. Nicholas Avenue, New York city. William Taylor and Charles Miller were injured, and the boiler and engine room, as well as the lower part of the elevator shaft, was wrecked.

(220.) — A locomotive boiler exploded, on August 2d, at Bolton, seven miles from Atlanta, Ga., on the Western & Atlantic railroad. Fireman J. L. Aenchbacker was killed, and Engineer N. V. Bell was severely bruised. The locomotive was demolished, and the baggage car derailed.

(221.) — On August 5th an explosion occurred in Hopper & Scott's silk mill, at Paterson, N. J. We have no precise information concerning the accident, but a newspaper report states that "the cylinder head of the boiler blew out with a great noise." We don't know just what that means, but we take it for granted that the head of the boiler gave way. The building was badly shaken, and a panic ensued among the girls. All fled in terror from the looms, and some of them fainted; but no one was injured.

(222.) — A boiler exploded, on August 5th, in T. M. Holmes' sawmill, at Syracuse, near Middleport, Ohio. John Riser was severely burned, and James Quillin was also burned to a lesser extent. The property loss was small.

(223.) — A safety boiler exploded, on August 6th, on the steamer *North West*, just after she left Detroit for Chicago. George Lewis and one other man whose name we have not learned, were badly scalded and burned. The accident delayed the steamer nine hours.

(224.) — On August 7th a boiler used in the construction of a bridge exploded at Mill River, near Fincastle, Botetourt County, Va. Charles Hayes was killed, and Henry Barnett was seriously injured.

(225.) — On August 7th a boiler exploded at Prairie Depot, near Bowling Green, Ohio, while it was being tested. It was thrown across the railroad tracks, damaging a building belonging to the Buckeye Pipe Line Company, knocking a hole in a car of coal, and damaging another small building.

(226.) — On August 7th a boiler exploded in F. W. Hedges' tile yard, two miles and a half west of Prairie Depot, near Bowling Green, Ohio. Nobody was injured. (This explosion is distinct from the one recorded in the foregoing paragraph.)

(227.) — A boiler exploded, on August 7th, in John Burton's sawmill, at Caney, near West Liberty, Ky. John A. Wells and William Burgess were killed. The mill was wrecked.

(228.) — On August 7th a boiler exploded at the Doolittle mining plant, two miles south of Reeds, near Carthage, Mo. Engineer Alexander Smith was fatally injured. The boiler, machinery, and building were all demolished.

(229.) — A boiler exploded, on August 9th, at Fairmount, Ind. Frank Gilchrist was seriously injured.

(230.) — On August 9th a locomotive boiler exploded at Troy Grove, near Sycamore, Ill.

(231.) — On August 10th a Mogul locomotive exploded, on the Chicago & Northwestern railroad, at Sycamore, Ill. (This is a distinct explosion from the one recorded in the foregoing paragraph.)

(232.) — A 65 horse-power boiler exploded on August 11th, in the Long Beach Hotel, at Long Beach, L. I. The kitchen and the hall at the east end of the dining room were wrecked. The explosion occurred at five o'clock in the morning, and on week days several of the employees would have been in the kitchen, and would doubtless have been seriously hurt. The explosion occurred on Sunday, however, when the help went to work at a later hour than usual, and nobody was injured. The damage to the hotel was said to be about $30,000, but we think it probably did not exceed $15,000.

(233.) — The man-head blew out of a boiler in the Ohio plant of the National Steel Co., at Youngstown, Ohio, on August 11th, seriously injuring Albert Mullineaux. It is said that Mullineaux was at work repairing the boiler at the time, and also that the fires had been built under it only a very short time, so that the pressure was not at all heavy.

(234) — A boiler exploded, on August 11th, on the steam yacht *Quail*, at Electric Camp, near McKeesport, Pa. Robert Chriswell and Henry C. Osborne were fatally injured, and Edward Miller, Charles Brosky, William M. Campbell, J. E. Henry, and Charles Smith were seriously injured. The victims were all mill workers except Campbell, who is the owner of the yacht.

(235.) — On August 12th a boiler exploded in the Weston Lumber Company's mills, at Groveton, N. H. Fireman Frank Boucher was instantly killed, and Henry Tyler was badly injured. The engine house was wrecked, and fragments of the building and machinery were blown to a distance of a mile. Three steel smoke stacks were thrown a hundred feet into the air. The property loss was estimated at $5,000.

(236.) — A slight boiler explosion occurred, on August 13th, in a heading factory at South Whitley, near Hartford City, Ind. Harry Carson was fatally scalded, and Fireman Lewis was also badly burned.

(237.) — On August 13th a slight boiler explosion occurred on the towboat Fred Nellis, at St. Louis, Mo. Engineer James H. Smith was fatally scalded, and two fragments of iron also struck him on the head, fracturing his skull.

(238).— The boiler of locomotive No. 2190 of the Southern Pacific Railroad exploded on August 14th, between Bloomington and the San Sevaine switch, near San

Bernardino, Cal. At the time of the explosion the head brakeman was in the cab with Engineer McCarty and the fireman. The brakeman and engineer were very badly injured, and the fireman was severely scalded.

(239.)—On August 14th the boiler of a steam threshing outfit, belonging to John Waite, exploded at Depew, near Emmetsburg, Ia. Engineer John Reddin was scalded on the left leg and on both feet, and another employee, named Taylor, was slightly burned.

(240.)—Owing to an overheated smokestack, fire broke out, on August 14th, at a temporary water works crib, two miles out in the lake from Cleveland, Ohio; and immediately after the fire broke out, the boiler exploded. As a result of the fire and explosion, eleven men were killed.

(241.)—On August 15th a boiler exploded in W. G. Jenkins' sawmill, at Mt. Hope, near Randolph, Mo. Nobody was hurt, and the property loss was small.

(242.)—On August 16th a flue failed in a boiler in the basement of the Hall building, at Kansas City, Mo. Fireman Frederick Mayfield was badly bruised and scalded, but will recover.

(243.)—A creosoting boiler exploded, on August 17th, in the Williamsport Wooden Pipe Company's plant, at Cammal, Pa. Considerable damage was done, but nobody was injured, as the explosion occurred at 4.30 in the morning, and nobody was in the building except the night watchman.

(244.)—On August 17th the boiler of a threshing machine outfit exploded on the Esperanza ranch, three miles from San Ardo, near Salinas, Cal. John A. Crane was killed almost instantly, and Henry Rutherford and V. Lipkey were seriously injured.

(245.)—On August 18th the steamer *Islander*, the flagship of the Canadian Pacific Navigation fleet, and the largest and fastest passenger steamer on the Victoria-Skagway route, collided with an iceberg off Douglass Island, Alaska, and sank within fifteen minutes after striking. Captain Foot and about sixty-five other persons, including passengers and members of the crew, were drowned. To add to the horror of the terrible disaster the *Islander's* boilers exploded as she went down, causing the death of many of those who were struggling in the water.

(246.)—A boiler exploded, on August 21st, in S. P. Quick's sawmill, at Elkdale, about two miles north of Crystal Lake, near Carbondale, Pa. Lewis Howell and Fireman James Phillips were seriously injured, and it is doubtful if Phillips recovers. The mill was completely demolished, hardly a single board of it being left standing.

(247.)—The boiler of a pump boat belonging to Loisel & Israel exploded, on August 22d, at Rapidan Landing, near Donaldsonville, in St. James parish, La. A man named Celestin was blown into the water and drowned, and Peter Bernard was fatally injured. James Hall, Lawrence Reed, Harry Washington, Albert Fletcher, Robert Harris, Gabriel Harris, Peter Gustave, Richard Bracksman, Henry Wells, Monroe Tyler, Harry Randolph, and Arthur Parker were also injured. The pump boat was damaged to the extent of about $1,000.

(248.)—On August 23d a threshing machine boiler exploded near Porter, Minn. Mrs. C. L. Christenson was instantly killed, and Lars Christenson, John Amundson, and one other man, whose name we have not learned, were injured.

(249.)—On August 26th a tube failed in one of the boilers of the fruit steamer *Adler*, as she was entering New York harbor, from Kingston, Jamaica, with a load of fruit. We have not learned of any personal injuries.

(250.)—The boiler of a drill engine exploded, on August 27th, at Jersey City, N. J., as the result of a collision with another similar engine. Engineer William C. Brown was severely scalded.

(251.)—A boiler exploded, on August 28th, in M. L. Peck's sawmill, on Sideling Hill, near Hancock, Md. Nooman Mann was instantly killed, and James Craig and Samuel Peck were badly injured.

(252.)—On August 28th the boiler of John Patterson's threshing machine outfit exploded on Burwell Consins' farm, three miles from Blackstone, Va. Algernon Jenkins and a man named Pryor were killed, and Daniel L. Thomas was badly injured.

(253.)—The port boiler of the steamer *City of Trenton* exploded, on August 28th, on the Delaware river, opposite Hampton Court, near Philadelphia, Pa. The main and upper decks were blown into the river, carrying many persons with them. It is difficult to get the names of the killed and injured correctly, but so far as we know them they are as follows: J. D. Crew, Miss Elizabeth Green, Arthur Lansing, Matthew Mable, August Mable, James O'Connell, William Dunn, William H. Keene, William Nelson, Jessie Stratton, and two unknown persons were killed, and Mrs. Edna Van Schoick, Miss Fanny Keene, and Theresa Rhein were fatally injured. In addition, about fifteen others are missing, and it is believed that most of these were killed. Some thirty others were also injured so badly that they had to be removed to the hospital for treatment, and the total number of injured is believed to have been about fifty.

Taking the Bull by the Horns.

A certain general manager has developed what seems to us to be quite a novel way of dealing with the union problem. Shortly after employing a man in his machine shop he received several letters from another town informing him that this man was a very bad specimen, that he was an agitator from Agitatortown, that he stimulated the workmen to do all sorts of disagreeable things, and that he was a bad citizen generally, and a bad man to have about a shop — a disturbing element, in short. Calling the man into his office, the manager said to him: "I understand that you are an agitator, and that you devote a good deal of energy to stirring up dissatisfaction and trouble." "I don't know that I have done anything particularly wrong in that line," the man replied, "although I have taken an active part in some labor difficulties." "Well," said the superintendent, "if you can handle men in the way these letters say you can, and make them do things that they otherwise would not do, I think you can handle them in this shop if you have a mind to; and I want you to take charge of all the lathe work, and see that it is performed in good shape, and that a full day's work is done. In other words, I should like you to be foreman of the lathe department." The man was astonished, of course, but he said that he would take hold of it and do the best he could, and this he has been doing ever since ; the superintendent being ready to testify that he is a most excellent and satisfactory foreman in every particular. He knows what a day's work is, and requires that it be delivered by every man every day ; and the men appear to be perfectly satisfied to do it for him, continuously and uniformly. — *American Machinist.*

The Locomotive.

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

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The New Star in Perseus.

In 1892 the astronomical world had an excellent illustration of the fact that there is still a good chance for an industrious amateur astronomer to distinguish himself, even though his instrumental means may be of the poorest; for in January of that year Mr. Thomas D. Anderson, of Edinburgh, Scotland, armed only with a star atlas and a pocket spy-glass magnifying ten diameters, discovered a previously unknown star in the constellation Auriga. He could hardly believe that the star had escaped the attention of the eagle-eyed professional astronomers in charge of the big telescopes in the world's leading observatories, so he very modestly sent an anonymous postal card about it to Professor Copeland, Scotland's "astronomer royal," calling his attention to it. The information was quickly telegraphed over the whole world, and a systematic study of the stranger was begun at once, with results that were almost startling. Let us quote a few words about what happened, from The Locomotive of November, 1892:

"It happened that numerous photographs of this part of the sky had been made at the Harvard College Observatory at about the time of Anderson's discovery, and a subsequent examination of the negatives showed that the star had unobtrusively recorded itself upon twelve of them, on days ranging from December 12, 1891, to January 20, 1892. At the time of its discovery by Mr. Anderson it was of about the fifth magnitude, and plainly visible to the eye. A subsequent careful examination of star maps showed pretty conclusively that nothing had been seen in that place by earlier observers. The Harvard photograph of December 10th shows it as a star of the fifth magnitude, while a photograph of the same region made in Germany on December 8th by Max Wolf fails to show it, although other stars of the ninth magnitude (40 times fainter than stars of the fifth magnitude) are shown.

"Careful measures of the brightness of the new star were made from day to day, and it was found to go through a remarkable series of fluctuations, corresponding, no doubt, to disturbances to which the star was subjected. After the beginning of March the fluctuations died away, and the star faded rapidly and with considerable regularity, so that some one suggested that it might furnish us with a test of the accuracy of Dulong's law of the radiation of heat — though, as we shall see later, it is by no means certain that the star grew faint on account of loss of heat. So rapidly did it fade that on March 20th it was fourteen times as faint as it was on March 8th. On April 1st it was down to the thirteenth magnitude, or perhaps the fourteenth; and on April 24th it was seen at Mt. Hamilton, and was of the sixteenth magnitude.

"It had gone the way of all other 'new' stars, and astronomers had given it up as a phenomenon that was past. But nearly four months later, on August 17th, it was again seen at the Lick Observatory, appearing as a star of the 10.5th magnitude; and when Professor Barnard examined it he perceived that it was really 'a small, bright nebula, with a tenth magnitude nucleus.' The brighter part of the nebula was 3″ in diameter, and outside of this was a fainter nebulous extension that was perhaps 30″ in diameter.

"The phenomena so far described are as follows: On December 8, 1891, no star as bright as the ninth magnitude was visible in this part of the heavens. On December 10th a star of the fifth magnitude, distinctly visible to the naked eye, was there. From this time until about the 1st of March, 1892, the newcomer fluctuated greatly in brightness, but from the 1st of March onward it faded away with considerable regularity until, when it was last seen, on April 26th, it was, perhaps, of the sixteenth magnitude. It was then supposed to have permanently disappeared; but on August 17th it was again seen, far brighter than it was on April 26th, and it was found to consist of a tenth magnitude star, surrounded by a nebulous envelope. This in itself is a sufficiently remarkable cycle of changes, but let us see what the spectroscope had to tell us. When the star was first seen it had a complicated spectrum, composed of bright lines, on the violet side of which were dark lines looking like shadows of the bright ones. This was interpreted as meaning that the star really consisted of two bodies of similar chemical composition, one of which was approaching us and the other receding from us. Measures of the displacement of the lines showed that the body giving the dark lines was approaching us at the enormous speed of 300 miles per second, while the one giving the bright lines was receding at the rate of 420 miles per second! * These velocities were maintained for at least a month, during which time the distance between the two bodies must have increased by an amount equal, at least, to twenty times the earth's distance from the sun.

"After the reappearance of the star in August, its spectrum was found to be entirely changed. It had taken on an appearance characteristic of the nebulæ; and a couple of days later Mr. Barnard saw it nebulous, as explained above. Professor Campbell of the Lick Observatory has also found indications of tremendous changes in the velocities of the two bodies composing the star; but this needs verification before we can accept it as a fact.

"Astronomers have proposed various theories to account for the remarkable outburst of light from the new star. The first explanation that occurs to one is that two comparatively dark stars, coursing along through space, have come into collision with one another, and that so much heat has been developed by the consequent slackening in speed that the bodies have been heated up to strong incandescence. It is also held by some that the phenomenon was produced by the crashing together of two vast clouds of meteoric stones. (This supposition is in accordance with Lockyer's famous 'meteoritic hypothesis.') Others point out that it is not necessary to suppose that an actual *collision* took place, but that the two stars approached each other so closely that enormous tides were raised in both of them, the resulting friction of these tides being the cause of the heat that was generated. This theory seems fanciful, but it is undoubtedly tenable. The strongest objection to it is the suddenness with which the star burst forth.

"Whatever theory we adopt concerning the cause of the sudden brilliance of the star, we have to face a far more difficult question when we consider the reasons for its fading away so quickly. Those of us who know how long it takes a large ingot of metal to cool will be slow to believe that a body at least comparable in size and heat with the sun could possibly cool down in a few months to the extent to which this new star has cooled."

* For an account of the principles on which this conclusion is based, see THE LOCOMOTIVE for June, 1890.

All this is by way of preface; for while Mr. Anderson, the poorly equipped amateur astronomer, certainly did discover a most interesting new star before the big observatories suspected its existence, it would be not at all unreasonable to suppose that his discovery was a happy accident, and that it would be illogical to hold out his fortuitous good fortune as an inducement to other amateurs to exert themselves in a like manner. "Surely," it might reasonably be said, "it cannot be supposed that the finely equipped observatories of the world will be caught napping in that manner again." But events have proved that this is an erroneous view of the case; for this same Mr. Anderson has again forestalled all others by the discovery of a second "new" star which promises to be even more interesting than his first one. The discovery was made last February, and the star increased in brightness so rapidly that in four days from the time that it was invisible in ordinary telescopes, it had become the brightest star in the northern heavens. As its advent was prominently mentioned in the newspapers, it is probable that many of our readers saw it at the time of its greatest brilliancy.

Professor W. W. Campbell, Director of the Lick Observatory, has recently issued a bulletin about this star, from which we quote below:

"Many interesting facts concerning it have been brought to light. To mention only a few, its brightness diminished irregularly from that of the most prominent star in the northern sky in February, until in June it was on the limit of visibility for trained and sensitive eyesights, where it has since remained. The star's atmosphere was violently disturbed, as shown by a study of its spectrum in the spring months, and since June, at least, the spectroscope has shown that it is now a nebula, though retaining to the eye, and in the telescope, the point-like form of an ordinary star. The disturbance that gave rise to the new star was sufficiently violent to convert it from a dark, invisible body into a gaseous nebula.

"In August, Professor Max Wolf, of Heidelberg, Germany, secured a four-hour exposure photograph of the region of the sky containing the new star. His negative showed the existence of some extremely faint nebulous patches about five minutes of arc south of the star, but with no evidence of any relationship between the nebulous clouds and the star. On September 20th Ritchey, at the Yerkes Observatory, photographed the same region with a more efficient instrument, and found that the nebulous cloud was very nearly circular, some ten minutes of arc in diameter, but of varying intensity in its different parts, with the new star situated near the middle of the nebulosity.

"A recent photograph, secured by Professor Perrine with the Crossley reflector [on November 12th, we believe], recorded the principal features of the nebulous cloud. He compared his photograph with the Yerkes photograph of the same object, and made the interesting discovery that the brightest portion of the nebula, at least, and perhaps the whole nebula, had moved to the southeast more than one minute of arc in the past six weeks. This observation is in all respects unique. Motion on this enormous scale has never been observed for any celestial body outside the solar system, and it is morally certain that the observed phenomenon is closely related to the violent disturbances which gave birth to the star. It is perhaps as wonderful and important as any fact yet determined in connection with new stars."

When Professor Campbell says that motions as rapid as that of the new star have been observed in the solar system, he means, of course, that in the solar system we see bodies apparently move across the sky with angular velocities as great or greater; but when we take account of the enormously greater distance of the new star, we shall find that neither in the solar system nor elsewhere have we ever had any knowledge of a body moving with a velocity anything like as great, when expressed in miles per second.

To calculate how many miles per second the new star is traveling, we should need to know how far off it is, and what angle its direction of motion makes with the line of sight from us to the star. In the case of the other star discovered by Anderson, observations made for the determination of the star's parallax showed that the distance was too great to be measured by any means at our disposal. It certainly exceeded 500 million million miles. We do not know how far away the present star in Perseus is, but we can probably take the figure just given as the smallest value that can be admitted for it. As regards the direction that the star's line of motion makes with the line joining the star and the earth, we can make no intelligent guess whatever; but if we assume that the motion is entirely at right angles to this line, the result that we shall obtain for the star's velocity will be the *least* value that the present observations will be consistent with.

Making these two unfavorable suppositions, it is easy to show, by a little arithmetic, that the star must have traveled 145,000,000,000 miles, at the very smallest admissible estimate, in the six weeks during which the observed motion took place. If we divide this by 42 (because there are 42 days in six weeks), and again by 86,400 (because there are 86,400 seconds in a day), we find that, at the very least estimate, the star must have been traveling at the enormous and unparalleled speed of 40,000 miles per second! It must be admitted that this result appears to transcend possibility; yet we can avoid it only by admitting that the star did not actually move as the photographs indicate that it did, or by supposing that it is really a comparatively near celestial neighbor, in spite of the present evidence to the contrary. We are not aware that spectroscopic observations (which give the velocity of a star in the line of sight, directly in miles per second,) have ever indicated a velocity greater than 500 miles per second. If we assume that this is the actual velocity of the new star in Perseus, and that the motion across the heavens indicated by the photographs was real, then it follows that we must admit that the star is not more than about 6,000,000,000,000 million miles away. This would correspond to a parallax of about 3″, which is three times as great as the parallax of the nearest fixed star that is now known, and would indicate that the new star is much nearer to us than any other extra-solar body. We shall await the result of further study upon this star with much interest.

The Development of the Bituminous Coal Industry.

There are no more interesting recitals in the annals of trade than that of the development of the fuel industries, for commerce and industry are very largely dependent upon the fuel supply. For many years the chief source of the world's fuel supply has consisted of those hydrocarbon compounds found in nature and known as coal. Scientists have long disputed over their origin, while in the meantime modern industry has adapted them to its varied requirements, and as a result has brought about achievements scarcely dreamed of a century ago. In the diversified fields of industry from which the capitalist reaps his millions and the workman toils for the necessities of life the coal trade has played a most important part. In its development we see the mightiest struggles of genius, the boldest strokes of business stratagem, the most gigantic projects involving the expenditure of enormous capital, and the organization of great armies of employees. The coal trade has constantly undergone an evolution involving a struggle for "the survival of the fittest," whether that of inventive genius, mechanical superiority, labor or capital.

In its adaptation to the uses of modern economic industry anthracite coal preceded bituminous, but of recent years the latter fuel and its products has had a much wider use in the iron and steel and allied industries, and present conditions foreshadow a continuance and even a rapid increase of this lead. The original area of the anthracite coal fields in this country did not exceed 500 square miles, and embraced the great field in Eastern Pennsylvania and the comparatively unimportant fields in Massachusetts, Rhode Island, Colorado, and New Mexico, while the bituminous fields already partially exploited in this country exceed 200,000 square miles, which shows conclusively that the latter coal is to form the fuel of the future.

Anthracite coal was first discovered in this country in Rhode Island in 1768, and in 1791 this fuel was discovered near Mauch Chunk, in Eastern Pennsylvania. The first discovery of coal in America was that of a bituminous vein near the present site of Ottawa, Ill., mentioned by Father Hennepin in 1679. The first coal mine opened in this country was a bituminous mine near Jamestown, first worked in the latter part of the seventeenth century. It is not the purpose of this article to trace these fuel industries through the period of their early development, but rather to trace the growth of the bituminous coal trade and the benefits which it has conferred upon modern industry.

The development of the bituminous coal industry up to 1850 was confined to the eastern part of the country. Then, as now, Pennsylvania held the lead, with Virginia, Illinois, Maryland, and Ohio making up the residuum of the output. The soft coal production in 1850 was, in round numbers, 10,000,000 tons. As yet the railway development of the country had not really been begun, and the iron and steel industries had not yet emerged from that period when charcoal formed the principal fuel. The coal trade then depended upon the rivers for transportation to the markets. In the development of the soft coal fields of Western Pennsylvania we can divide the industry into a number of epochs in accordance with the development of transportation facilities. The latter days of the seventeenth century witnessed the opening of small mines for local consumption; this was followed by the days of keel-boating down the Ohio and Mississippi; about 1817 the flatboating epoch began; in the early forties the development of the slackwater systems on the upper Ohio streams ushered in the days of steamboating as applied to the coal-carrying traffic; in the meantime the coking industry was undergoing its infantile vicissitudes; then came the iron way of the railroad; lastly, the introduction of modern mining appliances and advanced mine engineering practice marks the highest point in the history of this great fuel industry.

Coming down to 1870, we find nineteen States and Territories producing soft coal, and in that year the output was 17,000,000 tons; ten years later twenty-five States and Territories were producing 43,000,000 tons; by 1890 the number of bituminous coal producing States had increased to twenty-eight, and the aggregate output for that year was 111,000,000 tons. During the past ten years the industry has been developed in no new States, but many new fields have been exploited in the already soft coal producing States, as will be seen from the fact that the output for 1900 was, in round numbers, 208,000,000 tons. While, in part, the marvelous increase in the soft coal output for the past ten years has been due to the development of new fields, this is not entirely the case. During this period the introduction of the mining machine, the application of electricity and compressed air to mining operations, steel tipples and automatic tipple appliances, and the advancement of mining engineering, have had much to do with the development of the industry, as have the stimulating influences of the great industrial revival which this country has experienced during that time.

The Western Pennsylvania field, better known as the Pittsburg coal field, has during all these years maintained its lead with comparative ease, the production for 1900 being, in round numbers, 78,000,000 tons. Of the other principal coal States Illinois follows with 25,000,000 tons; West Virginia, 22,000,000; Ohio, 17,000,000; Alabama, 8,000,000; Indiana, 6,000,000; Kentucky and Iowa, each 5,000,000; Kansas a little over 4,000,000.

According to geology the bituminous coal fields of our country are classed in seven groups. The Triassic field embraces the Richmond basin in Virginia, and the Deep River and Dan River areas in North Carolina. The maximum output of this field was reached many years ago, and its present annual production does not exceed 50,000 tons. While not the largest in area, the Appalachian field far exceeds all other fields in importance, its annual production being about two-thirds of the entire bituminous output of the country. It embraces Central and Western Pennsylvania, Southeastern Ohio, Western Maryland, West Virginia, Eastern Kentucky and Tennessee, Northwestern Georgia, and Northern Alabama. It contains the well-known Connellsville coking field, the Clearfield and Pittsburg gas and steaming coal seams, and the Monongahela field in Pennsylvania; the Blossburg and Cumberland fields in Maryland; the Pocahontas and New River fields in Western Virginia; the Fairmount, Flat Top, Kanawha, Georges Creek, Elk Garden, and other important fields in West Virginia; the Massillon and Hocking fields in Ohio; the Jellico field in Kentucky and Tennessee; and the Birmingham field in Alabama. The central field, including the coal areas in Indiana and Illinois, and Western Kentucky, has a considerable area and a large production, as will be seen from the production of States given above. The Western field embraces the States of Iowa, Missouri, Nebraska, Kansas, Arkansas, and Texas and Indian Territory. In extent it is the largest field in the country, and in production it ranks third. The Rocky Mountain field includes the coal areas in Colorado, Idaho, Montana, New Mexico, North Dakota, Utah, and Wyoming. This field is rapidly increasing in importance. In 1887 the production of the field was about three and one-half million tons. Within three years the annual output was doubled and the production for 1900 was, in round numbers, 14,000,000 tons. While California and Oregon produce small quantities of coal their combined annual output does not exceed 200,000 tons. The Washington field is being rapidly developed, and the output of the State has increased from 1,263,689 tons in 1890 to 2,418,834 tons in 1900.

The aggregate of the world's output of all kinds of coal for last year was about 800,000,000 tons. The production of bituminous coal in this country was more than one-fourth of the world's mineral fuel production. It exceeded that of Great Britain; was one-fourth greater than that of Germany; five times the production of Austria-Hungary; six times that of France; fourteen times that of Russia; and fifty times the production of Canada. All kinds of mineral fuel produced by Continental Europe last year exceeded our bituminous production by a little more than one-fourth. More than a third of a million men are employed in the bituminous coal mines of our country, while a like number are engaged in its shipment, in the manufacture of coke, fuel gas, and other accessories of the industry, and in the other labor required in handling the product from the mines to the markets. The office forces of the concerns engaged in the industry aggregate thousands, and there are superintendents, foremen, fire bosses, engineers, electricians, and thousands of other skilled laborers dependent upon the soft coal industry. The industry has stimulated the construction of thousands of miles of railway, and the great trunk lines of the country are reaping rich revenues from the bituminous coal carrying trade. The sum total of the capital invested in this great fuel industry makes another interesting recital.

The economic methods of coal mining and fuel operations already adopted in the Old World have been made necessary, because of the depleted condition of the coal fields there. So far as concerns the bituminous coal industry, there is no danger of an early depletion of the fields of this country; but this does not mean that we are not adopting the more economic measures in every department of the industry. Allowing for the variation of the bituminous coal measures of this country, which run from a little less than four feet to eight or nine feet in thickness, it would not be far out of the way to estimate a production of 10,000 tons to the acre, which would give our entire bituminous coal area a producing capacity of 1,280,000,000,000 tons. At the present rate of mining the depletion of this area would require something like 6,000 years. However, it must be remembered that thousands of acres of barren territory are embraced within this coal area, the mining operations extending over the past sixty or seventy years have been quite extensive and thousands of acres of coal have already been rendered unminable, and future operations will make it impossible to mine much of the coal. However, it will be seen that so far as concerns the bituminous coal supply this country has nothing to fear as to the future.

Already American bituminous coal is playing an important part in the export trade, and is being received with favor in Europe in competition with the Welsh product. Our exportation of bituminous coal has grown from 1,138,681 tons in 1890 to 5,411,329 tons in 1900. It has been only a few years ago that American coal was practically unknown in the European markets, while during the past year our soft coal was exported to eleven countries of Europe to the aggregate amount of over a quarter of a million tons. The scarcity of the Welsh product caused by the Boer war gave an impetus to the market for our soft coal in Europe, and it seems to have found a permanent market there. Last year our soft coal was exported to fifty countries, and American coke was sent to twenty-two foreign countries, the total exportation of this soft coal product being about 400,000 tons. Pennsylvania, West Virginia, and Maryland bituminous coal figures most largely in the export trade, owing to the advantageous location of the fields of these States with respect to the great Atlantic ports. — WILLIAM GILBERT IRWIN, in *The Scientific American*.

"Explosive D."

Since the first days when shells were used in warfare, it has been the dream of military experts to invent an explosive safe enough to be fired from an ordinary gun in large masses, and yet destructive enough, at the same time, to practically annihilate any object that it should squarely strike. The number of substances that have been tried and found wanting in some important respect is great; but the new explosive now in the possession of the United States Government appears to fulfill practically all of the exacting requirements. Its composition is a jealously guarded secret, but it is known as "explosive D."

It is not many years since it would have appeared impossible to manufacture an explosive that could be fired out of a modern cannon with absolute safety to those about the gun, and which would resist the shock of being suddenly stopped by impact against an armor plate that it could not penetrate, and yet which would explode promptly and with extreme violence, when the proper impetus was communicated to it, by a suitable fuse, or other equivalent device. Yet all these things have now been accomplished by the new "explosive D." We do not mean to say that they have not been accomplished, to a comparable degree, by other explosives also; but the new explosive appears to be decidedly superior to all others that have yet been tried.

The recent comparative tests of maximite and "explosive D," which were made by this government at Sandy Hook, are described in a recent paper by Capt. E. B. Babbitt which is printed in *Engineering News*. The final test was to be the firing of a twelve-inch armor-piercing shot at a twelve-inch harveyized armor plate. An experiment of this kind was bound to be both impressive and (to a certain extent) dangerous; and the experimenters led up to it by what might be called easy stages. Shells loaded with the explosive, but uncapped, were first fired through plates of various thicknesses, and these tests having been successful, the experimenters proceeded to the trials with shells loaded and capped. The first one is described picturesquely by Capt. Babbitt:

"At last," he says, "the final test was reached. Imagine the tensions as, from a safe distance, we stood with eyes to our glasses, anxiously watching the distant field. The target, a 5¾-inch tempered steel plate, well backed with oak, defiantly faces the long, slender 12-inch rifle. The red flag waves from the firing bomb-proof. It is answered. The flag falls, a bank of smoke from the gun, a flash of light at the plate, a dense, black, foreboding mass of smoke interspersed with flying timbers and bits of plate, two mighty roars in quick succession, a sigh of relief and satisfaction from the observers, and, for the first time, a 12-inch armor-piercing shell, loaded and fused, has passed through heavy armor. While later, heavier plates were used, and the results were therefore more satisfactory, the first success ever stands out most vividly in the minds of the experimenters."

In the final trial a shell, loaded and capped, was fired against a 12-inch plate, as has already been said. The official record of this last test is as follows: "A 12-inch armor-piercing shell, charged with 'explosive D,' 58.6 lbs. Weight of charged shell, complete, 1,010 lbs. Fired May 17, 1901, with Frankford Arsenal detonating, armor-piercing fuse, complete, against a piece of 12-inch face-hardened steel plate. Pressure in gun, 20,000 lbs. per square inch. Velocity about 1,875 feet per second. Shell detonated in plate, and completely demolished plate and backing,— all being carried forward and swept away. Fragments of plate were thrown to a distance of 200 to 300 feet, and gave evidence that the plate was penetrated by the shell."

The consequences of a shell of this sort penetrating the interior of a battleship can be only feebly imagined. Capt. Babbitt concludes his paper with the words, "I think I am safe in saying that the results just enumerated are unique, and so far surpass those previously obtained as not to admit of comparison with them."

In looking over some of the back numbers of our exchanges, we observe an item in the *Engineers' List* for March, 1898, to which we desire to refer, in the interest of fairness. In the issue of that paper for November, 1897, an article was printed without proper credit to this company (as it appeared to us at the time), and in The Locomotive for the month of January next following we expressed our sentiments on the subject quite fully. In the copy of the *Engineers' List* for March, 1898, which is now before us, the editor of that paper makes an explanation (which we had overlooked until today) to the effect that he copied the article from another mechanical paper in which credit to us was omitted; and he adds that he was not aware that it came from The Locomotive originally. We therefore desire to retract all that we said about the assumed dishonesty of the *Engineers' List*, and to apologize for the lateness of this reparation.

The Locomotive.

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Furnace Arch Bars.

The erection of brick settings for horizontal tubular boilers raises a number of problems in connection with the expansion and contraction of the walls as they are alternately heated and cooled; and if these are not well understood, the settings are likely to crack and give a good deal of trouble. But if the setting is correctly designed, there should be no great difficulty in erecting it in such a manner that it will have a long life, and do good service.

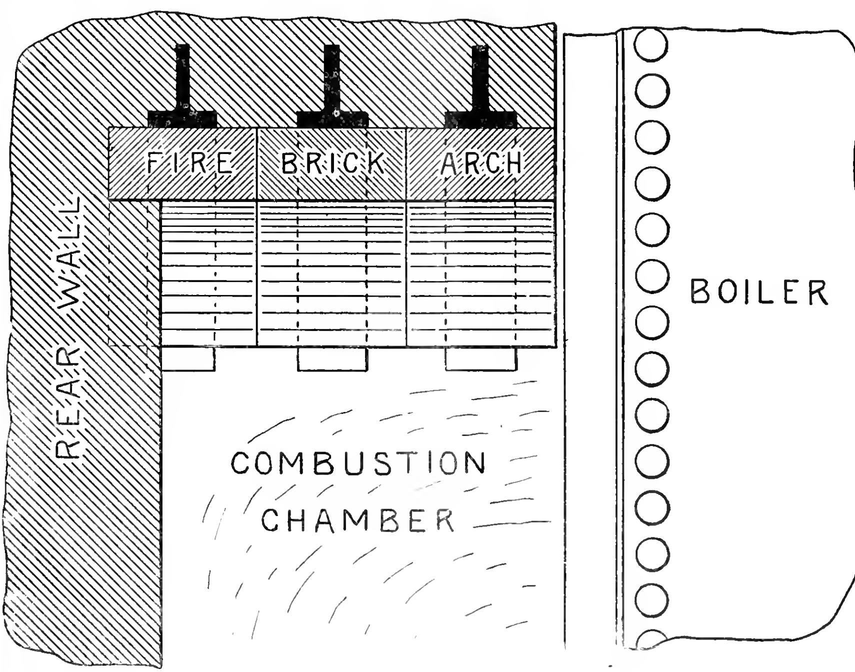

Fig. 1. — Showing the Arch Bars in Position.

There is one part of the setting, however, which offers special difficulties, and which is forever getting out of order, if it is not put in carefully and correctly. We refer to the arch over the back connection, where the setting closes up against the back head of the boiler. All the other walls of the setting are vertical, or nearly so; but in this place the bricks must be set in the form of an arch, or its equivalent, and the result is, that there is danger that they will fall out after they have been in service a little while, or at least loosen so that the setting will leak air badly, and the draft be injured.

The arch, as has long been known, is an ideal structure for carrying a steady load, under ordinary circumstances; but when it is built of brick, and exposed to the high temperature that prevails in the back connection of a boiler setting, it is not durable unless it has some support in addition to the mutual pressure between its component parts.

The rear arch in a boiler setting is often turned from the back wall forwards toward the boiler instead of being sprung from one side of the setting to the other, the extra support being obtained, in this case, by passing horizontal fore and aft tie rods through the arch, so as to prevent it from falling forward against the boiler head. This con-

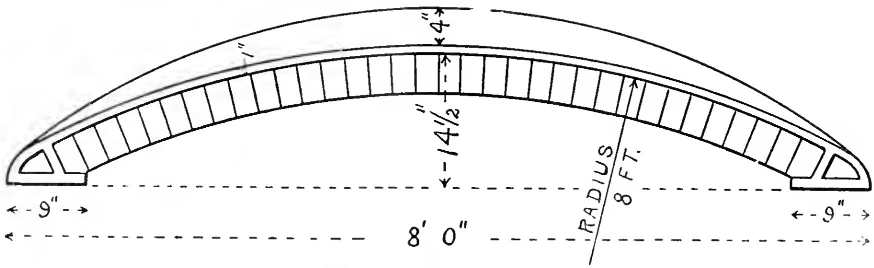

Fig. 2. — Side View of Arch Bar for 72-Inch Boiler.

struction often works very well, and we have sometimes recommended it in the past. We do not consider that an arch that is sprung from the rear wall forward is as good, however, as one that is sprung from one side of the setting to the other, provided proper support is furnished for the latter.

When an arch is thrown from one side of the setting to the other, it is customary to support it by cast-iron bars in some manner or other, so that it will have more strength and durability than could be expected from its form alone. This is a correct idea, but it is often carried out in a way that we cannot recommend; for it is not at all

Fig. 3. — Top View of Arch Bar for 72-Inch Boiler.

uncommon to see these cast-iron supporting bars disposed below the fire brick of the arch, in such a way as to be exposed to the full heat of the furnace gases. Under these circumstances the bars are almost sure to warp, sooner or later, and then they are even worse than useless. We have seen such cast-iron bars twisted into the most fantastic shape, by the heat to which they had been subjected.

The ideal way to arrange a rear arch in a boiler setting is to spring it from side to side, and support it by a cast-iron arch bar that is so designed that no considerable part of the metal is exposed to the direct heat of the furnace gases. A form of bar that accomplishes this end satisfactorily is shown in the accompanying illustrations. Fig. 2 shows the size and shape of the bar that is used with the standard setting of the Hartford Steam Boiler Inspection and Insurance Company, for 72-inch boilers. It consists of a curved piece one inch thick, cast to a radius of 8 feet, and provided at the back with a rib which is 4 inches deep at the middle, and tapers down to nothing at the ends. The brick are laid up against the bar in an arch, as shown, and they are held in position at either end by projections cast upon the bar. A top view of the arrangement is given in Fig. 3, where it will be seen that the bar that supports the brick is only 4″ wide, so that the brick project beyond it to a distance of $2\frac{1}{2}$″ on either side. These cuts explain themselves sufficiently, we think, so that further verbal description is unnecessary. Fig. 4 shows a similar bar, designed for a 42″ boiler. It is drawn to a different scale from Figs. 2 and 3, so that the arch looks much flatter; but this is not really the case, for the radius of that part of the casting against which the brick rest is 8 feet, just as before, and the apparent difference in this respect between the two cuts is due to the difference in scale alone.

In Fig. 1 we have shown the arches in position. Three of them, arranged side by side, are sufficient to cover the space between the boiler and the rear wall in most cases, but more could be used if necessary. The ends of the iron supporting bars rest on the side walls of the furnace, and the rear wall is built up around the arch, as shown.

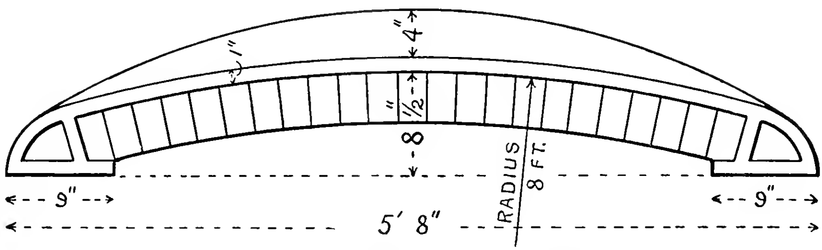

Fig. 4. — Side View of Arch Bar for 42-Inch Boiler.

In order that these arch bars may be durable and give satisfaction, the brick that they are to hold and support must be placed in position properly and securely. This is a matter of so much importance that it may be profitable to describe the way in which it should be done. The arch bar that is to be made ready is first turned bottom upwards, and propped up in a convenient position. The brick that are to go in it are next selected. If "arch brick", curved to an 8-foot radius, can be had, they should be used. If not, then common firebrick may be used instead, but every third or fourth brick will have to be beveled in that case, so that no large spaces will be left between them when they are in position against the bar. The last brick to be put in should be the key brick, in the middle of the arch. This will have to be driven in endwise, of course. No very thin brick should be used in the arch, and if the length of the bar is such as to call for half a brick or so to fill, then several bricks should be each trimmed a little, so that the reduction in thickness should not be very marked in any one of them.

After the brick that are to go in the bar have been carefully selected and fitted so that they will go into position satisfactorily, they should be wetted, coated with a thin paste of fire clay and water, and put in place in the bar. The bar, with the brick in position, should next be turned right side up, and the spaces between the brick well filled with a paste made of fire clay, ground firebrick, and water. After the whole has dried and hardened, the arch may be placed in position, and if the processes here described have been intelligently carried out, there should be little likelihood of the completed arch giving trouble.

Arch bars made in this way are coming into very general use, and many of the leading boiler makers have patterns from which all ordinary sizes of the bars can be cast.

Inspector's Report.

JULY, 1901.

During this month our inspectors made 10,846 inspection trips, visited 20,546 boilers, inspected 10,066 both internally and externally, and subjected 939 to hydrostatic pressure. The whole number of defects reported reached 19,134, of which 947 were considered dangerous; 68 boilers were regarded unsafe for further use. Our usual summary is given below:

Nature of Defects.	Whole Number.	Dangerous.
Cases of deposit of sediment,	1,634	63
Cases of incrustation and scale,	3,917	85
Cases of internal grooving,	202	14
Cases of internal corrosion,	1,424	33
Cases of external corrosion,	987	31
Broken and loose braces and stays,	1,014	106
Settings defective,	553	32
Furnaces out of shape,	640	26
Fractured plates,	340	46
Burned plates,	509	27
Blistered plates,	190	4
Cases of defective riveting,	2,991	39
Defective heads,	96	12
Serious leakage around tube ends,	2,870	147
Serious leakage at seams,	371	19
Defective water-gauges,	351	71
Defective blow-offs,	261	77
Cases of deficiency of water,	15	6
Safety-valves overloaded,	120	33
Safety-valves defective in construction,	54	20
Pressure-gauges defective,	564	25
Boilers without pressure-gauges,	31	31
Unclassified defects,	41	0
Total,	19,134	947

Boiler Explosions.

SEPTEMBER, 1901.

(254.) — On August 13th the boiler of a locomotive exploded, on the Denver & Rio Grande railroad, about a mile east of La Veta, near Pueblo, Col. The shock was terrific, and the engine was completely wrecked. Engineer L. P. Woods was killed, his body being blown to pieces; and Fireman M. S. Maple was hurt so badly that he died a few hours later.

(255.) — Hugh M. Gayner was instantly killed, on August 28th, by the explosion of a boiler used in drilling an oil well on the Tuttle heirs' farm, some ten miles north-east of Sistersville, Va. The engine house was wrecked and blown away. One fragment of the boiler was thrown to a distance of 500 feet.

(256.) — On August 28th a boiler exploded in J. H. Gibbs & Son's grist mill, at Edmore, near Ionia, Mich. Nobody was hurt. The property loss was about $2,000. This mill has been peculiarly unfortunate, as this is its second boiler explosion, and it was also once destroyed by fire.

(257.) — On August 29th the boiler of a traction engine exploded on the farm of Edwin Bass, Jr., in Berlin Township, about a mile east of Malden, Ill. Engineer Abbott Lawrence had his leg broken, but nobody else was injured. The engine belonged to James Watson, of Berlin.

(258.) — A boiler exploded on August 30th, in Frederick Brueningsen's repair shop, at Hastings, Neb. Nobody was injured, but the building in which the boiler stood was almost completely wrecked.

(259.) — A boiler exploded, on August 31st, in the Eagle Foundry, at Corry, Pa., near the shops of the Climax Engine Company. George Neville and William Hazel were seriously injured, but both will recover. The boiler was blown through the roof of the building to a height of fifty feet, taking the entire roof with it, and badly wrecking the upper portion of the structure. [This explosion and the foregoing ones were received too late for insertion in the regular August list.]

(260.) — A boiler exploded, on or about September 1st, in E. A. Poarch's sawmill, at Stony Creek, near Petersburg, Va. We have not learned of any personal injuries, but the mill was wrecked.

(261.) — On September 2d a boiler exploded on a dredge boat on Moose Creek, near Salmon City, Idaho. Superintendent Dunlap was instantly killed, and four of the workmen were seriously injured. The boilers were new, and had been worked only about four months.

(262.) — A boiler exploded on September 3d, in Savage & Williams' cotton gin at Personville, near Mesa, Tex. Mr. J. M. Williams, one of the owners of the gin, was killed, and the foreman, Mr. John Beasley, was badly scalded, and may not recover. The gin was completely wrecked.

(263.) — On September 3d the boiler of a threshing outfit belonging to G. Edwards & Son, exploded on the John L. Saunders farm, at Honey Creek, near New Castle, Ind. Asa Fadley, the engineer, was injured so badly that it was thought that he could not recover, and his death was reported to have occurred; but according to later advices he was improving, and it was thought probable that he would recover. David Richmond was also injured seriously.

(264.) — The boiler of a threshing outfit exploded, on September 3d, at Daileyton, some twelve miles north of Greeneville, Tenn. Engineer Alfred Harris was instantly killed, and Charles Newberry was injured so badly that he died a few days later. John Hatley, John Linebaugh, and John Wattenbarger were injured seriously but not fatally. Mr. Wattenbarger was the owner of the boiler.

(265.) — A boiler exploded, on September 3d, in the Musser sawmill, at Muscatine, Iowa. Robert Carter, David L. Dulgar, and John Dulgar were badly bruised and scalded, and at last accounts it was thought probable that two of them would die. The south wall of the building in which the boiler stood was blown out, and the building and its contents were practically ruined.

(266.) — A boiler exploded, on September 4th, in M. L. Peck's sawmill on Sideling Hill, near McConnellsburg, Pa. Noonan Mann was instantly killed, and James Craig and Samuel Peck, a son of the owner of the mill, were badly injured. The sawmill was completely wrecked.

(267.) — On September 4th a boiler exploded in Joseph Clark's sawmill, at Earlville, near Townsend, Del. Engineer Edward Manning was instantly killed, and Harry Clark, a son of the owner of the mill, was badly injured. We have seen no estimate of the property loss.

(268.) — A boiler exploded, on September 5th, in Conaway & St. Clair's sawmill, about three and one-half miles southeast of New Lexington, Ohio. Dent Brown and Newton Brown were seriously injured.

(269.) — On September 5th a boiler exploded in Andrew Plew's shingle mill at Starrucca, Wayne county, Pa. Mr. Plew was instantly killed. His son, George Plew, had his leg broken, twice, below the knee. Another son was slightly injured. Albert Osborn's arm was broken, and his face was badly bruised. The building in which the boiler stood was completely wrecked.

(270.)—On September 6th a threshing machine boiler exploded on Dewitt Tolbert's farm, near Sykeston, Wells county, N. D. Lafayette Tolbert was injured severely, though not fatally.

(271.) — On September 11th a boiler exploded in a cooper shop at St. John's, N. F. Two men were killed and several others were injured. The building in which the boiler stood took fire, and the fire spread to other buildings, and was not brought under control until it had caused a property loss of about $500,000.

(272.) — On September 12th three explosions occurred in the works of the American-Schultze Powder Company, at Oakland, N. J. The first explosion was that of a boiler, and almost immediately following there were two others, one in the magazine, and one in the mixing-house. William Titus, Arthur Curry, John Dupont, Richard Van Blarcan, and Harrison Weyble were killed, and Bartholomew Burns and Andrew Lassenger were fatally injured. William Weatherworks, Abram McMonnies, Frederick Titus, Frederick Titus, Jr., William Titus (son of the William Titus that was killed), and John Farrell were injured. All three explosions occurred within an interval of about six seconds.

(273.) — On September 16th the boiler of a threshing outfit exploded on the Radway farm, about six miles southeast of Frederick, S. D. Anthony Nelson, one of the owners of the bursted boiler, was instantly killed, and Benjamin Olstedal was injured so badly that it was thought probable that he could not recover.

(274.) — A boiler exploded on September 21st, in the Electric Light plant at Sheldon, Ill. Ernest Pawley was instantly killed. Leonard Snow and Frank Slavic were seriously injured. It was thought probable, at last accounts, that Mr. Slavic would die. The property loss was estimated at $12,000.

(275.) — On September 19th the boiler of Mr. E. E. McCargar's threshing outfit exploded some four miles north of Ansley, Neb. William Brown, the fireman, was instantly killed, and Mr. McCargar himself was badly injured, and may not recover.

(276.) — A boiler exploded, on September 19th, in H. B. Crouch's tobacco factory at Prestonville, near Carrollton, Ky. The building in which the boiler was located was blown to atoms, and parts of the machinery were thrown to a distance of 100 yards. There were eight persons at work in the building, but fortunately no one was hurt.

(277.) — A boiler exploded in the Water & Electric Light plant, at Rockdale, Tex., on September 19th. The entire plant was transformed into a tangled mass of brick, iron, and timbers, and bent and twisted machinery. There were six men in and about the plant at the time. Fireman Robert Wilson, who was evidently standing in front of the boiler, was thrown to a distance of eighty feet. He was mangled and scalded beyond recognition, and lived only a few moments. R. H. Ames, George De Bord, Charles Arthur, Henry Jones, and Will Pleasants received minor injuries.

(278.) — On September 20th a boiler exploded in John Wright's sawmill, at Bridgeville, Del. R. G. Auklem and John Coulbourn, and two other men whose names we have not learned, were badly scalded. The property loss was about $3,000.

(279.) — A boiler exploded, on September 22d, in the electric light plant and water works at Wilmar, Minn. So far as we can learn, the only person injured was Nelson Bredeson, who received some slight bruises. The brick building in which the boiler stood was leveled to the ground, and the property loss is estimated at $25,000. The dome of the boiler was carried over several houses, and dropped about 300 feet away. Portions of the wreckage were thrown to a distance of 2,000 feet.

(280.) — The boiler of locomotive No. 590, on the Michigan Central Railroad, exploded, on September 24th, at New Buffalo, near Jackson, Mich. Fireman Michael Wiley was instantly killed, and Engineer J. B. Palmer and Brakeman F. J. Crouch were slightly injured. The accident consisted in the failure of the crown sheet.

(281.) — On September 24th a boiler exploded in the New Westerly Granite Company's quarry, at Amherst, near Milford, N. H. Charles Caldwell received injuries that are believed to be fatal. John Bianchi and Edward Bills were injured to a lesser extent.

(282.) — On September 26th the boiler of a threshing machine outfit exploded on the farm of John Doyle, at Eden, near Galena, Ill. John Ford was killed. Fragments of the engine were scattered over an area of 40 acres.

(283.) — On September 27th a boiler exploded at the National Steel Company's blast furnace, at Sharon, Pa. Nobody was injured, but the boiler house was wrecked, and the property loss will amount to about $2,000.

(284.) — A boiler exploded on September 27th in Speace's limestone quarry, near Montpelier, Ind. Engineer John Cripe was blown through the air about fifty feet, and fell into another quarry. He was dead when found. His father, who was standing within ten feet of his son when the boiler exploded, was not injured.

(285.) — On September 29th a safety boiler exploded in the yard of the San Francisco Brick Company, San Francisco, Cal. Fireman Gardner and his wife, who was in the boiler room at the time, were badly scalded, and Mrs. Gardner may not recover.

(286.) — On September 30th a boiler exploded at Cooper, Selz & Co.'s cotton gin, at Pilot Point, Tex. Nobody was injured.

(287.) — A boiler exploded, on September 30th, in the lower part of Bienville Parish, La. John Glann was injured so badly that he died a short time afterwards.

(288.) — On September 30th a flue collapsed in the boiler of locomotive No. 909, on the Milwaukee passenger train, as it was pulling into Omaha, Neb. Fortunately the engineer and fireman had just stepped out of the cab, and so escaped injury.

The Locomotive.

HARTFORD, DECEMBER 15, 1901.

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

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

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THE index and title page to the volume of THE LOCOMOTIVE that ends with the present issue are in preparation, and will be mailed free to those that preserve their copies for binding, upon application, by mail, to the Hartford office of this company.

UP to noon of December 1, 1901, the Pacific Surety Company did a considerable volume of boiler insurance along the Pacific coast; but on that date its entire boiler business was permanently transferred to the Hartford Steam Boiler Inspection and Insurance Company; and in the future the Pacific Surety Company will devote itself entirely to fidelity, surety, and plate glass insurance. The Hartford Company is represented on the Pacific coast by Messrs. Mann & Wilson, 306 Sansome St., San Francisco, Cal.

ERRATUM.— In the article on the new star in Perseus, in the issue of THE LOCOMOTIVE for November, we said, on page 171, that "we must admit that the star is not more than 6,000,000,000,000 million miles away." The word "million" should be omitted, so as to make the passage read, "not more than 6,000,000,000,000 miles away."

Technical Education in England.

Not so very many years ago, it was fashionable, in Europe, to sneer at the people of the United States, and to say that we are a nation of shopkeepers and money-makers, without any great amount of culture, and with only a superficial knowledge of the facts of art and science. But there is now a marked tendency to give us a little more credit for what we have done and are doing. Our marvelous industrial and commercial successes have forced our European friends to study us a little more carefully, and the result has been that a more intimate acquaintance has shown them that we are not *altogether* bad. We admit, ourselves, that there is still much for us to do; and in fact it is this confident belief in the even greater future that lies before us that stimulates us to put forth our best efforts, at the present day, to hasten our progress in every branch of industry and knowledge. We are sorry to say it, but we are afraid that the discovery that we are "good fellows" was not made, in Europe, until our successes in industrial competition forced it upon a somewhat unwilling public. In England, in particular, there has been the liveliest interest, for some years past, in all things American; and the English press has been having heart-to-heart talks with itself, to see what is the reason that we have come up so rapidly, and to try and devise ways and means to keep in the game. We have printed extracts from English papers, from time to time, illustrating this fact;

and we reproduce, in this issue, an article from London *Engineering*, in which an apparently honest and sincere comparison is made between English technical schools and those of Germany and the United States. There can be no doubt about the value of a first-class school of this character, and our recent remarkable successes in the foreign markets is doubtless due, in some measure at least, to the fact that we have been turning out, for some years past, an annual crop of youngsters who are pretty well grounded in the principles of science and engineering, and better prepared to take hold of the problems of life than we were, at the same age. Education will never give brains to a man who was born without them; but an education that is really worthy of the name will cultivate a power of independent observation, and a systematic mode of thinking, that must necessarily redound to the advantage, not only of the individual, but also of the nation to which he belongs.

The Massachusetts Institute of Technology, to which the writer of the quoted article refers, is only one of a goodly number of excellent institutions of the same sort, that are engaged in the work of preparing our young men for greater usefulness, and thereby incidentally giving our foreign friends increased cause for worriment.

We have received, from the D. Van Nostrand Company, a copy of Mr. Leslie S. Robertson's excellent book on *Water Tube Boilers*, and have examined it with much interest. The book is based on a course of lectures delivered at University College, London, and has been issued in its present form because there is no standard book on this subject, that is not beyond the means of the general run of readers who would be interested in the matter that it contains. It begins with a well-illustrated account of the history of the water tube boiler, showing how the modern types have been gradually evolved from earlier ones that could not be used in these days of high pressures and high efficiency. The question of circulation is then taken up, and the general conditions that a water tube boiler must fulfill are considered. The numerous plans that have been proposed, for realizing, in practice, the conditions that theory shows to be necessary, are then taken up at considerable length, and the book closes with a chapter on boiler accessories, in which various types of feed-water heaters and purifiers and the like are discussed. The work is very well done throughout, so far as we have observed, and we take pleasure in commending it to the attention of those who desire information on the subject of which it treats. It is finely printed, on good paper, and the illustrations, for the most part, are excellent. (The D. Van Nostrand Company, 23 Murray St., New York. Price, $3.00.)

In our issue for August, 1901, we printed extensive extracts from a lecture on "Economy in Marine Engineering," delivered at Sibley College, by Mr. W. M. McFarland. In this article the following paragraph occurs: "The first steam war vessel of our navy, the *Fulton*, built in 1837, had for her chief engineer Charles H. Haswell; . . . and an extract from her steam log for a portion of January, 1838, shows that the maximum steam pressure was eleven pounds, the vacuum twenty-four inches, and the maximum revolutions per minute, eighteen." A correspondent calls our attention to the fact that this vessel was not the first warship in our navy to be propelled by steam, that distinction properly belonging to the *Demologos*, which was authorized by Congress in March, 1814, was built at Fulton's engine works, and was completed and successfully tried in New York harbor in June, 1815. The *Demologos* had central paddle wheels, protected by a double hull, and mounted a 100-pounder gun, which turned on a pivot. She was 156 feet long, 56 feet wide, and 20 feet deep, was rated at 2,475 gross tons, and cost $320,000. She was not completed until some months after the close of the war with England, and hence did not see any actual service. Fulton died on February 24, 1815, four months before her completion. In 1837, upon the completion of the second *Fulton*, to which Mr. McFarland refers, the *Demologos* became known as the *Fulton the First*; and the confusion that our correspondent points out was doubtless due to this double use of the name *Fulton*.

Ancient Engines.

We recently printed certain facts about two venerable Newcomen engines, that were believed to be the oldest now in operation in the world. Mr. R. S. Hale calls our attention to another engine of this sort, which is even older, and is still doing good work. "I was much interested," he says, "in the article in the October LOCOMOTIVE about the Newcomen engines now running in Scotland. There is also a similar engine at some mines near Bristol, England, which is still worked occasionally. It is run by a man now about 70 years old, who learned how to manage the engine from his grandfather, the grandfather, in turn, having run the engine all his life. The old boiler that formerly supplied steam at atmospheric pressure was discarded some thirty years ago, and steam is now supplied, through a reducing valve, from some comparatively modern boilers, which, however, run at only 20 pounds. I visited the plant three or four years ago, and found the engine much like those described by you, only larger. The cylinder, as I remember it, was about six feet in diameter. It was packed with water on top of the piston, and the old man in charge said that if he threw some earth in also, so as to made a sort of mud, the packing is much more effective! The engine is now run only every two or three weeks, and the owner told me that even with the extra amount of coal used they believed it to be cheaper to run this engine than to go to the expense of putting in a new one. An account of the engine may be found in London *Engineering* for October 25, 1895, where it is stated that the engine, according to the best obtainable information, was installed at about the time the pit was sunk, or in 1745. This would make the age about 150 years, or nearly half a century older than either of those described in THE LOCOMOTIVE. With modern engines we figure 5 per cent. as a proper depreciation charge; but if we felt sure that our modern engines would last as long as this one has lasted, one-fourth of one per cent. would be sufficient for a (theoretical) depreciation charge."

Upon referring to the issue of London *Engineering* that Mr. Hale mentions, we find the following data given: "The engine was originally supplied with steam from two haystack boilers which, about thirty years ago, were condemned as unsafe, and taken away. Steam has since been obtained from other boilers near, and reduced in pressure for this engine to $2\frac{1}{2}$ lbs. The engine is still [1895] worked about five hours a day and six days a week, to keep the South Liberty coal pit dry. The coal mine to which the pit belongs is about three miles from the center of Bristol, and owned by the Ashton Vale Iron Company, Bedminster. The pit, 750 feet deep, was sunk about 150 years ago, and the engine is said to be of the same age. The cylinder is 5 feet 6 inches in diameter, and the stroke is 6 feet. The cylinder is of iron, cast in one piece, with conical shaped bottom to drain the water, and weighs about six tons. The beam, which works with a curious creaking noise, is built up of many oak beams trussed together, and is 24 feet long, and about 4 feet deep. The engine makes about 10 or 11 strokes per minute, and works with several inches of water at the top of the piston, so that if the latter leaks, nothing but water passes through, and the vacuum is not injured. The following description of the working cycle may be of interest to young engineers. The engine is single-acting. The vacuum is produced below the piston from condensation of steam by the water jet, while the top is quite open to the atmosphere, and this forms the down motor stroke. The beam descends on one side, and lifts the water, pump rods, etc., on the other. The rods then fall, chiefly by their own weight, and the cycle recommences. There is no air pump."

Mr. Donkin had an indicator fitted to the engine, and from the card so obtained he calculated that the power developed was nearly 53 H. P. We may add that this engine (and doubtless every other Newcomen engine that may be found in operation) is provided with a valve motion, so that it is not necessary for the attendant to operate the valves by hand, as in the early days.

Technical Education.

While a great deal has been accomplished during the past few years in this country (England) in the matter of providing facilities for the scientific training of those to be engaged in the direction of our great manufacturing industries, much still remains to be done before our technical institutions can compare in magnitude or equipment with those of America or Germany. While, on the whole, ample facilities are now provided for elementary scientific training, the average Englishman is still unable to appreciate the necessity of more advanced work, so that, while money can readily be raised to equip almost any number of second-rate polytechnics, comparatively little is forthcoming towards the support of the institutions in which really advanced work is being carried on. A curious illustration of this habit of mind is to be found in the fact that, while no nation can show a more numerous selection of elementary treatises on chemistry, the great work of Roscoe and Schorlemmer is no longer published here, while a new edition has but recently been issued of the German translation. Our American friends used to be credited with a reputation for acquiring a mere smattering of the sciences, and for thinking this all-sufficient; but this reproach has long since ceased to be applicable, and the numerous establishments in which advanced work is done in the United States are exceptionally well endowed and well equipped. Again, while in England the average length of the course at a technical school is three years, in America it is four, and the students can hardly enter the school less well grounded than does the average public school boy here. In fact, most of our colleges have an extremely low standard for their entrance examinations, though there are one or two exceptions to this general rule. Experience seems to show that, while a three years' course suffices to give an intelligent youth a fair grasp of principles, it affords him little opportunity of carrying out research work on his own initiative, which would give him a most valuable training in compelling him to think for himself. We know that the professors of some of the principal schools have been anxious to have a fourth year's post-graduate course of this character, and to a certain extent have been able to carry out their wishes; but such a course, though not "post-graduate," forms a portion of the regular curriculum at many American schools. Not unfrequently the graduating theses in these schools have in this way made contributions of permanent value to engineering data.

In spite of the fact that a four years' course is usual abroad, the age at which students are admitted is generally higher than in this country, being 18 in place of 15 or 16, as here. Even so, the number of such students is considerably greater than here.

In England there were, in 1900, 345 third-year and 52 fourth-year engineering students at the technical schools of the United Kingdom, and of these some had entered at the age of 15. In the Charlottenburg (Germany) Technical High School alone there were, in 1900, 235 third-year and 242 fourth-year students in engineering; while about 300 students annually leave the Massachusetts Institute of Technology, after completing a four years' course.

Although the output from English schools is so low, as compared with that of our principal competitors, it is to be feared that it is still rather in excess of the demand. In the case of the Massachusetts Institute of Technology, the number of applications from manufacturers for graduates is so great that every one is provided with an engagement before he completes his course. In this country (England) most of the students find some difficulty in getting a situation at all, and even then get either no pay whatever, or none to speak of, for a considerable period. This is not because they are found useless, since in more than one case within our knowledge these youngsters, whose services were gratuitous, were almost immediately put on work that was previously done by some of the best paid labor in the shops. Quite recently a large firm would consent only to take a youth of this kind as an ordinary four-year apprentice, so that if their proposal had been accepted, he would start, at the age of twenty-one, at a wage of five shillings a week, and at the age of twenty-five would have been earning the munificent sum of half a guinea ($2.50). In America, as already stated, the workshop managers have a higher appreciation of the advantages of a good grounding in scientific principles, and of the acquirement of a habit of accurate observation. They engage technical graduates readily, and find them useful in most unexpected directions. In our last issue we described how the Bethlehem Steel Company had employed a corps of such students to conduct the investigations by which they have succeeded in reducing their staff of laborers to one-quarter its original size. It is simply impossible to conceive of a British firm dealing with a question of this kind in this way. If there was a suspicion that the laborers were too numerous for the work done, the management might possibly give a draftsman a fortnight to look into the matter, in conjunction with a foreman; but they would never agree to keep a special staff at work for many months in a thorough investigation of the whole question, as the Bethlehem Company did. Indeed, even in the States the scheme of employing a number of inexperienced youths in such a matter excited no little ridicule when first broached, but the result has shown the acumen of the management.

In addition to having but a short course of study, our English technical schools suffer largely from the imperfect education of the raw material entering them. As already indicated, the entrance standard has in most cases to be fixed at a low level in view of the deficient nature of the instruction provided in the larger public schools, and in the private schools modeled thereon. A reform in this regard will doubtless be effected, ultimately, as the matter is attracting serious attention in at least one of the leading universities, where it is said to be most exceptional for a public school man to make his mark, while in order to get their pupils into the army without the assistance of a crammer, the heads of the public schools agitated, a short time ago, for a reduction of the standard. Whether their wishes in this respect were acceded to or not, we do not remember; but we are credibly informed that 60 per cent. of the candidates at the last examination spelled "cannon" as if the word had reference to an ecclesiastical official. Unfortunately, the system of education which leads to such results is warmly supported in the public press, which at the same time is governed by the delusion that it is the workmen in an establishment, and not the managers, who are in need of technical instruction. Any reform in the present system of secondary education is met by a cry that what is needed is culture. The latter quality is difficult to define: but if we may take Emerson as a guide, it consists in an ability to write and talk gracefully and intelligently on a wide range of subjects.

Up till recent years, the practical applications of science were so few that there was, perhaps, little necessity that a man of culture should have an understanding of engineering matters; but, at present, mechanism enters into every department of our daily life, and no one can avoid having to touch upon it in conversation or in writing. It is here that the old system shows its weak points. The leader-writers of our great daily papers are largely recruited from Oxford, which, though singularly destitute of great names in either literature or science, furnishes the bulk of the second-class literary men who edit the daily papers and monthly reviews. These write on all subjects, and generally well; but when their evil stars compel them to discourse on scientific or technical matters, their ignorance of the most common elementary facts is little less than astounding. In the nature of things, these gentlemen unfortunately have a great influence over public opinion, and it is doubtless largely due to them that we see the present waste of funds in the establishment and support of second-rate polytechnics, while the higher-class institutions are most inadequately endowed. It is possible, however, that this state of affairs is a necessary preliminary to teaching the public the supreme importance of work of higher quality. The man who has some elementary knowledge of scientific matters will spot the absurdities that now too frequently fall from the pens of the average leader-writers, and a demand will ultimately arise for gentlemen of a wider culture, and less restricted education, to direct the energies of the Press. Till this time arrives, we fear that our leading technical schools must continue to compare badly, both in equipment and in the dimensions of their teaching staffs, with similar establishments abroad.— *Engineering* (London).

Concerning Wireless Telegraphy.

We have been frequently asked to express our views on the subject of wireless telegraphy, but have refrained from doing so up to the present time, lest we might do injustice, inadvertently, to the several experimenters who are investigating the possibilities of the art. These possibilities are now fairly plain, and we commend to our readers the following article, from the *Electrical Review* of November 30th, which expresses the view that we take of the matter, as clearly as we could hope to express it ourselves :

"For some time past the advertising columns of the daily papers in this country have been largely patronized by various wireless telegraph companies offering stock in their enterprises for sale. It is noticeable that none of these companies is offering to sell instruments, or to transmit messages. Doubtless, numerous certificates of stock have been sold, and, doubtless, these are engraved with ink as green, and with engine turning as elaborate, as ever decorated a railroad bond. The American public is today very much the same as it was when the late illustrious P. T. Barnum made his discovery that it liked to be fooled. Companies for the creation of power from liquid air have bloomed and withered ; the exploitation of the stock of a concern for extracting gold from sea-water was attended with no little success. Doubtless, if somebody incorporated a concern for extracting sunshine from cucumbers, the stock would find a ready sale, but it would properly belong to the province of the technical press to warn investors that such securities are founded, to say the least, on a somewhat dubious basis. Concerning the wireless telegraph companies, it may truly be said that there is no doubt that wireless telegraphy is possible. There is also no doubt that it is possible to operate a number of different systems for the sending of messages without wire. There is equally little doubt that the art has much probable future utility, though expert opinions vary in respect to its extent.

"So far, the only commercial success that has attended any such system has been developed by Mr. Marconi and his associates, and the patents which they hold are believed to be of a fundamental character. One or more of the companies now advertising stock for sale has actually carried on wireless communication. Assuming that the concerns are entirely *bona fide*, and that they will achieve the fullest measure of success in signaling, it should be pointed out that the possible earning power of a wireless telegraph system is not so large as to justify the extravagant claims made for the value of the securities. So far as has been made public, there is not today any system which is strictly non-interfering. The erection in New York of a wireless telegraph station which would operate to Philadelphia, for example, would, in the present state of the art, probably interfere with the proper working of any other systsm whatever anywhere in the region from Boston to Baltimore and west as far as Pittsburg. This one fact of itself is sufficient to retard the commercial development of the system.

"Without in any way detracting from the superb work which has been done by Mr. Marconi and his associates, it may be said that, even with the large funds at their command and with the powerful assistance of the British government, they have been able to adapt their system so far only to certain limited varieties of marine signaling. It is believed by those who are most familiar with the situation that the actual use of space signaling methods will for a long time be limited to some such applications. It is in this branch of the business — ocean signaling — that wireless telegraphy has its greatest opportunity. In the face of these facts the public should be warned that the claims made by the various concerns with stock for sale are not founded upon any work actually accomplished, so far as is known to the electrical profession, and is not in the nature of things likely ever to meet with such success as would justify the investment of any considerable sum in the enterprise."

The foregoing article, while correct in the main, is perhaps not entirely fair to the wireless telegraph in the matter of interference of different messages sent in the same neighborhood. It has been found possible to "tune" the transmitters and receivers so that a given receiver will not respond to any message except one sent by its own proper transmitter, or by some other transmitter that is tuned to something like the same pitch. It will doubtless be possible to send a small number of messages through the same region of space, without their interfering with one another; but there is no present promise that very many messages can be sent in this way. The general judgment pronounced by the *Electrical Review*, that the greatest opportunity for wireless telegraphy lies in ocean signaling, therefore appears to us to be quite sound.

ON September 23d new records were established at the Edgar Thompson plant of the Carnegie Steel Company, Braddock, Pa. On that day the day turn made 106 blows and 1602 tons of ingots. The night turn made 119 blows and 1789 tons of ingots, a total of 3391 tons ingots in 24 hours. The day turn in the blooming mill made 107 heats and turned out 1435 tons, the night turn made 118 heats and turned out 1545 tons, a total of 2980 tons of ingots bloomed in 24 hours. On the same day No. 1 rail mill turned out 2285 tons of finished rails. A smaller mill turned out 445 tons of rails, making the total production of 2730 rails in 24 hours. These records for output have never been equaled. During the month of September the output of ingots and rails was the greatest in the history of that record-breaking plant. The total tonnage of ingots amounted to 74,400 tons, of which the blooming mill broke down 65,310 tons and the rail mill finished 59,810 tons. All previous records for rolling structural shapes at the structural mill at Homestead, Pa., were also broken for the same month by about 3,500 tons. — *The Manufacturer.*

In telegraphy, a woman's Morse signals are as feminine as her voice or her handwriting. I have often put to the test my ability to distinguish between the Morse of a man and that of a woman, and only once have I been deceived. I one day encountered a sender at the other end, a stranger, who for hours "roasted" me as I seldom had been "roasted" in my telegraphic experience. The dots and dashes poured from the sounder in a bewildering torrent, and I had the hardest kind of work to keep up in copying. With all its fearful swiftness the Morse was clean-clipped and musical, though it had a harsh, staccato ring that indicated a lack of sentiment and feeling in the transmitter. From this, and from a certain dash and swagger, I gathered, before the day was out, a pretty distinct impression of the personality of the transmitter. I conceived him to be of a well-kept, aggressively clean appearance, with a shining red complexion and close cropped hair; one, in brief, whose whole manner and make-up bespoke the self-satisfied sport. That he wore a diamond in his loudly striped shirt-front I considered extremely likely, and that he carried a tooth-pick between his lips was morally certain.

Next day I took occasion to make some inquiries about the unknown of my fellow operator.

"Oh, you mean TY," he said, laughing (for that was the official designation of the unknown). "Yes, for a girl, she is a fly sender."

It was mortifying to find that I had mistaken the sex of the sender, but I was consoled when I afterwards met the young woman. The high coloring was there, and the self-satisfied air; so also were the masculine ties, the man's vest, and the striped shirt-front. Nor were the diamond pin and the toothpick wanting. When she introduced herself by her sign, called me "Cully," and said I was "a crack-a-jack receiver," I was convinced that it was nature, and not I, that had made the mistake as to her sex. — L. C. Hall, in *McClure's Magazine.*

The Steam Thresher.— The *American Machinist* says that at a recent dinner held in New York, and attended by engineers, a manufacturer of engines in Canada read the following letter received by him some time ago from a French-Canadian customer: "Dear Sir: Le engine which I procur from you for drive thrash machine he is all rite correc and he work much more quiet as thrash machine all but one thing which is place in wheel and is mak for drive le valv which work front and back for admit le steam out an in le cilindar. My brother Philip who is certificat engineur at Montreal he call hit le governeur as he cant mak hit work to. Le engine he run correc all day like clock but when we stop him by shut trotle valve le governeur he mak some bad noise more worse as thrash machine. Mon frere Philip he try tight le spring but wich hit mak le engine go like two forty horse an cause him run fas then slow lik winmill. Nex mon frere he loose le spring — mon dieu — I think that time le governeur he smash his self in little piece. All my man come scare and all these man have stack hees dud til engine be fix. S'il vous plait send explanation how repair those trouble an mak me satisfy in al respec. Your frien, ———."